AN EVALUATION OF A NORTHERN BOBWHITE (COLINUS VIRGINIANUS) PARENT-REARED RELEASE IN SOUTH CAROLINA

by:

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A THESIS

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ABSTRACT

Northern bobwhites (*Colinus virginianus*) have experienced large, range-wide declines mainly attributed to the loss of early-successional habitat. Bobwhite population recovery is predicated on sound habitat management. Even when adequate habitat exists, low bobwhite densities and limited dispersal capabilities may limit population recovery. Restocking techniques, including release of pen-reared birds, wild bobwhite translocation, and the use of wild-strained, parent-reared captive-raised bobwhites have been explored as surrogates to natural recolonization. In this study, I evaluated survival and reproduction of parent-reared bobwhites, compared to resident bobwhites, on a private property in South Carolina from April 2009-April 2013. I used a sequential modeling approach to evaluate adult survival and nest survival using Program MARK. Bobwhite survival was best explained by temporal (annual and weekly) effects and group (parent-reared vs. resident) effects. Weekly bobwhite survival for both parent-reared and resident bobwhites was too low to produce a stable population. Parent-reared bobwhite survival was lower than resident bobwhites during the first 3 weeks post-release but similar during later weeks. Parent-reared bobwhites released in August had higher survival (S = 0.884, 95% CI = 0.862, 0.903) than birds released in early fall (S = 0.707, 95% CI = 0.621, 0.782). Nest survival and other reproductive parameters for parent-reared and resident bobwhite were similar. The viability of the parent-reared release system as a restocking technique is limited as currently constructed and future modification is needed if it is to produce a viable bobwhite population.

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CHAPTER I: INTRODUCTION

Numerous grassland bird species have experienced range-wide population declines in recent decades, more so than any other guild of North American birds (Askins 2007). These widespread declines are attributed to the loss and/or degradation of early-successional habitats over the last century (Knopf 1994, Brennan and Kuvlesky 2005). Several factors have contributed to this loss of habitat. Modern agriculture practices are more intense and cleaner than in the past, aided by increased use of pesticides, which has reduced the diversity of annual and perennial forbs and legumes and insect species on the landscape that greatly benefit grassland bird species. Habitat fragmentation, urbanization, afforestation, and the reduction of fire on the landscape have also contributed greatly to the loss of early successional habitats (Knopf 1994, Brennan and Kuvelsky 2005). Beyond changing land uses, the potential negative impacts of climate change on grassland habitat should not be overlooked as a possible contributing factor (Finch 2012). These changes in land use practices have impacted both private and public lands alike, reducing the opportunity for consumptive resource use, especially for low-mobility species such as game birds (Burger et al. 2002). The loss of this guild of bird species may also have major ecological and economic impacts, as many of these species play important roles in seed dispersal and pest control (Weeny et al. 2011).

It is widely accepted that sound habitat management is the best way to abate wide-spread population declines and ensure sustainable populations (Palmer and Wellendorf 2007, Sisson et al. 2006). Exacerbating this problem, many grassland obligate species have low dispersal capabilities from source populations, resulting in low probabilities of recolonization and a high risk of extirpation in a fragmented landscape (Bijlsma et al. 2000, Frankham et al. 2004, Tallmon et al. 2004). Habitat restoration at a scale required to facilitate natural recolonization of habitats by non-migratory bird species in North America is challenging, particularly given the highly fragmented landscape and smaller, more isolated habitat patches. Populations occupying smaller, more isolated habitat patches are more vulnerable to stochastic events (e.g., weather) (Brennan and Kuvelsky 2005). Rising predator abundance, associated with a decrease in trapping, reduction of the fur trade, and the protection of raptors have further hindered the recovery of grassland birds (Rollins and Carroll 2001). Taken collectively, even when adequate habitat is present or restored, grassland bird abundance may be too low to allow populations to recover (Martin et al. 2017). Reintroductions and translocations have become an option to fulfill restoration objectives for early-successional species in areas where they are currently absent (Griffith et al. 1989). Successful reintroductions and translocations are higher in areas of high-quality habitat and often involve species with the potential for a high rate of increase (Griffith et al. 1989, Seddon et al. 2007). Reintroductions are typically considered successful if they produce a viable population, although the definition of success is vague among researchers and will vary widely among species (Griffith et al. 1989, Kleiman 1991). For high generational-turnover (r-selected) species, population growth is inherently linked to productivity counterbalancing low survival rates indicating that individuals released must survive long enough to breed (Griffith et al. 1989, Burger et al. 1999). Although small scale, local population recovery is possible using translocation, its feasibility requires reliable source populations, thereby limiting large-scale population recovery efforts. As such, understanding the efficacy of alternative restocking techniques may provide insight to large-scale population recovery following habitat restoration efforts where animal abundance limits natural re-population (Palmer et al 2012).

Northern bobwhite (*Colinus virginianus*; hereafter, bobwhite) are a good model species to explore alternative population restocking options because they are an early-successional species with high turnover rates that have experienced large, range-wide declines (Stoddard 1931, Peterson 2002). Bobwhites are a popular North American game bird, with major commercial and socio-economic importance (Burger et al. 1999). The economic impact of bobwhites in the Red Hills and Albany regions of Georgia has been found to be $194 million and $125 million respectively (Fleckenstein 2014 and 2018). Bobwhites were once historically found in 35 states throughout much of the eastern, southern, and mid-western portions of the United States (Figure 1). They have experienced range-wide declines, as much as 4.2% per year from 1966-2015. Local and regional extirpations have resulted in range contraction such that only 25 states now support bobwhite populations (Sauer et al. 2017). Range-wide population declines of bobwhites are representative of numerous species subject to the large-scale loss of habitat as a consequence of more intensive agriculture, afforestation, and the lack of prescribed fire (Brennan 1991). Fire is such an important factor for bobwhite survival that they have been nicknamed the "fire bird" (Stoddard 1931).

Numerous restocking methods have been explored in recent decades in an attempt to re-establish, augment, or bolster bobwhite populations. The most common restocking techniques include release of pen-reared birds and translocation. Although pen-reared releases have been used for decades to augment hunting, it has proven to be an ineffective conservation tool to increase wild bobwhite populations mainly due to low survival of pen-reared birds (Roseberry et al. 1987). Other concerns with the release of pen-reared birds include the potential for disease transmission, displacement of native bobwhites, increased resident bobwhite mortality and the dilution of the native bobwhite gene pool (Davidson et al. 1980, Landers et al. 1991, Sisson et al. 2000). Low survival rates of pen-reared birds are likely due to the lack of imprinting between chicks and their parents (Palmer et al. 2012). The loss of this pre-and post-hatch learning period

Northern Bobwhite Range

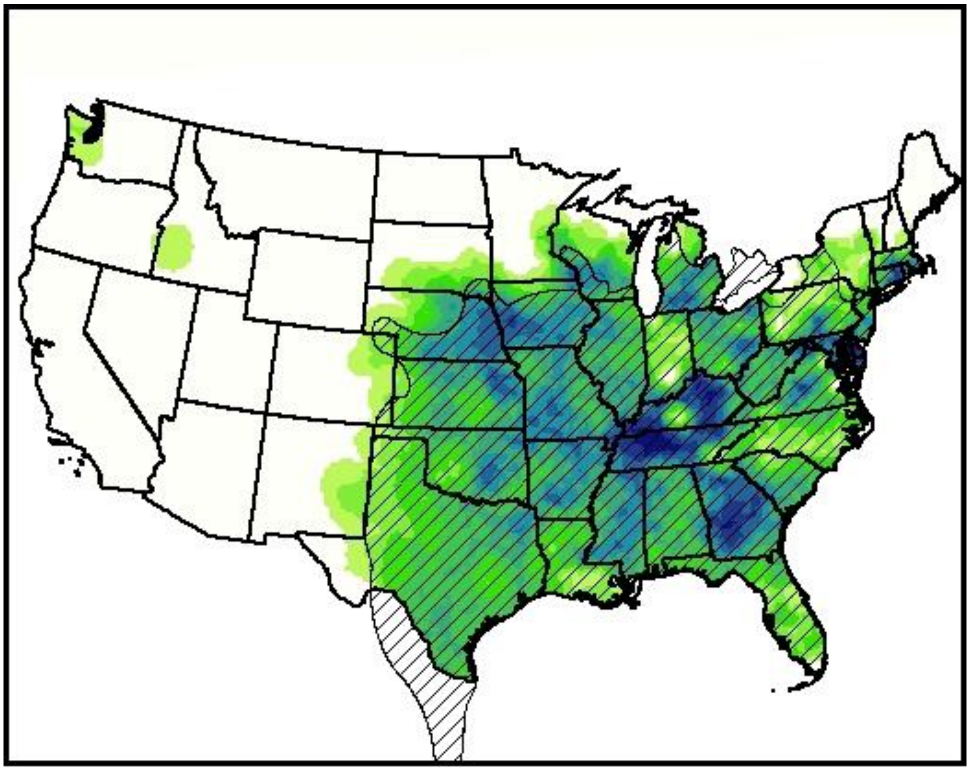

Figure 1. Northern Bobwhite range in the conterminal United States. Range developed using the Breeding Bird Survey (BBS) data and other call count data as available; shaded region on scale of light-green (lower) to dark blue (higher) represents the relative bobwhite density based on weighted point data. The hatched area represents the historical range of bobwhite.

(Map and caption from National Bobwhite Conservation Initiative 2011 pg. 2) has a significant, negative impact on many important social skills, including predator recognition and avoidance, sexual selection, recognition of alarm calls, food selection, and parenting skills (Hess 1973, Dowell 1992, Lickliter and Harshaw 2010). Translocation of wild bobwhites prior to the breeding season has proven to be a successful technique to re-establish bobwhites (Terhune et al. 2006a, b, Terhune et al. 2010, Sisson et al. 2012). Despite using translocation to successfully restore bobwhite populations, it may not always be a feasible option at a large-scale, due to high management and opportunity cost as well as limited source populations (Sisson et al. 2017).

More recently, an alternative restocking technique was developed using adoptive parent-rearing of wild-strain bobwhite chicks that includes pre- and post-hatch imprinting with adult bobwhites via auditory and visual imprinting cues that positively affected chick survival (Palmer et al. 2012). This method provides an opportunity to produce a high-yield of captive-reared birds with wild bobwhite characteristics such as parental provisioning and natural foraging behavior, but the survival of parent-reared birds post-release is uncertain. Therefore, I obtained field research data collected by Tall Timbers and evaluated the reproduction and survival of parent-reared (PR) bobwhites compared to resident bobwhites on a private property located in South Carolina during 2008-2013. I hypothesized that (1) the timing of release influences survival of parent-reared bobwhites such that environmental conditions, disparity in vegetation composition, weather, predator abundance, or unfamiliarity with the new environment might impact their success post-release; (2) parent-reared bobwhite survival would be lower than resident bobwhites during the first few weeks post-release. Past studies of parent-reared and translocated bobwhite survival have found that survival the first few weeks post release is low; as such, I hypothesized that (3) parent-reared bobwhites released later in the breeding season (September) would have a higher probability of survival to the following breeding season; (4) home range size influences survival. I predicted that parent-reared bobwhites would have a larger home range, when compared to resident bobwhites, which would cause higher mortality rates due to increased movement and exposure to predators; and, (5) nest survival rates, as well as other reproductive parameters (nests/hen, number of successful nests, broods/hen, and chicks/hen) would be similar between parent-reared and resident bobwhites.

CHAPTER II: METHODS

2.1 Study Area

Field research was conducted on a 1957 ha private plantation in Georgetown County, South Carolina (33.50659°N 79.47139°W) from August 2008-April 2013 (Figure 2, Figure 3). Land cover was comprised of 52 % loblolly pine (*Pinus taeda*) savanna (~30 m^2 basal area/hectare), 11% longleaf pine (*P.palustris*) savanna (<50 m basal area/hectare), 10% bottomland hardwoods (mixed oak [*Quercus* spp.] and American sweetgum [*Liquidamber styraciflua*]), and 12% fallow fields. The remainder of the habitat consisted of waterfowl impoundments, ponds, and planted pines. The understory of the pine savannas consisted primarily of little bluestem (*Schizachyrium scoparium*), broomsedge (*Andropogon virginicus*), big blue-stem (*A. gerardi*), blackberry (*Rubus fruticosus*), saltbush (*Baccharis halimifolia*) and wax myrtle (*Morella cerifera*) (McGrath et al. 2018). Climate was subtropical with hot summers and mild winters, and average annual rainfall of 125 cm (U.S. Climate Data 2015). Average elevation was 1.3 m above sea level and topography was generally flat (US Geological Survey 2014). Management activities consisted of prescribed burning on a 2-year fire return interval and winter disking of fallow fields. Bobwhite hunting was also conducted on the property during the winter months. Hunts occurred in the mornings and evenings and lasted approximately 2.5 hours per hunt. Hunting parties generally consisted of 2-4 hunters, 2 guides, and 2 pointing dogs (McGrath et al. 2018).

2.2 Parent-rearing Process

Wild-strain bobwhite eggs were obtained from abandoned nests at Tall Timbers Research Station. Daily nest checks of radio tagged, nesting bobwhite hens allowed researchers to

Location of Study Site

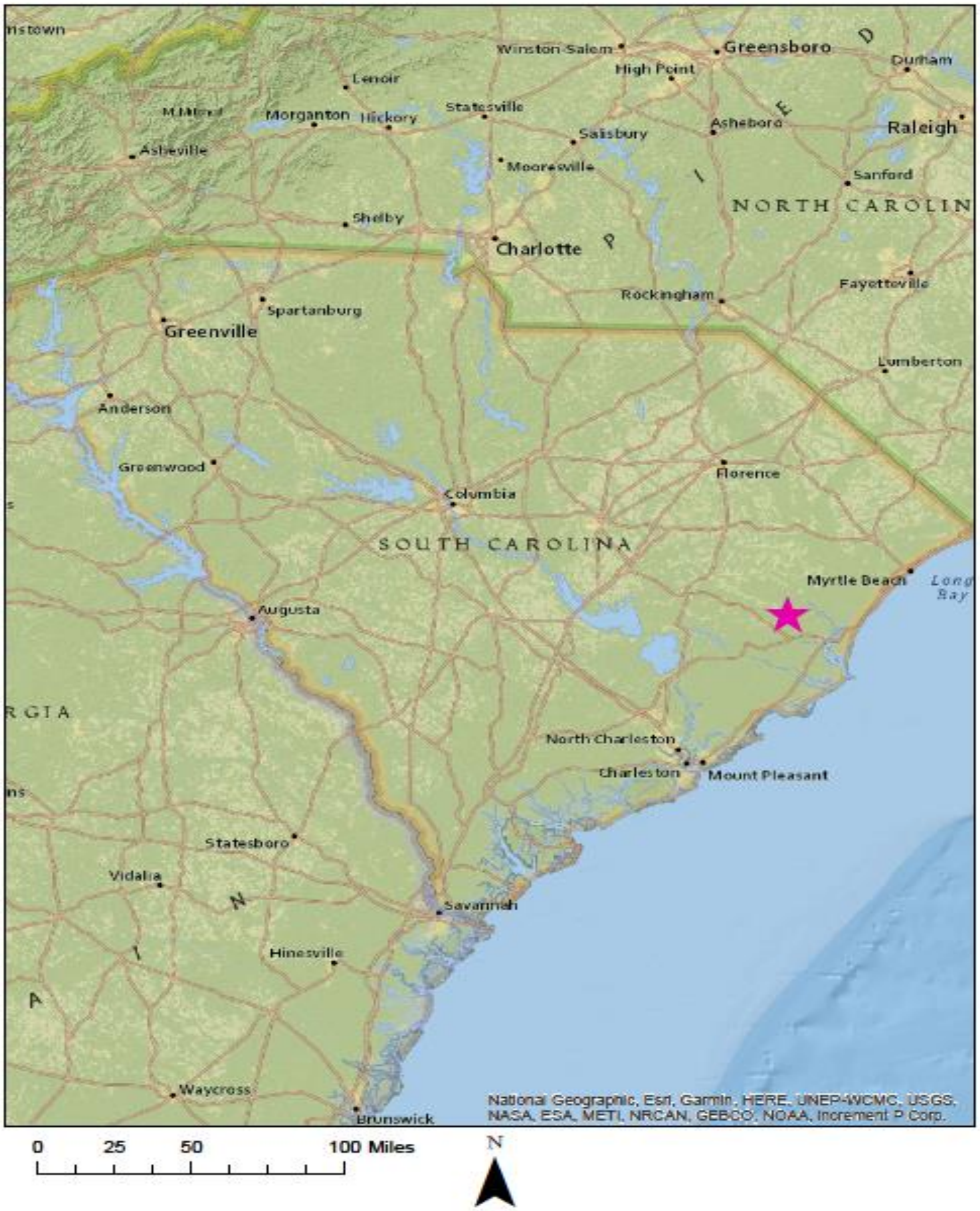

Figure 2. Location of study site (star), a 1957 ha private plantation in Georgetown County, South Carolina, USA (33.50659°N 79.47139°), where research was conducted from 2009-2013.

Property Outline of Study Site

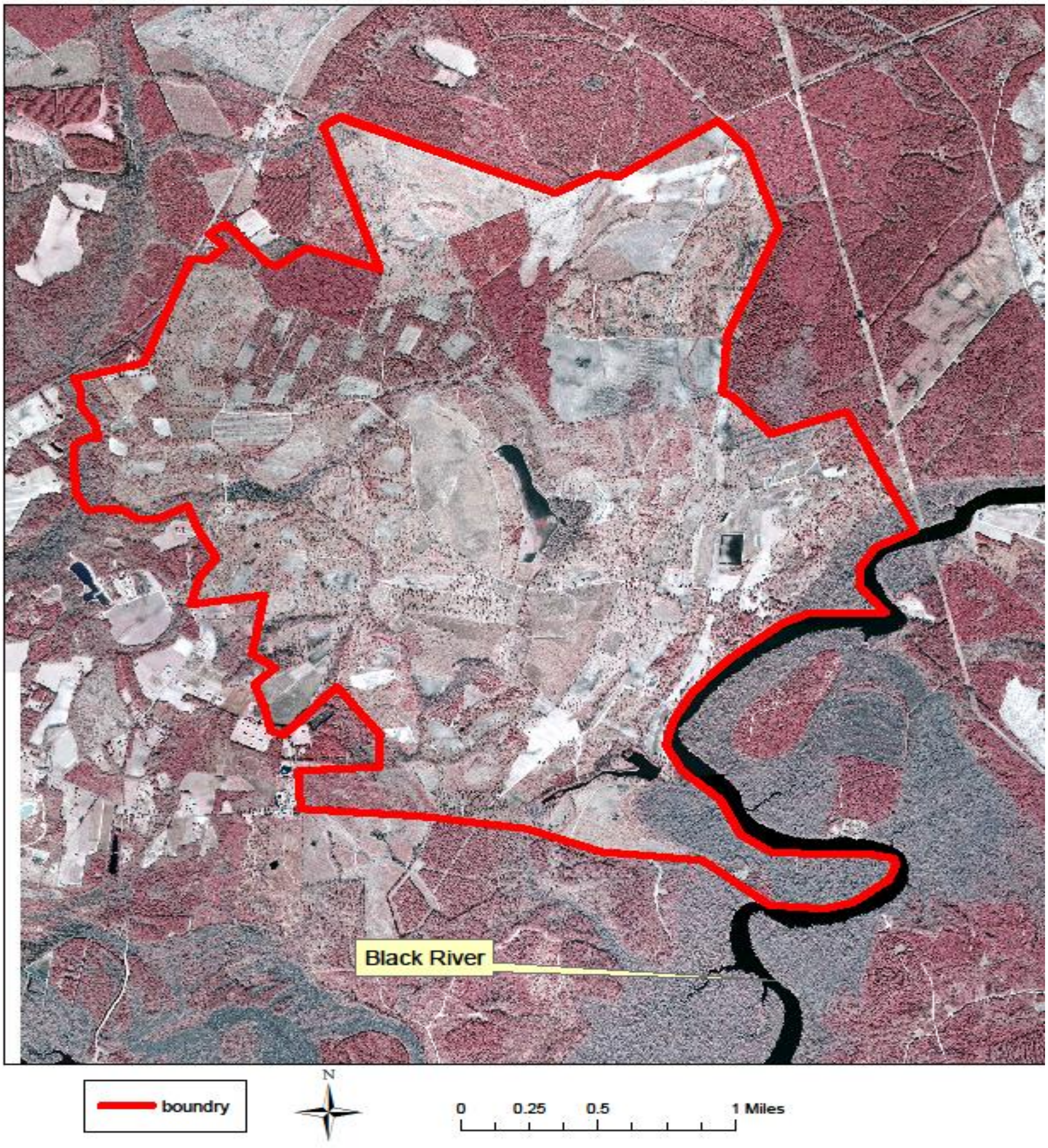

Figure 3. Property outline of study site, a 1957 ha private property near the Black River in Georgetown County, South Carolina, USA, (33.50659°N 79.47139°W) where research was conducted from 2009-2013.

determine when a nest had been abandoned or the hen had been depredated. These eggs were hatched in an incubator and chicks were reared in a brooder. These birds were then used to lay eggs for this study so that wild genes could be maintained in release groups, whereby all parent-reared individuals were no further than first-generation removed. An audio-recording of bobwhite hen vocalizations was played ~36 hrs before hatching (Lickliter 2005). Upon hatching, chicks were introduced to a wild-strain bobwhite foster parent within 6 hours of hatching to trigger the visual imprinting cue. If an adult rejected a brood, it was removed and another adult was added. Successful adoption was characterized by adults showing brooding proclivities and vocalizing with chicks (Palmer et al. 2012). Adopted chicks were held overnight in a brooding box to help strengthen their bond and protect them from the elements (Stoddard 1931). The brood and parent were then released into a rearing pen for 35-42 days until release into the wild. Rearing pens were trapezoidal shaped, with 5m long sides, 1m wide on the short side, and 3.6m wide on the long side. Rearing pens contained natural vegetation and birds were fed a mixture of proso-millet (*Panicum miliaceum*) and milo (*Sorgum bicolor*), with minimal human contact (Palmer et al. 2012, Lunsford et al. 2017).

2.3 Survival Analysis – Capture, Tagging and Release

Resident bobwhites were trapped in winter and spring of 2011-2012. Bobwhites were trapped with confusion-style funnel traps, baited with a sorghum and cracked corn mix (Stoddard 1931). All traps were checked daily starting approximately at sunset. Individuals were marked with uniquely numbered, aluminum leg bands (National Band and Tag, Newport, KY, USA), and each bird’s sex, age, and mass (g) was determined at the time of capture. Age was determined using the coloration of the primary covert feathers (Rosene 1969). Very high frequency (VHF) necklace style radio-transmitters (6.4 g radio tag; Holohil Systems Carp, Ontario, Canada) were placed on 4-6 individuals/covey. Transmitters were Holohil model RI-2BA with a frequency range of 148.000-151.999. Battery life on transmitters was 6-8 months with a range of approximately one mile, depending on habitat type and terrain. Only individuals weighing >132g were outfitted with VHF radio-transmitters in order to minimize radio-handicapping (Palmer and Wellendorf 2007, Terhune et al. 2007).

PR bobwhite chicks (~6 weeks old) were released on the study area in 2011-2012. One cohort was released in early August of each year, with another cohort released in the fall (late September/early October) of each year, to coincide with natural peaks in hatching. A subset of PR bobwhite chicks were outfitted with necklace style 3 g VHF radiotransmitters (American Wildlife Enterprises, Monticello, FL), with a frequency range of 148.000-151.999, battery life of 6-8 months, and a range of approximately one mile depending on habitat type and terrain. Transmitters were <5% body mass in order to minimize radio handicapping. Because chicks were too small to receive leg-bands, PR chicks were marked with uniquely numbered patagial wing tags (Smith et al. 2003).

All handling and processing of bobwhites followed animal welfare guidelines approved by Tall Timbers Research Station Institutional Animal Care and Use Committee permit number GB-2001-01-15.

2.4 Survival Analysis – Telemetry

Radio-tagged bobwhites were located 2-3 times per week to assess survival and obtain locations to determine home range size and resource use. Hand-held 3-element Yagi antennas and ATS Telemetry Receivers (ATS, Isanti, MN, USA) were used to locate radio-tagged bobwhites using the homing method which involved conducting telemetry on foot and collecting signal strengths at several different angles to determine a bird's location (White and Garrott 1990, Kenward 2001). Bird locations were recorded on aerial photography maps in the field and later transcribed to ArcGIS 10.3, ESRI ®. Radio collars were recovered immediately when a mortality signal was detected. Mortality signals were activated when radio collars did not move for >12 hours, and were characterized by a faster pulse signal heard over the radio transmitter. The cause of mortality was determined by analyzing evidence (plucked feathers, chewed transmitters, etc.) at the kill site (Dumke and Pils 1973). Mortalities were categorized as large avian, small avian, mammal, hunter harvest, snake, or unknown. I used the ADEHABITAT package in program R to calculate 95% adaptive kernel home range (R Core Team 2017) (Appendix A). R is a free, open- source language software suite for statistical computing. R allows for more flexibility in statistical computing since it is an open-source language, rather than a preset package like other statistical software. The ADEHABITAT package is used to compute home range in R. I only conducted home range analysis on birds with ≥ 20 telemetry locations (Seaman and Powell 1996).

2.5 Survival Analysis – Analytical Approach

I used the known-fates model in Program MARK to evaluate two *a priori* candidate model suites, allowing for staggered entry of individuals (White and Burnham 1999) (Appendix B). I chose the known fates model because the fate of every tagged bobwhite was known at the beginning of each encounter interval. Other models (e.g. Cormack-Jolly-Seber) have a detection probability less than one and the fate of each individual is not known at each encounter interval (White and Burnham 1999). I estimated survival on a weekly basis from August 1 – April 30 for the years (2011-2012 and 2012-2013). I recorded birds as either alive, dead, or censored for each weekly interval. The first model suite incorporated temporal effects. I compared a priori models to test for a weekly-interval effect on survival (i.e. 1 week, 2 week, 3 week …….8 week, yearly) as well as a temporal model that incorporated annual survival. In models that contained weekly effects, survival was held constant for the weeks after the weekly effect. I employed a sequential modeling approach using Akaike's Information Criterion (AIC_c) to compare candidate model sets. The model with the lowest AIC_c value was considered the best approximating model, given the data (Burnham and Andeson 1998). Best approximating model selection was based on ΔAIC_c that were calculated in program MARK. This was calculated as the difference in current AIC_c and the minimum AIC_c . The plausibility of each model was assessed using Akaike weights, w_i. The best models had the highest Akaike weights (Burnham and Anderson 1998, Anderson et al. 2000).

My second model suite evaluated group effects of year (YR) (2011-2012 and 2012-2013), bird type (resident and parent-reared (PR)), time of release (TOR) (August or early fall), and home range (HR) size (ha). I also incorporated the highest-ranking temporal model into this model suite. This model suite allowed me to isolate and evaluate group level effects on survival. I used a sequential modeling approach to compare candidate model sets. I compared *a priori* models using each individual covariate by itself, as well as models using a combination of individual covariates to determine the effect of the interaction between individual covariates on bobwhite survival. I made direct comparisons of covariates by reporting beta (β) estimates and respective 95% confidence intervals (Nakagawa and Cuthill 2007, Terhune et al. 2010). Program MARK does not allow for the reporting of confidence intervals below 95% (White and Burnham 1999). Reporting of betas and 95% confidence intervals is mandatory to assess the magnitude and precision of any effects and their biological importance (Nakagawa and Cuthill 2007).

2.6 Reproductive Analysis – Capture, Tagging and Release

Bobwhites were trapped in winter and spring of 2009-2010 with confusion-style funnel traps baited with a sorghum and cracked corn mix (Stoddard 1931). All traps were checked daily (2009: 9 March-27 March; 2010: 8 March-22 April) starting at approximately sunset. Individuals were marked with uniquely numbered, aluminum leg bands (National Band and Tag, Newport, KY, USA). Bird type was determined (PR vs. resident), as well as sex, age, and mass at time of capture. Age was determined using the coloration of the primary covert feathers (Rosene 1969). The same model 6.4g VHF necklace style radio-transmitters were used as in section 2.3 above. (Holohil Systems Carp, Ontario, Canada). Transmitters were placed on 4-6 individuals/covey. Only individuals weighing >132 g were outfitted with VHF radio transmitters in order to minimize radio-handicapping (Palmer and Wellendorf 2007, Terhune et al. 2007).

2.7 Reproductive Analysis – Telemetry

Radio-tagged bobwhites were located 2-3 times per week during the breeding season (1 April – 30 September). Hand-held 3-element Yagi antennas and ATS Telemetry Receivers (ATS, Isanti, MN, USA) were used to locate radio-tagged bobwhites using the same methods as in section 2.4 above (White and Garrott 1990, Kenward 2001).

2.8 Reproductive Analysis – Nest Success

Bobwhite nests were flagged after radio-marked adults were located in identical locations on consecutive days (McGrath et al. 2017). Nest presence was visually confirmed once the adult was located away from the potential nest site (Burger et al. 1995). Nests were checked daily to determine clutch size and hatch date until the nest failed (no eggs hatched, adult predated) or was successful (hatched $\geq$ 1 egg) (McGrath et al. 2017).

2.9 Reproductive Analysis – Analytical Approach

I calculated nests/hen, number of successful nests, broods/hen, and chicks/hen for both resident and PR bobwhites, in both 2009 and 2010, as well as pooled across all years. The number of radio-marked hens alive on 15 April was used for these calculations, as this was considered the beginning of the nesting season. Successful nests are reported as the proportion of nests that hatched ≥1 egg (Palmer et al. 2012).

I used the nest survival model in Program MARK (Appendix C) to calculate nest survival rates which allowed for the evaluating competing models with the inclusion of multiple covariates (White and Burnham 1999). I developed models to explicitly test hypotheses about year, bird type, and group. Each encounter history included the bird tag number, Julian date (JD) nest was found, JD nest was last active, JD of fate (successfully hatched or depredated), as well as two covariates: year (2009 or 2010) and bird group (Resident or Parent-reared [PR]).

I compared models developed *a priori* based on biological insight in Program MARK to analyze nest survival rates using the logit-link function in the nest survival model. I built models using each individual covariate by itself, as well as models using a combination of individual covariates to determine the effect of the interaction between individual covariates on bobwhite nest survival. I compared the candidate model sets using AIC_c and interpreted the significance of each based on β values and 95% confidence intervals. The model with the lowest AIC_c value was considered the best approximating model. Individual covariates with 95% confidence intervals that did not overlap zero were considered to be informative.

CHAPTER III: RESULTS

3.1 Survival

During the course of the study, 254 birds were monitored until a known fate cause. Of these, 51 were censored. These individuals either moved off the study area, their radio signal was lost, or the radio transmitter came off the bird. The remaining mortalities were categorized as large avian (n=37), small avian (n=37), mammal (n=45), hunter shot (n=9), trap induced (n=3), snake (n=1), and unknown (n=71).

I included 328 bobwhites in my survival analysis (162 in 2011 and 166 in 2012), which included 212 resident bobwhites (101 in 2011 and 111 in 2012) and 116 PR bobwhites (61 in 2011 and 55 in 2012). Seventy-six PR bobwhites were released in August (40 in 2011 and 36 in 2012) and 40 in the fall (21 in 2011 and 19 in 2012).

Average estimated weekly survival was low (S = 0.880, 95% CI = 0.865, 0.894; β_{weekly} = 1.996, 95% CI = 1.86, 2.13) across all years and bird types (Table 1). Time of release ($\beta_{\text{fall release}}$ = -1.175, 95% CI = -1.578, -0.773; Figure 4) had a negative effect on survival. PR bobwhites released in August had higher survival rates (S = 0.892, 95% CI = 0.877, 0.905) than PR bobwhites released in the fall (S = 0.718, 95% CI = 0.637, 0.787). Bird type also had a negative effect on survival ($\beta_{\text{parent-reared}}$ = -1.009, 95% CI = -1.288, -0.729; Figure 5). PR bobwhites had lower survival rates (S = 0.788, 95% CI = 0.7501, 0.8220) than resident bobwhites (S = 0.9108, 95% CI = 0.8952, 0.9241). Annual variation did not adequately explain survival by itself (β_{year} = 0.220, 95 % CI = -0.051, 0.491; Figure 6). Year and bird type influenced survival such that resident bird survival was higher ($\beta_{\textit{bird type}}$= 2.293, 95% CI = 2.057, 2.528) than PR bobwhites, and survival was higher in 2012 (S = 0.893, 95% CI = 0.871, 0.909) than 2011(S = 0.868, 95%

Average Weekly Survival Rates of Parent-reared and Resident Bobwhites

Table 1. Average weekly survival rates for parent-reared and resident bobwhites on a private plantation in Georgetown County South Carolina, USA 2011-2013.

Week	Survival Estimate	Standard Error	Lower 95% CI	Upper 95% CI
1	0.778	0.044	0.680	0.852
2	0.667	0.057	0.548	0.767
3	0.712	0.063	0.575	0.818
4	0.844	0.054	0.708	0.924
5	0.861	0.058	0.707	0.941
6	0.935	0.044	0.776	0.984
7	0.929	0.049	0.755	0.982
8	0.808	0.077	0.613	0.918
9	0.619	0.106	0.402	0.797
10	0.667	0.075	0.507	0.796
11	0.680	0.093	0.478	0.831
12	0.818	0.082	0.604	0.930
13	0.857	0.094	0.573	0.964
14	0.462	0.138	0.224	0.718
15	0.875	0.117	0.463	0.983
16	0.600	0.155	0.297	0.842
17	0.813	0.098	0.553	0.938
18	0.750	0.077	0.574	0.870
19	0.939	0.026	0.862	0.974
20	0.955	0.022	0.885	0.983
21	0.939	0.026	0.862	0.974
22	0.935	0.025	0.864	0.971
23	0.978	0.015	0.917	0.995
24	0.967	0.019	0.902	0.989
25	0.966	0.019	0.900	0.989
26	0.951	0.024	0.876	0.981
27	0.960	0.023	0.883	0.987
28	0.959	0.023	0.880	0.987
29	0.958	0.024	0.877	0.986
30	0.939	0.029	0.849	0.977
31	0.788	0.071	0.617	0.895
32	0.875	0.068	0.676	0.959
33	0.857	0.132	0.419	0.980
34	0.949	0.029	0.854	0.984
35	0.915	0.036	0.812	0.964
36	0.759	0.046	0.658	0.837
37	0.750	0.054	0.630	0.841
38	0.979	0.021	0.864	0.997

Effect of Time of Release on Survival

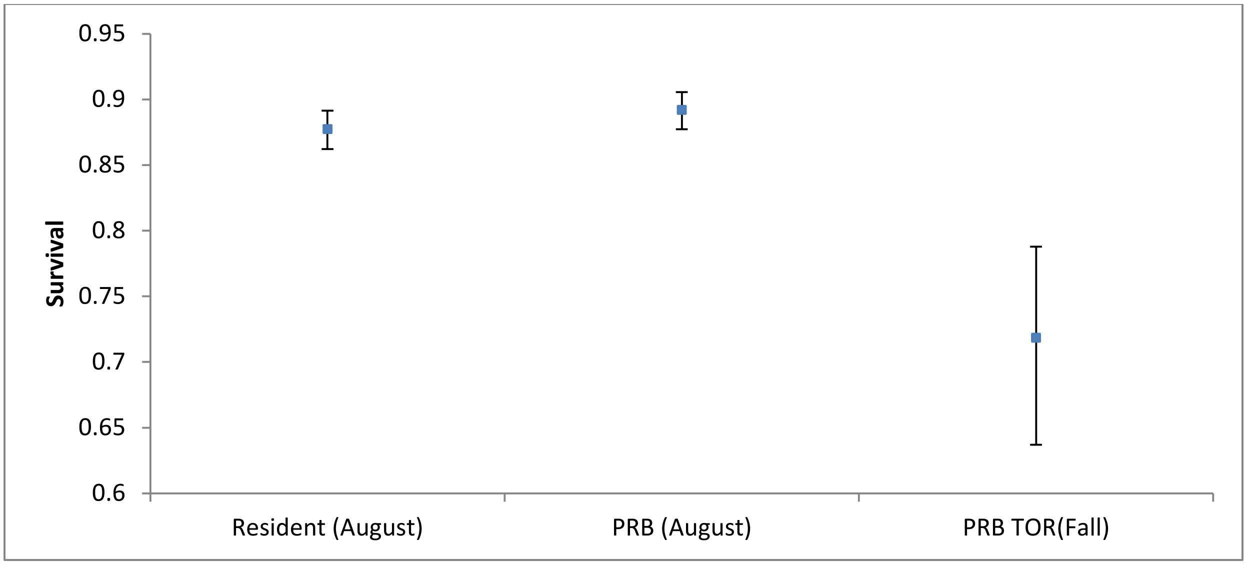

Figure 4. Effect of Time of Release (TOR) (August vs Fall (Sept/Oct.) on weekly survival rates of parent-reared bobwhites (PRB) compared to resident bobwhites with 95% confidence intervals on a plantation in Georgetown County, South Carolina, USA, 2011-2012.

Weekly Survival Rates

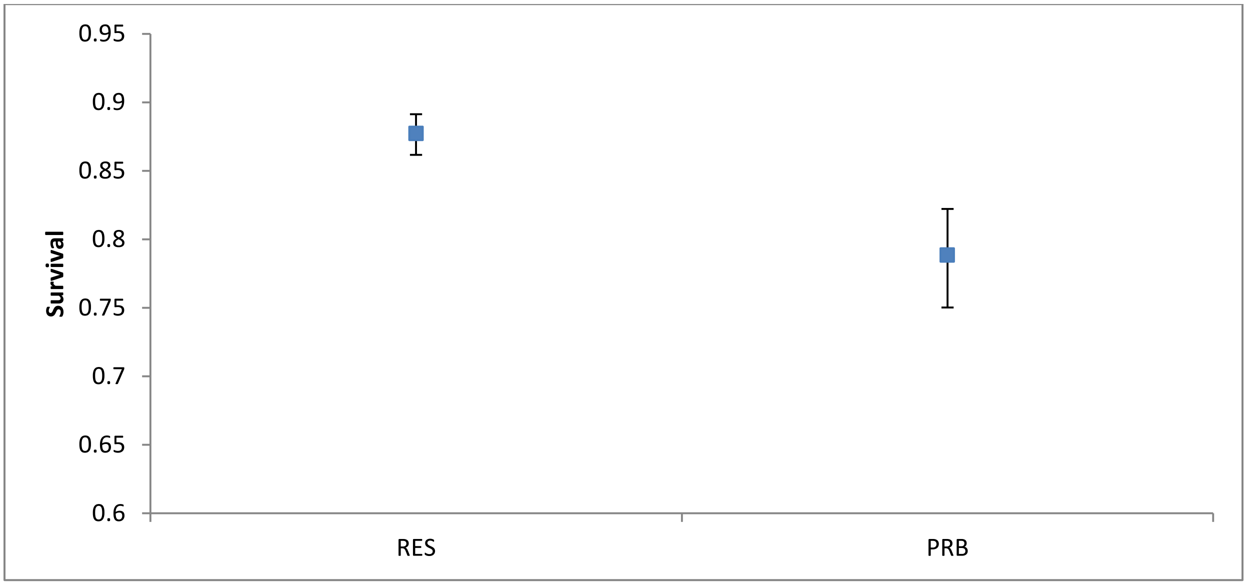

Figure 5. Weekly survival rates of resident (RES) vs. parent-reared bobwhites (PRB) with 95% confidence intervals on a plantation in Georgetown County, South Carolina, USA, 2011-2013.

Weekly Survival Rates Categorized by Year

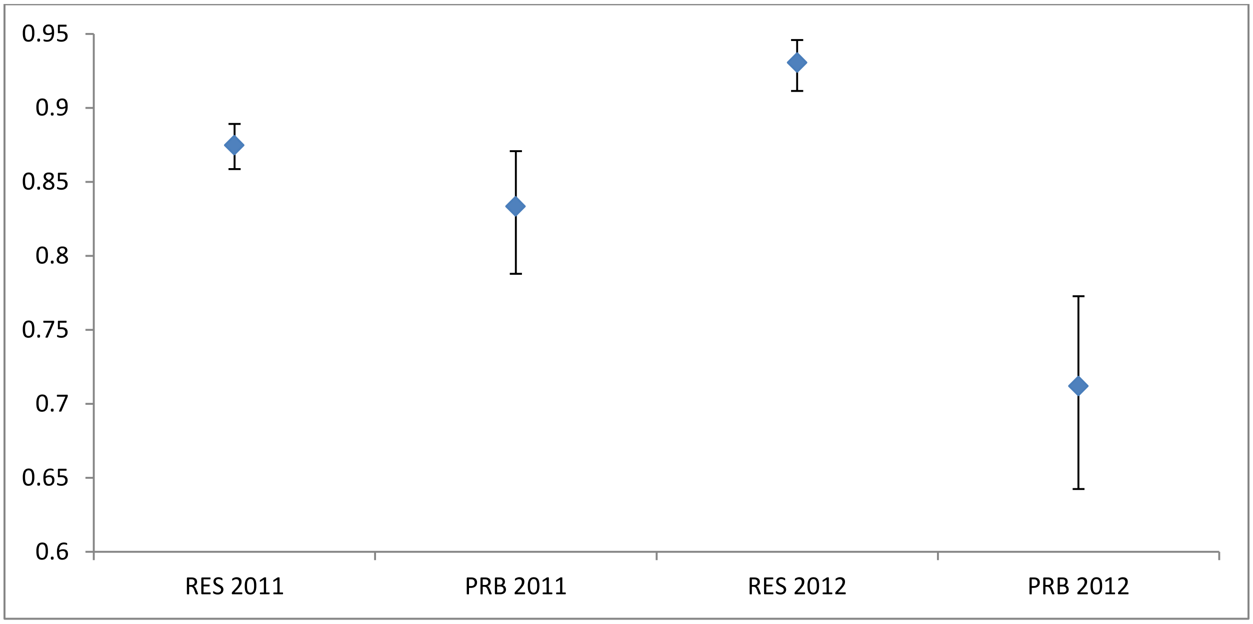

Figure 6. Weekly survival rates for resident (RES) and parent-reared bobwhites (PRB) categorized by year, with 95% confidence intervals, on a plantation in Georgetown County, South Carolina, USA, 2011-2012.

CI = 0.846, 0.888). Time of release also impacted parent-reared bobwhite survival whereby late summer survival was higher (β_{August} = 2.032, 95% CI = 1.83, 2.232) than the early fall (September) release cohort.

The best fitting temporal model included a three-week post release interval effect (Table 2; β = 2.183, 95% CI = 2.029, 2.337). Individual group covariates (YR, bird type, TOR) improved overall model fit when compared to the 3-week interval effect model. The most parsimonious group model (w_i = 0.57) that maximized explained variance included a three-week interval effect on survival and an interaction of year and bird type (Table 3; $\beta_{\text{3week + YR+ bird type + YR*birdtype}}$ = 2.139, 95% CI = 1.89, 2.387).

Home range size did not have an effect on survival ($\beta_{\text{home range}}$ = -0.016, 95% CI = -.0521, 0.020). It is possible that small sample size may have precluded a detection of a difference in the data. Twenty-nine bobwhites qualified for home range analysis (PR = 9, Resident = 20) and home range between both bird types was similar (PR = 12.12 ha, 95% CI = 10.01, 14.23); (resident = 11.35 ha, 95% CI = 10.31, 12.12)).

3.2 Reproduction

A total of 70 radio-tagged hens were alive on 15 April pooled for both years (n_{2009} = 30, n_{2010} = 40). Forty-five resident hens (n_{2009} = 19 and n_{2010} = 26) and 25 PR hens (n_{2009} = 11, n_{2010} = 14) were radio-tagged on 15 April across both years (2009, 2010). Resident hens produced 28 nests across both years (n_{2009}=10, n_{2010}=18). PR hens produced 16 nests across both years (n_{2009} = 7, n_{2010} = 9). Nest survival was S = 0.44 (95% CI = 0.29, 0.61). Pooled daily survival rates for nests were S = 0.96 (95% C I= 0.94, 0.98). Daily survival rates were similar between bird types (($S_{\text{parent-reared}}$ = 0.96, 95% CI = 0.92, 0.98)(S_{resident} = 0.96, 95% CI = 0.94, 0.98)). The most

Temporal Survival Rate Models of Adoptive Bobwhite Chicks

Table 2. Akaike's Information Criterion rankings for models approximating temporal survival rates of adoptive bobwhite parent-reared chicks released on a plantation in Georgetown County South Carolina, USA 2011-2013.

Model	Num. Par	AICc	Δ AICc	wi	Model Likelihood	Deviance
3-week	2	1424.086	0	0.37	1	1420.08
3-week * t[a]	4	1425.607	1.521	0.17	0.47	1417.59
4-week	2	1425.808	1.722	0.16	0.42	1421.80
4-week *t	5	1426.306	2.221	0.12	0.33	1416.28
5-week * t	6	1427.756	3.670	0.06	0.16	1415.71
5-week	2	1427.787	3.7012	0.06	0.16	1423.78
6-week *t	7	1429.295	5.209	0.03	0.07	1415.24
8-week * t	9	1431.027	6.941	0.01	0.03	1412.94
7-week * t	8	1431.033	6.947	0.01	0.03	1414.96
6-week	2	1433.581	9.495	0	0	1429.58
8-week	2	1435.739	11.653	0	0	1431.73
2-week * t	3	1437.158	13.072	0	0	1431.15
2-week	2	1437.582	13.496	0	0	1433.58
1-week	2	1437.582	13.4957	0	0	1433.58
7-week	2	1437.712	13.626	0	0	1433.71
1-week * t	2	1459.351	35.265	0	0	1455.35
Year Design Matrix	2	1464.662	40.576	0	0	1460.67
. Design Matrix	1	1465.203	41.117	0	0	1463.20

[a]time

Group Survival Rate Models of Adoptive Bobwhite Chicks

Table 3. Akaike's Information Criterion rankings for models approximating group survival rates of adoptive bobwhite parent-reared chicks on a plantation in Georgetown County, South Carolina, USA 2011-2013.

Model	Num. Par.	AICc	Δ AICc	wi	Model Likelihood	Deviance
3-week+YR[a]+PRB[b]+YR*PRB	5	1387.15	0	0.565	1	1377.12
3-week+TOR[c]	3	1387.71	0.56	0.43	0.76	1381.69
3-week + PRB	3	1396.36	9.21	0.01	0.01	1390.35
3-week + YR+PRB	4	1397.85	10.70	0	0	1389.83
Year + PRB + Yr*PRB	4	1404.21	17.07	0	0	1396.19
. + PRB+TOR	3	1416.23	29.09	0	0	1410.22
. + PRB	2	1419.42	32.28	0	0	1415.41
Year + PRB	3	1421.28	34.13	0	0	1415.27
3-week + YR	3	1423.86	36.71	0	0	1417.85
3-week	2	1424.09	36.94	0	0	1420.08
Year + TOR + Yr*TOR	4	1435.02	47.87	0	0	1426.99
. +TOR	2	1439.08	51.93	0	0	1435.07
. +HR[d]	2	1466.46	79.32	0	0	1462.46

[a]Year
[b]Parent-Reared Bobwhite
[c]Time of Release
[d]HR

parsimonious nest survival model was the naïve S(.) model (w_i = 0.289)(Table 4) suggesting that other variables of interest such as group (PR versus resident; β = 0.026, 95% CI = -0.96, 1.01) and year (β= -0.68, 95% CI = -1.71, 0.36) did not help to explain variation observed in nest survival. Twenty-four total nests were produced across both years (n_{2009} = 12, n_{2010} = 12). Resident hens produced 14 successful nests across both years (n_{2009} = 6, n_{2010} = 8). PR hens produced ten nests (n_{2009} = 6, n_{2010} = 4) (Figure 7). Across both years, the number of nests produced per hen for resident hens was 0.62 (n_{2009} = 0.53, n_{2010} = 0.69). The number of nests produced per hen for PR hens, across both years, was 0.64 (n_{2009} = 0.64, n_{2010} = 0.64) (Figure 8). The number of PR hens that produced multiple nests was five across both years (n_{2009}=2, n_{2010}=3). The number of resident bobwhites that produced multiple nests was five across both years (n_{2009}=1, n_{2010}=4). Broods produced per hen for resident birds was 0.31 across both years (n_{2009} = 0.32, n_{2010} = 0.31). PR hens produced 0.40 broods per hen across both years (n_{2009} = 0.55, n_{2010} = 0.29) (Figure 9). Across both years, resident hens produced 3.2 chicks per hen (n_{2009} = 2.79, n_{2010} = 3.50). PR hens produced 4.2 chicks per hens across both years (n_{2009} = 5.82, n_{2010} = 2.93) (Figure 10).

Nest Survival Rate Models for Resident and Parent-reared Bobwhites

Table 4. Akaike's Information Criterion rankings for models approximating nest survival rates for resident and parent-reared bobwhites in South Carolina 2009-2010.

Model	Num. Par.	AICc	Δ AICc	wi	Model Likelihood	Deviance
S(.)	1	165.51	0	0.366	1	163.50
S(year)	2	165.74	0.24	0.325	0.89	161.72
S (birdtype)	2	167.52	2.01	0.134	0.37	163.50
S(year + birdtype}	3	167.77	2.26	0.118	0.32	161.72
S(year + birdtype + birdtype*year)	4	169.24	3.73	0.057	0.15	161.16

Daily Nest Survival Rates

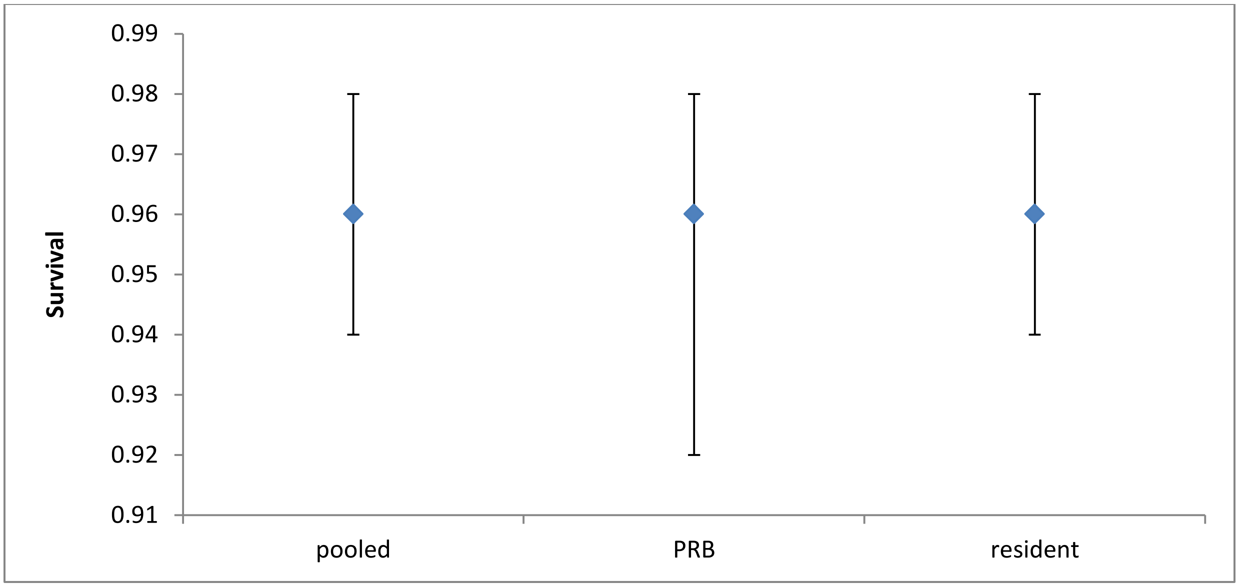

Figure 7. Daily nest survival rates for resident and parent-reared (PR) bobwhites and pooled across bird types for 2009-2010 at a study site in South Carolina.

Nests Produced Per Hen

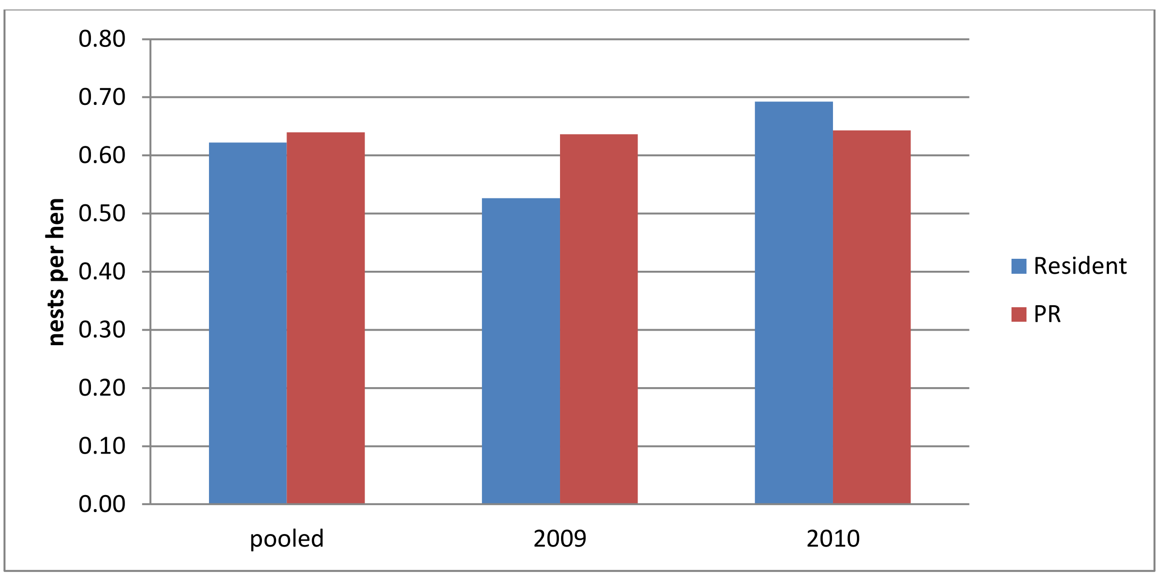

Figure 8. Nests produced per hen for resident and parent-reared bobwhites at a study site in South Carolina. Data shown includes pooled sample (2009, 2010), 2009, and 2010.

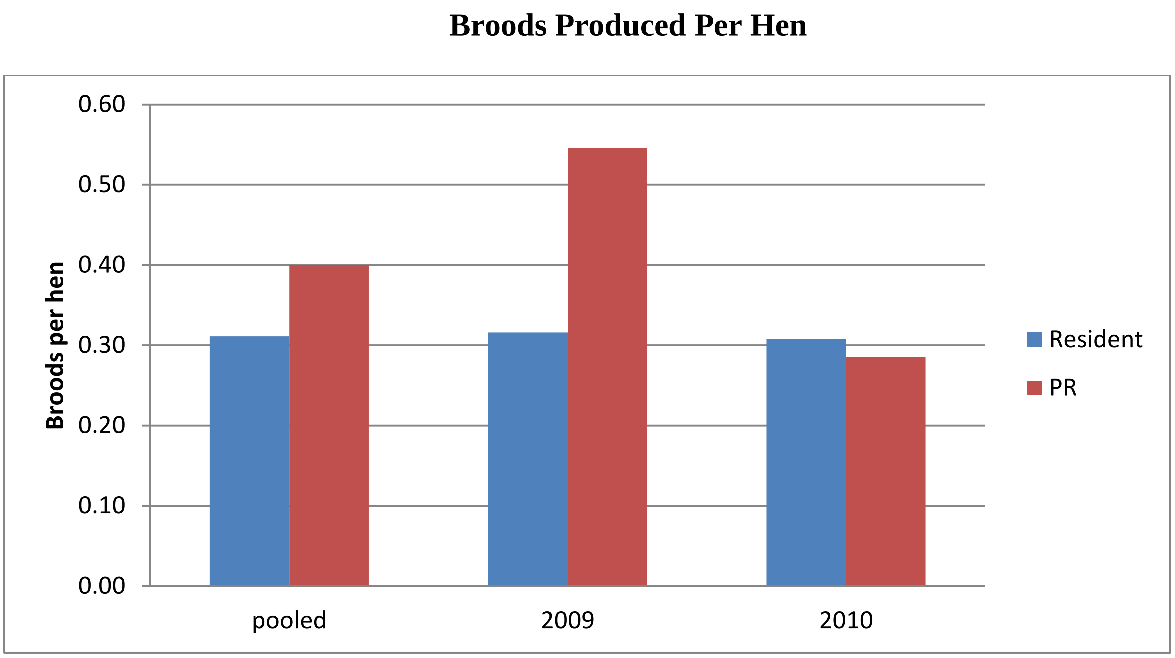

Figure 9. Broods produced per hen for resident and parent-reared (PR) bobwhites at a study site in South Carolina. Data shown includes pooled sample (2009, 2010), 2009, and 2010.

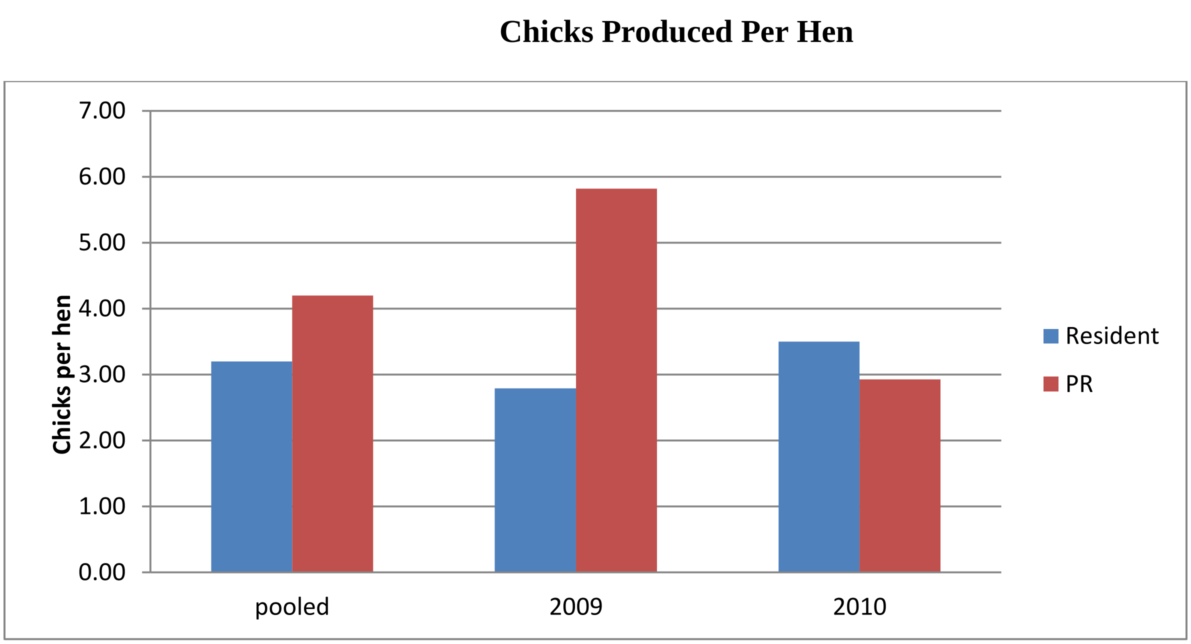

Figure 10. Chicks produced per hen for resident and parent-reared (PR) bobwhites at a study site in South Carolina. Data shown includes pooled sample (2009, 2010), 2009, and 2010.

CHAPTER IV: DISCUSSION

4.1 Survival

Average weekly survival rates in my study were low when compared to average weekly survival rates for bobwhite in the Southeast (S = 0.972; Terhune et al. 2007, Sisson et al. 2009). My results indicate that a high level of mortality of PR bobwhites should be expected the first few weeks post release. The results of my study support my prediction that timing of release effects survival of parent-reared bobwhites. PR bobwhites released in August were 7.63 times more likely to survive than those released in September/October. The initial three-week post-release period best explained variation in survival, supporting my hypothesis that PR bobwhites had a lower survival rate in the weeks immediately following release compared to resident bobwhites. Home range size was similar between bird groups. This is in contrast to my prediction that PR bobwhites would have a larger home range than resident bobwhites. Timing of release effected survival, but the most variation in the survival data was best explained by a model that contained the three-week interval, the covariates of Year and GROUP, and the interaction between the two.

Following the three-week post release interval, weekly survival rates of PR bobwhites tended to level off and were close to that of resident bobwhites. Similar results were reported in past PR bobwhite studies, as well as translocated bobwhites (Terhune et al. 2010, Bostick and Terhune 2015, Lunsford et al. 2017). This acclimation period is likely due to bobwhites being unfamiliar with the release site post-release. I did not evaluate site fidelity in my study, but if PR bobwhites moved large distances from the release site after release, this may have pre-disposed them to higher predation rates. PR bobwhites should be released into areas of high-quality habitat in order to minimize movement rates from the release site (Terhune et al. 2006a).

PR bobwhite survival in my study was lower than reported by Palmer et al. (2012), but similar to other parent-reared studies (Lunsford et al. 2017, Macaluso et al. 2017). Weekly resident bobwhite survival in my study was also lower (S = 0.880) than other bobwhite studies in the Southeast. This is concerning, as the minimum weekly survival rate needed to maintain a stable bobwhite population is 0.96 (Guthery and Lusk 2004, Sisson et al. 2009). This low survival rate could be symptomatic of a fundamental habitat problem on the study site during the over-winter period, however it is expected that even stable bobwhite populations can fluctuate from year to year due to a combination of biotic (e.g. vegetation, predator abundance) and abiotic (e.g. weather) factors on the study site (Palmer et al. 2002, Palmer and Wellendorf 2007). Higher amounts of rainfall in spring and summer can have a positive impact on vegetation growth, and consequently bobwhite survival, allowing for better habitat conditions heading into the fall and winter. The opposite could be said about drought conditions (Rosene 1969). Raptor migration is weather-dependent and cold fronts moving through the area can cause an influx of raptors moving into the area. Years with higher raptor populations can have a negative impact on bobwhite survival. The presence of higher numbers of raptors is probably not solely responsible for lower survival, but likely interacts with annual variation in vegetation composition influencing bobwhite survival (Holt et al. 2012). Short term studies may give a false understanding as to the true population trend that is occurring. Short term studies may occur during population upswings or downswings (Sisson et al. 2009). My study was only two years and may have occurred during a natural downturn in bobwhite population trajectory. This supports the need for more long-term research to help buffer against these annual, natural population variations in order to obtain a more accurate estimate of survival (Sisson et al. 2009).

I found that only two PR bobwhites (1.7%) survived to the following breeding season. The success of any restocking effort is predicated on released birds, especially for high-turnover species such as bobwhite, surviving long enough to reproduce and offset natural attrition (Griffith et al. 1989, Terhune et al. 2010). In contrast to low survival rates observed in my study, Palmer et al. (2012) reported survival rates from release until the breeding season of 14% and 30.1%, for PR bobwhites released in 2005 and 2006, respectively, which are lower than wild populations but reasonable to provide decent breeding abundance. The low survival estimates observed for PR and resident bobwhites in my study is concerning when compared to other studies.

Time of release impacted PR bobwhite survival such that birds released later in the fall had a lower survival rate than birds released in August. Average weekly survival rates for PR bobwhites in August was nearly 20% higher across all years than individuals released in the fall. Differences in survival could potentially be explained by differences in predator abundance and weather on the study area across both release periods. Later releases may coincide with natural peaks in raptor migration. Raptors may appear in southern latitudes throughout the year, but influxes may occur as cold fronts move through the area, which may occur more during fall, but will vary annually depending on climatic conditions (Mueller and Berger 1961). This suggests that more predators may be present to prey on naïve bobwhites that have just been released. Alternatively, later releases may coincide with lower nighttime temperatures, which are known to impact chick survival (Terhune et al. 2019). A parent-reared release in Maryland reported very low three-week post release survival (18.5%) for PR bobwhites released in fall, which coincided with below average nighttime temperatures, although this likely is not a concern in the Southeast at the age of birds upon release (Macaluso et al. 2017). The results of my study contrasts an earlier parent-reared bobwhite study which found that PR bobwhites released in September 2005 had a higher survival (S = 11.1%) until the March trapping season than bobwhites released in August (S = 6.2%) (Palmer et al. 2012). Weekly survival rates for PR bobwhites released in August in my study were very similar to that of resident bobwhites on the study area. This is encouraging for future refinement of the parent-reared release system as this seems to indicate that if all parent-reared bobwhites were released in August, that their survival rates would all be similar to that of resident bobwhites and would allow more to survive till the breeding season. Survival rates have been shown to vary between study sites, however, so more research into the timing of release is needed (Palmer et al. 2012).

4.2 Reproduction

My results support the hypothesis that nest survival, and other reproductive metrics (nests/hen, broods/hen, and chicks/hen) are similar between both PR and resident bobwhites. Daily nest survival rates were not evaluated in other parent-reared bobwhite studies. Nest survival rates in my study were similar to those found in other studies of translocated and wild bobwhites. Identical daily nest survival rates were reported for translocated and wild bobwhites in Georgia (S = 0.98) (Terhune et al. 2008). The most parsimonious model in my study was the naïve survival model (S(.)), which also ranked as the most parsimonious model for translocated bobwhites (Terhune et al. 2008). The lack of variation of nest survival rates between the groups is not unexpected. Although nest survival can be influenced by weather and vegetation composition, it is primarily driven by meso-mammal predation, whereby both groups were affected by the same predator community (Rollins and Carroll 2001).

Nests/hen were similar between PR and resident bobwhites. Broods/hen and chicks/hen were higher for PR than resident bobwhites. PR bobwhites also re-nested as readily as resident bobwhites, further indicating that reproductive parameters of parent-reared bobwhites are similar to that of resident, wild bobwhites. One PR bobwhite actually nested three times in 2010. The ability to re-nest allows bobwhites another opportunity to raise a brood if their first nest fails. In some instances, bobwhites will produce more than one successful nest during the nesting season, further aiding in their population growth (Stoddard 1931, Rosene 1969). These results were consistent with those found in past PR bobwhite studies (Palmer et al. 2012).

Modeling of reproductive metrics in other parent-reared avian species has produced similar results. Parent-reared red-legged partridges (*Alectoris rufa*) paired, nested, re-nested, and produced young at similar rates to wild partridges on the study area (Perez et al. 2015). Grey-partridge (*Perdix perdix*) were found to have significantly higher reproduction when they were parent-reared, as opposed to artificially reared (Buner and Schaub 2008). Parent-reared ring-necked pheasants (*Phasianus colchicus*) had higher clutch and brood survival than brooder-reared pheasants (Brittas et al. 1992).

Future research should be conducted to determine the number of PR bobwhites that would need to be released in order elicit a positive population response as well as the survival rates of chicks being raised by parent-reared chicks compared to resident chicks (Lunsford et al. 2019). Released animals must not only survive to reproductive age, but must breed successfully and have offspring that also breed in order for a reintroduction to be considered successful (Mathews et al. 2005). It is unclear whether PR bobwhites adequately rear broods and provide parental provisioning skills similar to wild bobwhites and whether stress associated with releases impacts PR chick growth, development, and survival. Thus, future research on parental provision and resulting chick survival impacts is warranted.

Looking solely at the reproductive metrics of PR bobwhites the parent-rearing technique shows promise as a restocking technique, if enough PR bobwhites can survive to the breeding season. Past studies, however, have shown extremely high mortality rates of parent-reared bobwhites for the first three weeks post-release (Lunsford et al. 2017, Macaluso et al. 2017).

4.3 Summary

If the parent-reared release system is to be a viable restocking technique, initial three-week survival must be improved substantially. Until this occurs, the viability of the parent-reared release system as a restocking tool is limited. If bobwhites cannot survive until the breeding season, they will not contribute toward future population growth. Survival rates, not reproduction, make the most contributions to variances in bobwhite population change (Sandercock et al. 2008). A population of 800 bobwhites, 10 years after restocking, is what would be considered an adequate number to produce a stable population (Martin et al 2017). It would seem that to achieve this number, managers could just release very high numbers of parent-reared bobwhites onto the study area in order to overcome the low survival rates and ensure enough parent-reared bobwhites survive until the breeding season. The time, effort, and expense that this would require would likely be too great to implement over a large scale, unless initial survival rates are improved. Approximately 800-1,600 ha of high quality habitat would also be needed to ensure the survival of a population of bobwhites, in order to buffer against extreme weather events that could cause local extinctions (Guthery 2000, Martin et al. 2017).

Survival rates of PR bobwhites vary between study sites, year, and time of release. In order to produce a viable bobwhite population (~800 birds) using the parent-reared release system several considerations may improve initial three week survival if this is to be considered a viable restock tool. Adequate habitat must be present on the area. This cannot be understated. (Guthery 2000). The lack of anti-predator behaviors imprinted on chicks during the rearing process is a possible reason for the high mortality rates experienced upon release (Beani and Dessi-Fulgheri 1998). Predator conditioning was successful with houbara bustards (*Chlamydotis undulata*) when captive-reared birds were exposed to live red fox (*Vulpes vulpes*) prior to release (van Heezik et al. 1999). As stated previously, weekly survival rates of PR bobwhites released in August in my study were very close to that of resident bobwhites. Releasing PR bobwhites prior to August has not been tested, and could possibly improve initial three-week survival (Lunsford et al. 2017). Other factors that may improve survival include varying the age of individuals at release, training PR chicks to seek out natural food (i.e. insects), transporting PR chicks at night prior to release, which may reduce stress vs. daytime transportation, and the release of PR chicks with adoptive parents, which may improve predator avoidance and foraging behavior (Lunsford et al. 2017). Future studies should take place over the course of several years in order to obtain a better understanding of survival rates on a particular property (Sisson et al. 2009).

CHAPTER V: MANAGEMENT IMPLICATIONS

Results from my study do not totally discredit the parent-reared release system as a viable restocking technique, but further refinement is needed prior to consideration as a conservation tool. Attempts to release bobwhites in August vastly improved initial three-week survival rates of PR bobwhites; however, survival rates were still too low to sustain a viable bobwhite population. Survival rates of August released PR bobwhites were, however, similar to that of resident bobwhite. The fact that survival rates of August released PR bobwhites and resident bobwhites were similar is promising for the future use of the parent-reared system. I do not recommend releases in late September and early October using my method. Future parent-reared release studies should attempt to release all PR bobwhites in August (or earlier), implement it over multiple years (Lunsford et al. 2017), or refine the process to improve survival. Releases of PR bobwhites prior to August have not been tested, and may be closer to the natural peaks of hatching, as opposed to releases later in the fall.

I recommend that those interested in using the parent-reared release system in the future should use an integrated approach to improve its value as a restocking technique. Combining earlier releases with predator conditioning pre-release, as well as increasing the number of PR bobwhites released (>1 bird per acre of release area) could improve survival rates enough to make the parent-reared release system a viable restocking technique (Lunsford et al. 2017, Macaluso et al. 2017). These factors must be combined with sound habitat management, both pre- and post-release (Guthery 2000). Even with improved survival rates, the usefulness of this technique will likely be limited in spatial extent to individual properties or management areas with a commitment to long-term habitat management (Palmer et al 2012). The parent-reared release system should be viewed as an option for land managers to use on a site-by-site basis.

The cost to produce the number of chicks necessary to produce a viable population of bobwhites using the parent-reared system has never been evaluated and should also be looked at in future research. If the cost to produce enough chicks for a viable population is too high, and initial three-week survival is not improved, managers should not use the parent-reared system. Managers should then implement translocation in areas where bobwhites are currently absent or in low abundance, in areas of high quality habitat (Lunsford et al. 2017).

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APPENDIX A: R SCRIPT USED IN HOME RANGE ANALYSIS

```
## Open neccessary libraries ##

library(maptools)
library(ks)
library(rgdal)
library(reshape)
library(raster)
library(adehabitat)
library(shapefiles)

## set directory ##

setwd("E:/Thesis/SCQP/Home_range_analysis")

raw.dat<-read.csv("Aug11Apr12.csv",header=T)
all.birds<-raw.dat[,2:5]

## Removing NA values ##
all.birds.clean<-na.omit(all.birds)

## Removing duplicate values ##
birds<-unique(all.birds.clean)

## Using split from data.frame to list of data.frames##
ID.Number<-split(birds,birds$BirdID)

## Removing individuals with less than 20 locations ##

fil.dat<-Filter(function(x) dim(x)[1] > 20, ID.Number)
length(fil.dat)
```

```
new.dat <- do.call("rbind", fil.dat)


#new.dat$id = paste("R",new.dat[,1],sep="")
new.dat$h = paste("ud$",new.dat$BirdID, "$h$h",sep="")
new.dat$con = paste("ud$",new.dat$BirdID, "$h$convergence",sep="")



idu = unique(new.dat[[2]])
#idu2 = unique(data[4])
converge=c()
hvalue=c()
birds=c()
status=c()


#### This code chunk is going to produce an excel file with each unique bird's LSCV h value
####


for (i in 1:length(idu)){
  newdata = subset(new.dat, BirdID == idu[i])
  loc = newdata[,c(3:4)]
  id = newdata[,c(2)]
  ud = kernelUD(loc, id, h="LSCV")


  bid = idu[i]
  birds=c(birds,bid)


  h = ud[[1]]$h$h
  hvalue=c(hvalue,h)


  con = ud[[1]]$h$convergence
  converge=c(converge,con)


  stat = newdata[,1][1]
  status =c(status,as.character(stat))
```

```
}

output = cbind(birds, converge, hvalue,status)
write.csv(output,"HVALUES2011.csv")


########################################

### This will be code for producing polygons ####



pthkde95 = "E:/Thesis/SCQP/Home_range_analysis/kde95_2011"
pthkde50  = "E:/Thesis/SCQP/Home_range_analysis/kde50_2011"


#### Home Range code for 2011 birds-- Parent-reared only ###



new.dat.pr <- subset(new.dat, Birdtype == "Parent-reared")
idu = unique(new.dat.pr[[2]])


for (i in 1:length(idu)){
  newdata = subset(new.dat.pr, BirdID == idu[i])
  loc = newdata[,c(3:4)]
  id = newdata[,c(2)]
  ud = kernelUD(loc, id, h=32.52457493)


  kv=list()
  class(kv)="kver"
  vec = getverticeshr(ud,95)
  shp = kver2shapefile(vec)
  filename=paste(pthkde95,id[[1]],sep="_")
  write.shapefile(shp,filename,arcgis=TRUE)


  vec = getverticeshr(ud,50)
  shp = kver2shapefile(vec)
  filename=paste(pthkde50,id[[1]],sep="_")
  write.shapefile(shp,filename,arcgis=TRUE)
```

```
}


####### 2011 Resident Birds ####################


pthkde95 = "E:/Thesis/SCQP/Home_range_analysis/kde95_2011"
pthkde50  = "E:/Thesis/SCQP/Home_range_analysis/kde50_2011"


#### Home Range code for 2011 birds-- Parent-reared only ###


new.dat.res <- subset(new.dat, Birdtype == "Resident")
idu = unique(new.dat.res[[2]])


for (i in 1:length(idu)){
  newdata = subset(new.dat.res, BirdID == idu[i])
  loc = newdata[,c(3:4)]
  id = newdata[,c(2)]
  ud = kernelUD(loc, id, h=31.98108611)


    kv=list()
  class(kv)="kver"
  vec = getverticeshr(ud,95)
  shp = kver2shapefile(vec)
  filename=paste(pthkde95,id[[1]],sep="_")
  write.shapefile(shp,filename,arcgis=TRUE)


  vec = getverticeshr(ud,50)
  shp = kver2shapefile(vec)
  filename=paste(pthkde50,id[[1]],sep="_")
  write.shapefile(shp,filename,arcgis=TRUE)


}
```

```
########################################## 2012##################


raw.dat<-read.csv("Aug12April13.csv",header=T)
all.birds<-raw.dat[,2:5]


## Removing NA values ##
all.birds.clean<-na.omit(all.birds)


## Removing duplicate values ##
birds<-unique(all.birds.clean)


## Using split from data.frame to list of data.frames##
ID.Number<-split(birds,birds$BirdID)


## Removing individuals with less than 20 locations ##
fil.dat<-Filter(function(x) dim(x)[1] > 20, ID.Number)
length(fil.dat)


new.dat <- do.call("rbind", fil.dat)



#### NOTE 2012 only has 3 birds, all parent-reared with over 20 locations ####



#new.dat$id = paste("R",new.dat[,1],sep="")
new.dat$h = paste("ud$",new.dat$BirdID, "$h$h",sep="")
new.dat$con = paste("ud$",new.dat$BirdID, "$h$convergence",sep="")


idu = unique(new.dat[[2]])
#idu2 = unique(data[4])
converge=c()
hvalue=c()
birds=c()
status=c()
```

```
#### This code chunk is going to produce an excel file with each unique bird's LSCV h value
####


for (i in 1:length(idu)){
  newdata = subset(new.dat, BirdID == idu[i])
  loc = newdata[,c(3:4)]
  id = newdata[,c(2)]
  ud = kernelUD(loc, id, h="LSCV")


  bid = idu[i]
  birds=c(birds,bid)


  h = ud[[1]]$h$h
  hvalue=c(hvalue,h)


  con = ud[[1]]$h$convergence
  converge=c(converge,con)


  stat = newdata[,1][1]
  status =c(status,as.character(stat))
}


output = cbind(birds, converge, hvalue,status)
write.csv(output,"HVALUES2012.csv")


########################################

## This will be code for producing polygons ####

pthkde95 = "E:/Thesis/SCQP/Home_range_analysis/kde95_2011"
pthkde50  = "E:/Thesis/SCQP/Home_range_analysis/kde50_2011"
#### Home Range code for 2011 birds-- Parent-reared only ###

new.dat.pr <- subset(new.dat, BirdType == "Parent-reared")
```

```
idu = unique(new.dat.pr[[2]])


for (i in 1:length(idu)){
  newdata = subset(new.dat.pr, BirdID == idu[i])
  loc = newdata[,c(3:4)]
  id = newdata[,c(2)]
  ud = kernelUD(loc, id, h=31.10140675)


  kv=list()
  class(kv)="kver"
  vec = getverticeshr(ud,95)
  shp = kver2shapefile(vec)
  filename=paste(pthkde95,id[[1]],sep="_")
  write.shapefile(shp,filename,arcgis=TRUE)


  vec = getverticeshr(ud,50)
  shp = kver2shapefile(vec)
  filename=paste(pthkde50,id[[1]],sep="_")
  write.shapefile(shp,filename,arcgis=TRUE)


}

#### This is currently not needed because there is only Parent-reared birds #####

####### 2012 Resident Birds ####################


pthkde95 = "E:/Thesis/SCQP/Home_range_analysis/kde95_2011"
pthkde50  = "E:/Thesis/SCQP/Home_range_analysis/kde50_2011"


#### Home Range code for 2012 birds-- Parent-reared only ###


new.dat.res <- subset(new.dat, Birdtype == "Resident")
idu = unique(new.dat.res[[2]])


for (i in 1:length(idu)){
```

```
  newdata = subset(new.dat.res, BirdID == idu[i])
  loc = newdata[,c(3:4)]
  id = newdata[,c(2)]
  ud = kernelUD(loc, id, h=31.98108611)


  kv=list()
  class(kv)="kver"
  vec = getverticeshr(ud,95)
  shp = kver2shapefile(vec)
  filename=paste(pthkde95,id[[1]],sep="_")
  write.shapefile(shp,filename,arcgis=TRUE)


  vec = getverticeshr(ud,50)
  shp = kver2shapefile(vec)
  filename=paste(pthkde50,id[[1]],sep="_")
  write.shapefile(shp,filename,arcgis=TRUE)



}
```

APPENDIX B: PROGRAM MARK ENCOUNTER HISTORIES USED FOR SURVIVAL ANALYSIS

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/* 11067 */ 00000000000000000000000000000000000000101010101010101010101010101000100010000010 1 0 0 0 0 27.0715297;
/* 11080 */ 00000000000000000000000000000000000001000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 11081 */ 00000000000000000000000000000000000101010101010101010101010101011000000000000000 1 0 0 0 0 30.84;
/* 11082 */ 00000000000000000000000000000000000000101010101010101010101010101000101010000010 1 0 0 0 0 30.668;
/* 11083 */ 00000000000000000000000000000000000000101010101010101010101010101000100010000010 1 0 0 0 0 34.922;
/* 11084 */ 00000000000000000000000000000000000000101010101010101010101010101000100011000000 1 0 0 0 0 30.96;
/* 11089 */ 00000000000000000000000000000000000010101010101010101010101010101000101100000000 1 0 0 0 0 36.148;
/* 11090 */ 00000000000000000000000000000000000000101010101010101010101010101000100011000000 1 0 0 0 0 27.0715297;
/* 11091 */ 00000000000000000000000000000000000000101010101010101010101010101000100011000000 1 0 0 0 0 27.0715297;
/* 11092 */ 00000000000000000000000000000000000001010101010101100000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 11102 */ 00000000000000000000000000000000000001010101010101010101010101010000000010000010 1 0 0 0 0 21.589;
/* 11106 */ 00000000000000000000000000000000000001010101011000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 11112 */ 00000000000000000000000000000000000110000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 11113 */ 00000000000000000000000000000000000001010101010101010101010101010000000011000000 1 0 0 0 1 22.293;
/* 11114 */ 00000000000000000000000000000000000001010101010101010101010110000000000000000000 1 0 0 0 0 21.876;
/* 11115 */ 00000000000000000000000000000000000001010101010101010101010101100000000000000000 1 0 0 0 0 22.022;
/* 11116 */ 00000000000000000000000000000000000001010101010101010101010101010101010110000000 1 0 0 0 0 22.859;
/* 11127 */ 00000000000000000000000000000000000001011000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 11128 */ 00000000000000000000000000000000000001010101010101010101010101010000000000110000 1 0 0 0 0 29.071;
/* 11129 */ 00000000000000000000000000000000000001010101010101100000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 11130 */ 00000000000000000000000000000000000001010101010101010101010101010000000000100000 1 0 0 0 0 24.343;
/* 11131 */ 00000000000000000000000000000000000001010101010101010101010101100000000000000000 1 0 0 0 0 21.301;
/* 11132 */ 00000000000000000000000000000000000000000000000000000000000000000000000000110000 1 0 0 0 0 27.0715297;
/* 11133 */ 00000000000000000000000000000000000001010101010101010101010101010000000010100000 1 0 0 0 0 34.273;
/* 11134 */ 00000000000000000000000000000000000001010110000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 11136 */ 00000000000000000000000000000000000001000110000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 11137 */ 00000000000000000000000000000000000001010101010101010101010101010000000011000000 1 0 0 0 0 23.115;
/* 11138 */ 00000000000000000000000000000000000001010101010101010110000000000000000000000000 1 0 0 0 0 27.0715297;
/* 11139 */ 00000000000000000000000000000000000001010101010101010101010101010000000011000000 1 0 0 0 0 27.0715297;
/* 11140 */ 00000000000000000000000000000000000001010101010101010101011000000000000000000000 1 0 0 0 0 27.0715297;
/* 11141 */ 00000000000000000000000000000000000001010101010101010101010101100000000000000000 1 0 0 0 0 32.707;
/* 11142 */ 00000000000000000000000000000000000001010101100000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 11143 */ 00000000000000000000000000000000000001010101010101010101010101100000000000000000 1 0 0 0 0 29.447;
/* 11146 */ 00000000000000000000000000000000000001010101010101010101010101010000000011000000 1 0 0 0 0 27.0715297;
/* 11203 */ 00000000000000000000000000000000000001010101010101010101010101000010011000000000 1 0 0 0 0 27.0715297;
/* 12003 */ 00000000000000000000000000000000000000000000000000000000000000000000100010000010 1 0 0 0 0 27.0715297;
/* 12004 */ 00000000000000000000000000000000000000000000000000000000000000000000100010000010 1 0 0 0 0 27.0715297;
/* 12005 */ 00000000000000000000000000000000000000000000000000000000000000000000100010000010 1 0 0 0 0 27.0715297;
/* 12006 */ 00000000000000000000000000000000000000000000000000000000000000000000100010000010 1 0 0 0 0 27.0715297;
/* 12010 */ 00000000000000000000000000000000000000000000000000000000000000000000100011000000 1 0 0 0 0 27.0715297;
/* 12012 */ 00000000000000000000000000000000000000000000000000000000000000000000100011000000 1 0 0 0 0 27.0715297;
/* 12013 */ 00000000000000000000000000000000000000000000000000000000000000000000100010000010 1 0 0 0 0 27.0715297;
/* 12023 */ 00000000000000000000000000000000000000000000000000000000000000000000100010000010 1 0 0 0 0 27.0715297;
/* 12026 */ 00000000000000000000000000000000000000000000000000000000000000000000100011000000 1 0 0 0 0 27.0715297;
/* 12029 */ 00000000000000000000000000000000000000000000000000000000000000000000100011000000 1 0 0 0 0 27.0715297;
/* 12033 */ 00000000000000000000000000000000000000000000000000000000000000000011000000000000 1 0 0 0 0 27.0715297;
/* 12034 */ 00000000000000000000000000000000000000000000000000000000000000000000100011000000 1 0 0 0 0 27.0715297;
/* 12035 */ 00000000000000000000000000000000000000000000000000000000000000000000100011000000 1 0 0 0 0 27.0715297;
/* 12038 */ 00000000000000000000000000000000000000000000000000000000000000000000100010000010 1 0 0 0 0 27.0715297;
/* 12039 */ 00000000000000000000000000000000000000000000000000000000000000000000000010110000 1 0 0 0 0 27.0715297;
/* 12040 */ 00000000000000000000000000000000000000000000000000000000000000000000000010110000 1 0 0 0 0 27.0715297;
/* 12043 */ 00000000000000000000000000000000000000000000000000000000000000000000000010110000 1 0 0 0 0 27.0715297;

```
/* 12044 */ 00000000000000000000000000000000000000000000000000000000000000000000000000001100000000 1 0 0 0 0 27.0715297;
/* 12045 */ 00000000000000000000000000000000000000000000000000000000000000000000000000000011000000 1 0 0 0 0 27.0715297;
/* 12047 */ 00000000000000000000000000000000000000000000000000000000000000000000000000000011000000 1 0 0 0 0 27.0715297;
/* 12051 */ 00000000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 12052 */ 00000000000000000000000000000000000000000000000000000000000000000000000000000000110000 1 0 0 0 0 27.0715297;
/* 12054 */ 00000000000000000000000000000000000000000000000000000000000000000000000000000000110000 1 0 0 0 0 27.0715297;
/* 12056 */ 00000000000000000000000000000000000000000000000000000000000000000000000000000000110000 1 0 0 0 0 27.0715297;
/* 12059 */ 00000000000000000000000000000000000000000000000000000000000000000000000000000000110000 1 0 0 0 0 27.0715297;
/* 12062 */ 00000000000000000000000000000000000000000000000000000000000000000000000000000000110000 1 0 0 0 0 27.0715297;
/* 12065 */ 00000000000000000000000000000000000000000000000000000000000000000000000000000000110000 1 0 0 0 0 27.0715297;
/* 12066 */ 00000000000000000000000000000000000000000000000000000000000000000000000000000000110000 1 0 0 0 0 27.0715297;
/* 90151 */ 00000000000000000000000000000000000000000000000000000000000000000000000000000000110000 1 0 0 0 0 27.0715297;
/* 90160 */ 10101010101010101000000000000000000000000000001010101010101010100000000000000000000000 1 0 0 0 0 31.209;
/* 90161 */ 11000000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 90164 */ 10100000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 90166 */ 10101010101010101100000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 90167 */ 10101010000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 90174 */ 10101011000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 90194 */ 11000000101011000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 90195 */ 10101010110000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 90197 */ 00000000000000000000000000000000000000010101011000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 10013 */ 00000000101010101100000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 100201 */ 10101010101010101100000000000000000000000101000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 100250 */ 10110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 100251 */ 10101010101010110000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 100262 */ 10101010101010101000000000000000000000010101010101010101010101000000000000000000000000 1 0 0 0 0 41.364;
/* 100262 */ 11000000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 100272 */ 00000100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 100335 */ 00000000000000000000000000000000000000010101010101010101010101010110000000000000000000 1 0 0 0 0 19.76;
/* 100339 */ 00000000000000000000000000000000000000010101100000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 100355 */ 00000000000000000000000000000000000000000000000000000000000000000000000000000000110000 1 0 0 0 0 27.0715297;
/* 100372 */ 11000000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 100377 */ 00000000000000000000000000000000000000000000000000000000000000000000000000100010000010 1 0 0 0 0 27.0715297;
/* 100381 */ 00000000000000000000000000000000000000000000000000000000000000000000000000100010000010 1 0 0 0 0 27.0715297;
/* 100388 */ 00001010000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 0 0 27.0715297;
/* 150928 */ 00000000000000000000000000000000000000000101010101010101010101010110000000000000000000 1 0 0 0 0 27.0715297;
/* 122 */ 00000000000000000010101010110000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 11074 */ 00000000000000000000000000000000000010001000001011000000000000000000000000000000000000 1 1 0 1 1 29.24242217;
/* 12016 */ 10101011000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 12094 */ 00000000000000000000000000000000100000001010101010101000001010000000101010101010101010 1 1 0 1 1 29.24242217;
/* 12108 */ 00000000000000000000000000000000001010110000000000000000000000000000000000000000000000 1 1 0 1 1 29.24242217;
/* 12109 */ 00000000000000000000000000000000001010101010101000000000000000000000000000000000000000 1 1 0 1 1 29.24242217;
/* 12110 */ 00000000000000000000000000000000001011000000000000000000000000000000000000000000000000 1 1 0 1 1 29.24242217;
/* 12111 */ 00000000000000000000000000000000001010000010101011000000000000000000000000000000000000 1 1 0 1 1 29.24242217;
/* 120292 */ 11000000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 120294 */ 10101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 120299 */ 10110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 120491 */ 10101010101010101100000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 120590 */ 11000000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 120602 */ 10101010101010101010101010110000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 23.783;
/* 120627 */ 10110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 120668 */ 10110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 120752 */ 10110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 120819 */ 10101011000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 120827 */ 10110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 120874 */ 10110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 120882 */ 11000000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 121105 */ 10101010101100000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 9.347;
/* 121112 */ 10110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 121113 */ 10101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 121243 */ 10110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
```

/* 121301 */ 101011000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 121309 */ 110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 121316 */ 101011000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 121318 */ 101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 121328 */ 101010101010101010101010110000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 47.63;
/* 121330 */ 101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 121332 */ 101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 121336 */ 101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 121337 */ 101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 121340 */ 101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 121347 */ 101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 121349 */ 110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 1 0 1 0 29.24242217;
/* 124236 */ 000000000000000000101010101100000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 124321 */ 000000000000000000101010101100000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 124327 */ 000000000000000000110000000000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 124366 */ 000000000000000000101010101100000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 124371 */ 000000000000000000101011000000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 124372 */ 000000000000000000101100000000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 125714 */ 000000000000000000110000000000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 125847 */ 000000000000000000101100000000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 125876 */ 000000000000000000110000000000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 125877 */ 000000000000000000010101011000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 125893 */ 000000000000000000110000000000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 125944 */ 000000000000000000110000000000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 125947 */ 000000000000000000101100000000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 125950 */ 000000000000000000110000000000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 125959 */ 000000000000000000101100000000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 125963 */ 000000000000000000101010101100000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 125972 */ 000000000000000000101100000000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 125974 */ 000000000000000000110000000000000000000000000000000000000000000000000000000000000000 1 1 1 1 0 29.24242217;
/* 3006 */ 101010101010000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3010 */ 110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3060 */ 110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3061 */ 101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3094 */ 101010110000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3344 */ 101010101100000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3357 */ 101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3415 */ 101000101010101010000010000010001100000000000000000000000000000000000000000000000000 1 0 0 1 0 30.829;
/* 3416 */ 110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3434 */ 101010101011000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3487 */ 101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3512 */ 101010101010101010110000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 25.972;
/* 3530 */ 101010110000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3534 */ 101010101010101011000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 40.565;
/* 3552 */ 101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3569 */ 101010101010101011000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 40.896;
/* 3592 */ 101011000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3626 */ 101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3825 */ 110000000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 3848 */ 101010101010101010100000010001010110000000000000000000000000000000000000000000000000 1 0 0 1 0 38.787;
/* 3887 */ 101100000000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 11070 */ 000000000000000000000000000000000000000100000000000000000000000000000000000000000000 1 0 0 1 1 29.24242217;
/* 11071 */ 000000000000000000000000000000000000010101010101010101010101010101010001100000000000 1 0 0 1 1 22.782;
/* 11072 */ 000000000000000000000000000000000000000001000000000000000000000000000000000000000000 1 0 0 1 1 29.24242217;
/* 11073 */ 000000000000000000000000000000000000000101010101010101010101010101010101010101010 1 0 0 1 1 25.337;
/* 11074 */ 000000000000000000000000000000000000010101010101010101010101010110000000000000000 1 0 0 1 1 22.490;
/* 11075 */ 000000000000000000000000000000000000000101010101010101011000000000000000000000000 1 0 0 1 1 29.24242217;
/* 11076 */ 000000000000000000000000000000000000010101010110000000000000000000000000000000000000 1 0 0 1 1 29.24242217;
/* 11079 */ 000000000000000000000000000000000000010101011000000000000000000000000000000000000000 1 0 0 1 1 29.24242217;
/* 11085 */ 000000000000000000000000000000000000010101010101100000000000000000000000000000000000 1 0 0 1 1 29.24242217;
/* 11086 */ 000000000000000000000000000000000000011000000000000000000000000000000000000000000000 1 0 0 1 1 29.24242217;

```
/* 11093 */ 0000000000000000000000000000000000010101010101010101010101010101100000000000000 1 0 0 1 1 22.490;
/* 11094 */ 0000000000000000000000000000000000110000000000000000000000000000000000000000000 1 0 0 1 1 29.24242217;
/* 11095 */ 0000000000000000000000000000000000001010101010101010101010101010001011000000000 1 0 0 1 1 29.24242217;
/* 11109 */ 0000000000000000000000000000000000010101010101010101010101000000000000000000000 1 0 0 1 1 29.24242217;
/* 12007 */ 0000000000000000000000000000000000000000000000000000000000000000000100011000000 1 0 0 1 1 29.24242217;
/* 12016 */ 0000000000000000000000000000000000000000000000000000000000000000000100010000010 1 0 0 1 1 29.24242217;
/* 12018 */ 0000000000000000000000000000000000000000000000000000000000000000010100000000000 1 0 0 1 1 29.24242217;
/* 100343 */ 1100000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 100400 */ 1100000000000000000000000000000000000000000000000000000000000000000000000000000 1 0 0 1 0 29.24242217;
/* 113415 */ 0000000000000000000000000000000000101010101010101000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 113848 */ 0000000000000000000000000000000000101010101010101010100000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116423 */ 0000000000000000000000010100000101011000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116446 */ 0000000000000000001100000000000000000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116448 */ 0000000000000000001011000000000000000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116485 */ 0000000000000000001000101010101011000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116534 */ 0000000000000000001010101010101011000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116542 */ 0000000000000000001010101010101100000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116547 */ 0000000000000000001010100000110000000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116568 */ 0000000000000000001010100010101100000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116582 */ 0000000000000000001010110000000000000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116591 */ 0000000000000000001100000000000000000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116591 */ 0000000000000000001100000000000000000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116613 */ 0000000000000000001011000000000000000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116661 */ 0000000000000000001100000000000000000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116713 */ 0000000000000000001010110000000000000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116718 */ 0000000000000000001010101100000000000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116723 */ 0000000000000000001100000000000000000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116773 */ 0000000000000000001011000000000000000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116886 */ 0000000000000000001000101100000000000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
/* 116889 */ 0000000000000000001010101010101100000000000000000000000000000000000000000000000 1 0 1 1 0 29.24242217;
```

APPENDIX C: PROGRAM MARK ENCOUNTER HISTORIES USED FOR NEST SURVIVAL ANALYSIS

```
/* 1890 */ 23 43 44 0 1 0 0 ;
/* 1854 */ 23 38 39 0 1 1 0 ;
/* 1837 */ 23 33 34 0 1 1 0 ;
/* 1853 */ 23 34 35 0 1 0 0 ;
/* 1880 */ 37 36 37 0 1 0 0 ;
/* 1834 */ 37 53 54 0 1 0 0 ;
/* 1858 */ 37 53 54 0 1 0 0 ;
/* 1847 */ 42 61 62 0 1 0 0 ;
/* 1830 */ 56 79 80 0 1 1 0 ;
/* 1837 */ 68 81 82 0 1 1 0 ;
/* 1820 */ 82 101 102 0 1 1 0 ;
/* 1868 */ 84 108 109 0 1 1 0 ;
/* 1830 */ 12 25 26 1 1 1 0 ;
/* 1806 */ 27 38 39 1 1 0 0 ;
/* 1817 */ 27 34 35 1 1 0 0 ;
/* 1877 */ 42 43 44 1 1 0 0 ;
/* 100180 */ 91 110 111 0 1 0 1 ;
/* 100211 */ 91 113 114 0 1 0 1 ;
/* 100210 */ 99 123 124 0 1 0 1 ;
/* 100187 */ 1 15 16 1 1 0 1 ;
/* 100188 */ 8 29 30 0 1 0 1 ;
/* 100205 */ 26 37 38 1 1 0 1 ;
/* 100187 */ 56 65 66 0 1 0 1 ;
/* 100193 */ 20 43 44 0 1 0 1 ;
/* 100200 */ 34 34 35 0 1 0 1 ;
/* 100207 */ 46 61 62 0 1 0 1 ;
/* 100047 */ 124 139 140 0 1 0 1 ;
/* 100215 */ 97 118 119 1 1 0 1 ;
/* 100214 */ 46 50 51 1 1 0 1 ;
/* 100090 */ 67 79 80 0 1 1 1 ;
/* 91940 */ 83 100 101 0 1 1 1 ;
/* 100097 */ 106 117 118 0 1 1 1 ;
/* 6549 */ 67 87 88 0 1 1 1 ;
/* 100090 */ 12 13 14 1 1 1 1 ;
/* 91940 */ 50 23 24 1 1 1 1 ;
/* 1818 */ 70 88 89 1 1 0 1 ;
```

```
/* 100101 */ 46 54 55 1 1 1 1 ;
/* 100101 */ 91 110 111 1 1 1 1 ;
/* 100090 */ 36 38 39 1 1 1 1 ;
/* 100225 */ 18 23 24 1 1 0 1 ;
/* 100180 */ 34 55 56 1 1 0 1 ;
/* 100211 */ 46 58 59 1 1 0 1 ;
/* 100210 */ 46 48 49 1 1 0 1 ;
/* 100178 */ 67 81 82 1 1 0 1 ;
```