EFFECTIVENESS OF SURROGATORS AS A PROPAGATION TOOL FOR NORTHERN BOBWHITES IN SOUTH-CENTRAL TEXAS

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EFFECTIVENESS OF SURROGATORS AS A PROPAGATION TOOL FOR NORTHERN BOBWHITES IN SOUTH-CENTRAL TEXAS

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ABSTRACT

EFFECTIVENESS OF SURROGATORS AS A PROPAGATION TOOL FOR NORTHERN BOBWHITES IN SOUTH-CENTRAL TEXAS

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Attempts to restore populations of northern bobwhites (*Colinus virginianus*) using game-farm quail have been documented since the early 1900s. Low restoration success rates are likely to the result of low post-release survival rates (8-15 days) and long distance dispersal from release sites averaging 2.33 km. Claims have been made that Surrogators®, a quail propagation tool, has increased success rates in both these areas. Following steps outlined in the Wildlife Management Technologies 2009 Surrogator System Guide, I tested the effectiveness of surrogators on bobwhite survival, dispersal, and habitat selection. I accomplished this by raising 1,000 bobwhites in two surrogators and conducting two trials per year in 2009 and 2010 on a 990-ha ranch in Wilson County, TX. Twenty bobwhites from each surrogator were fitted with transmitters 12 h before release. I attempted to locate each bobwhite daily for 3 weeks, followed by a

reduced effort of three times per week until mortality reached 100%. Transmitter attachment techniques used during 2009 failed; thus no data were recorded on mortality and dispersal. Bart and Robson's Maximum Likelihood Estimators of daily survival rates calculated for bobwhites released from surrogators A and B during the first trial 2010 were low (0.87 and 0.96, respectively). Daily survival rates of bobwhites calculated for surrogators A and B in the second trial of 2010 were also low (0.83 and 0.87, respectively). Mean distances traveled by bobwhites post-release during the first trial of 2010 were 401 m and 1,416 m for surrogators A and B, respectively. Dispersal statistics were not calculated for the second trial of 2010 because of small sample size ($n < 2$). There was no difference in habitat use. My results do not support the use of surrogators as an effective means of restoring wild populations of northern bobwhites in southern Texas.

CHAPTER I

INTRODUCTION

Northern bobwhites (*Colinus virginianus*) (hereafter, bobwhite) are one of North America's most economically important game bobwhites, especially in southern and midwestern United States (Brennan 1999, Burger et al. 1999). The decline of bobwhites first became a matter of concern to wildlife managers in the early 1900s (Leopold 1931). Subsequently, concern grew among game biologists when it was determined bobwhite populations had become substantially reduced or lost along its northern range and a trend of declining numbers was documented in the central portion of its distribution (Brennan 1993). Broad-scale data derived from Christmas Bird Counts, U.S. Fish and Wildlife Service Breeding Bird Surveys, and state game agencies provided strong evidence of a widespread decline throughout the United States (Brennan 1991, 1993). Annual estimated declines from 1966 to 1988 in the United States averaged 1.8% with estimated declines of 0.7% in the central range and 3% in the eastern distribution (Droege and Sauer 1990). These declines were attributed primarily to habitat loss from changing land use patterns in agriculture and forestry and expanding urbanization (Leopold 1933, Rosene 1969, Lehmann 1984, Wilkins and Swank 1992, Brennan 1993, Sotherton et al. 1993). Bobwhite populations in Texas have declined at an estimated rate of 5.6% per year since 1980 (Texas Parks and Wildlife 2005).

Though many factors are likely involved in these declining population trends, habitat loss and fragmentation are likely causes (Veech 2006).

Attempts to restore bobwhite populations in suitable habitat using game-farm or pen-reared quail have been made since the early 1900s and continued into the present (Handley 1938, Wilson 1986, Perez et al. 2002). Propagation of game birds in captivity has long been regarded as a "quick fix" for better hunting (Hart and Mitchell 1947). Propagation of quail for release in hunting is well documented from the 1930s and 1940s (McAtee 1930, Barron 1935, Poyner 1936, Bass 1937, Nestler and Bailey 1941, Hart and Mitchell 1947). However, this method of replenishing quail populations proved unsuccessful. Two of the most recognized problems associated with restoration of quail by pen-raised birds were low rates of post-release survival, averaging 8-15 days, and long distance dispersal from release sites (Baumgartner 1944, Buechner 1950, Roseberry et al. 1987, Oakley et al. 2002). Baumgartner (1944) reported the mean distance traveled by game-farm bobwhites released into the wild was 2.33 km and Oakley et al. (2002) estimated bobwhite home ranges to be 1.7–65.8 ha.

Long-term population decline estimates of 2.4% per year by bobwhites throughout North America, coupled with unsuccessful attempts to restore populations, led to the development of a game-bird propagation tool called The Surrogator® (hereafter, surrogator) (Church et al. 1993). Surrogators are a game bird propagation tool which provides food, water, heat, and shelter for day-old chicks through the ensuing first 5 weeks of life. During the 5-week-period, the only contact chicks have with humans is during weekly maintenance of the surrogator and when removing mortalities. After 5 weeks, chicks are released into the wild. Surrogators are manufactured by Wildlife Management Technologies (WMT) in Wichita, Kansas and were developed to enhance existing methods of releasing pen–reared game birds for the purpose of supplementing existing wild populations.

Wildlife Management Technologies asserts 300,000 quail have been released from surrogators in 2006 with a survival rate of 65% (Wildlife Management Technologies 2009). Wildlife Management Technologies also claim home range behavior (i.e., site fidelity) is instilled in quail by raising them in the surrogator and imprinting them to a area And that surrogator allow quail released at 5 weeks-of-age, and with minimal human contact and proper use of the surrogator, results in retention of natural survival instincts and behaviors (Wildlife Management Technologies 2009).

The objectives of my study were to test claims of increased survival rates, minimal dispersal rates, and retention of natural behaviors made by WMT when the surrogator is used according to guidelines prepared by the company. In this study I tested the hypothesis that the surrogator is an effective means of supplementing populations of bobwhites in south-central Texas.

CHAPTER II

STUDY AREA

This study was conducted on the 990-ha, high fenced, Sheffield Ranch (29°11'23.53"N, 97°49'22.31"W) located 12.8 km southwest of Nixon, TX (Wilson County) (Fig. 1), in the Rio Grande Plains ecological area near the northern extent of the South Texas Plains ecoregion (Gould 1975). The Sheffield Ranch, however, has characteristics of both the South Texas Plains and Post Oak Savannah ecoregions. Approximately 70% of the ranch is native south Texas mesquite thickets consisting largely of honey mesquite (*Prosopis glandulosa*), granjeno (*Celti spallida*), black brush (*Acacia rigidula*), and various cacti species (*Opuntia* spp.). However, oaks (*Quercus* spp.) are the predominant cover in riparian areas. Grass species predominately found on the ranch include bufflegrass (*Pennisetum ciliare*), bristle grass (*Setaria* spp.), windmill grass (*Chloris truncata*), sideoats grama (*Bouteloua curtipendula*), and little bluestem (*Schizachyrium scoparium*). At the time of release, there was an abundance of forbs including Texas croton (*Croton texensis*) and western ragweed (*Ambrosia psilostachya*).

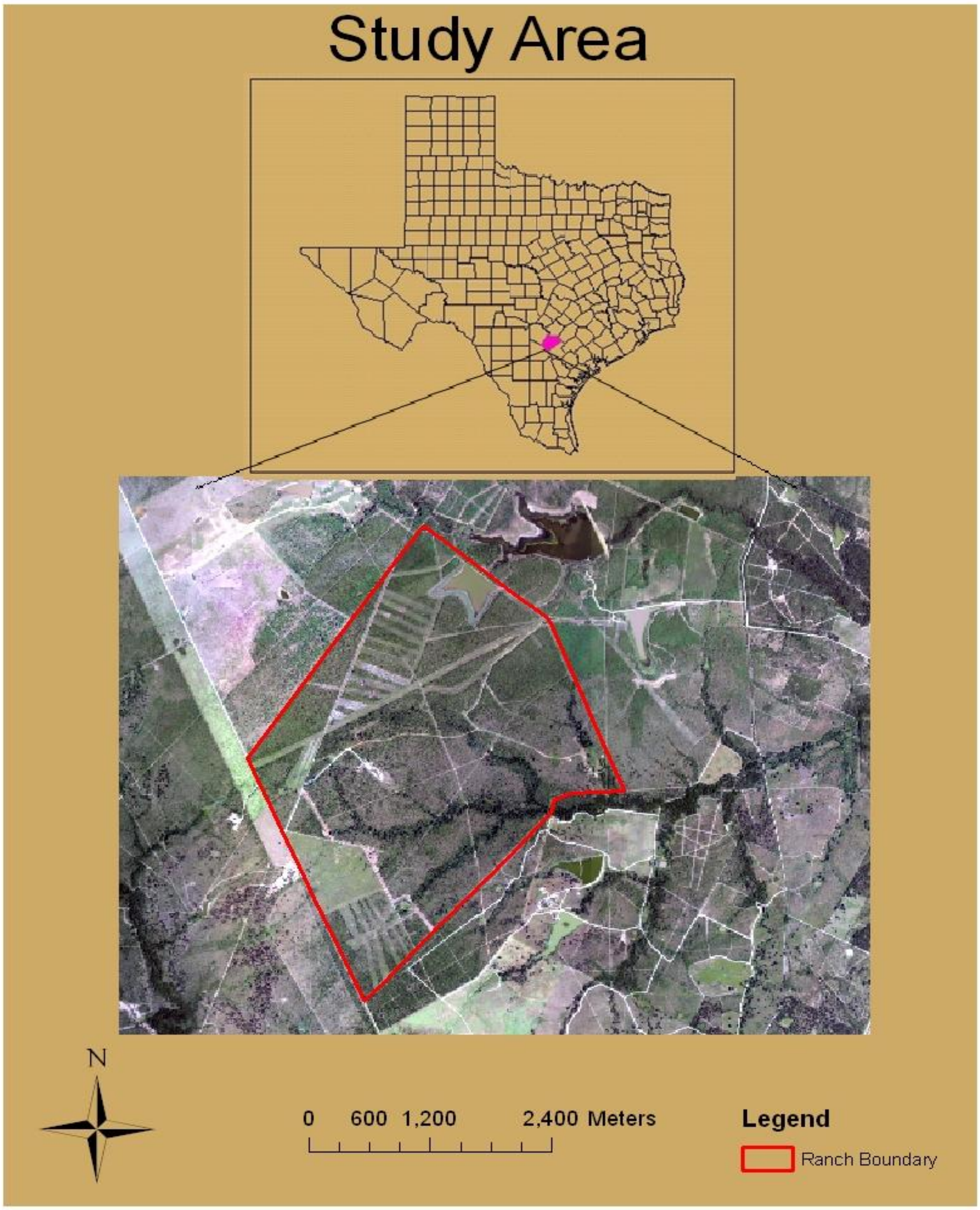

Figure 1.Map of Wilson County, Texas with an enlarged map of the study area bordered in red.

CHAPTER III

METHODS AND MATERIALS

Site selection.---My study was conducted during 2009 and 2010 using two surrogators. I carefully followed guidelines in the WMT Surrogator System Guide (2009) given to individuals who purchase a surrogator during the course of my study. Two trials were conducted each year using both surrogators placed at different locations on the ranch (~1,500 m apart) in areas I categorized as suitable bobwhite habitat. I defined suitable habitat as areas providing shade during the hottest hours of the day, for example under large oak trees, and with ample vegetative cover for food and escape from predators (Wildlife Management Technologies 2008). Once a suitable location was identified, all vegetation and leaf litter were removed from the immediate surrounding area for ease of maintenance. A 1.83 m x 3.05 m fence was constructed around each surrogator using 1.83 m T-posts and cattle panels 1.52 m in height to keep resident wildlife from damaging or disturbing surrogators. Surrogators were set up following guidelines in the Wildlife Management Technologies Surrogator System Guide (2009). In 2009 surrogators were moved to new locations between Trials 1 and 2. In 2010 the same locations were used for both trials.

Predator Surveys - Mammal.---I conducted mammalian predator surveys for 6 weeks during each trial beginning 3 weeks prior to and continuing 3 weeks post-release using track identification and infrared motion detecting digital cameras (Moultrie model MFHCDC game camera, EBSCO Industries, Inc., Alabaster, AL) at scent stations to inventory possible mammalian predators present at release sites. Two scent stations were constructed at each release site using sandy soil, survey stakes, predator attracting scents, and an infrared motion detecting digital camera. Scent stations were placed within 200 m of each surrogator.

Scent stations were constructed by spreading a layer of sandy soil in a 3-m diameter circle. The soils were used as the medium for acquiring and identifying tracks. A survey stake was vertically driven into the ground in the center of the circle. I attached a 5 x 5 cm foam rubber square to the top of the stake with a nail and applied 5 drops of Murray's Synthetic Fermented Egg Lure (Murray's Lure and Trapping, Walker, WV) on and around the head of the nail. I then placed a digital camera on a nearby tree to verify species identity at each scent station. I checked stations for prints daily and cameras and scents were checked twice weekly.

Predator Surveys - Avian.---I conducted avian predator surveys during the same period as mammalian predator surveys. Avian predator surveys were conducted once weekly beginning at approximately 0800 h along a 16-km driving route (Fig. 2) with two surveyors driving at a constant speed of 26 km/h in a utility vehicle, stopping only when sighting an avian predator. I recorded the time and species of bird for each observation.

Surrogator Use.---In 2009, 250 1-day-old bobwhite chicks were purchased from Wheeler Game Farm (Montgomery, TX) for Trial 1 with 125 chicks placed in each surrogator on 13 July after which they were maintained for 5 weeks. During this period, weekly maintenance was conducted on surrogators as recommended by Wildlife Management Technologies. This included adding water, removing fatalities, application of ant bait, and adjustment of heat settings. Each 5-week-old chick was color leg-banded for future identification and 20 randomly selected bobwhite chicks from each surrogator were fitted with a 1.5 g radio-transmitter (American Wildlife Enterprises, Monticello, FL).

Transmitters were attached by clipping feathers along the posterior element of the dorsal feather tract and gluing the transmitter to the back using cyanoacrylate glue (Warnock and Warnock 1993) after which chicks were returned to surrogators. I released the bobwhites from each surrogator by opening all doors approximately 30 min after sunrise the following morning (i.e., 14 August). The area was evacuated, allowing for a soft release as recommended by Wildlife Management Technologies (Wildlife Management Technologies 2008). I returned to remove surrogators and fencing material from each release site 12 h later, after confirming that all bobwhites had left the units.

Trial 2 conducted in 2009 also used 250 1-day-old quail chicks acquired from Wheeler Game Farm (Montgomery, TX), and 125 chicks were placed in each surrogator (on 26 August). Methodology followed that of the first trial and bobwhite chicks were released on 5 October.

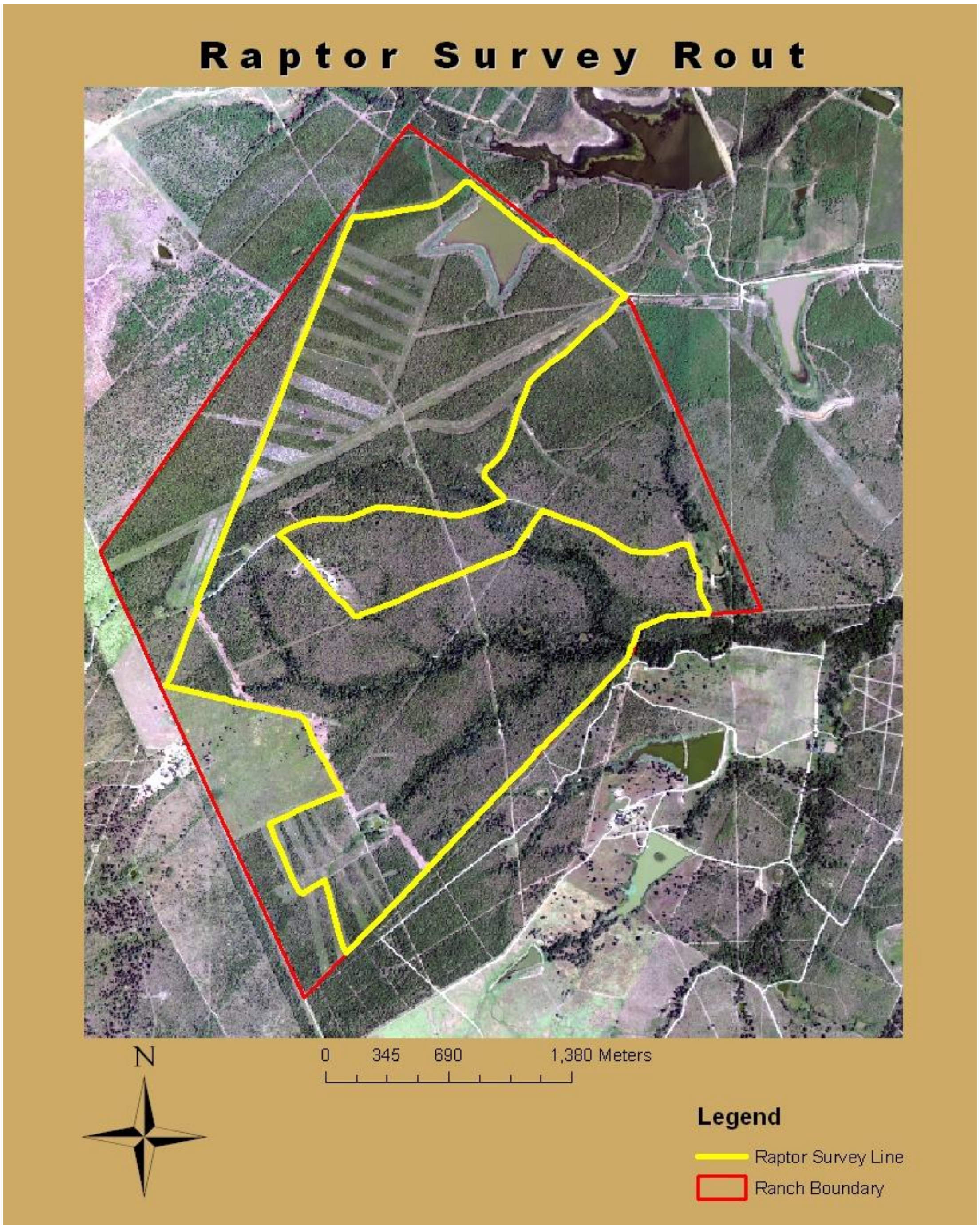

Figure 2. Map of the raptor survey route (shown in yellow) conducted once weekly on the Sheffield Ranch in Wilson County, Texas in 2010.

The methodology used in 2009 was followed again in 2010 with two exceptions. First, bobwhite chicks were purchased Outdoor Access Quail Farm (Devine, TX) and, second, 3.5 g necklace transmitter (Advanced Telemetry Systems, Isanti, MN) were used. Transmitters were attached using elastic string to allow for growth of the bobwhite with releases taking placed on 17 July and 2 October.

Radio-tracking.---I used a telemetry receiver Model D50 (Advanced Telemetry Systems, Isanti, MN) to locate every bobwhite released from both surrogators and a Garmin eTrex Vista HCx hand-held Global Positioning Systems (GPS) unit (Garmin, Inc., Olathe, Kansas) to determine each individuals location. I radio-tracked bobwhites on alternating days for 7 days. Because mortality reduced the population size by day 7 each bobwhite chick was located daily for 2 weeks. Following the 3 week period, individual bobwhites were located three times weekly until mortality reached 100%.

Analyses.--- I calculated a Bart and Robson's Maximum Likelihood Estimator (Bart and Robson 1982) of daily survival rates for each surrogator within each release in 2010 (Ecological Methodology, Version 7.0; Program: Radio Telemetry Survival Rates; Krebs 2009). I extrapolated daily survival estimates to estimate survival at the first day of the 2010 bobwhite hunting season (105 and 33 days), and an annual survival rate (365 days). I assessed habitat selection of bobwhites released from surrogators by testing whether bobwhites dispersed randomly or selected cover in the immediate area of a surrogator. When observation points were accessible, I measured height and angle to the top of nearest vegetation in the four cardinal directions at the point of observation of a quail to calculate a cone of vulnerability (Kopp et al. 1998). Observation points were deemed inaccessible when they were located beneath large brush piles or in dense stands of live brush, in which case, vulnerability to avian predation was calculated as 0.0%.

I downloaded the 2010 National Agriculture Imagery Program Mosaic Map from the Texas Natural Resources Conservation Services and imported it into ArcGIS, V 9.3 (Environmental Systems Research Institute, Inc., Redlands, CA). I then transferred observation locations of bobwhites and surrogator release sites from the GPS unit to ArcGIS using Garmin software obtained from the Minnesota Department of Natural Resources. I created a map using layers of observation points from each release site, locations for both surrogators, and dispersal locations of bobwhites released from surrogators. I then joined the observation location layer to the release site layer of both releases through a distance spatial join function, thus, creating a distance attribute with the measured distance (in meters) of each bobwhite observation to its respective release site. I then reclassified observations to include bobwhites observed a minimum of five times to allow for acclimation to transmitters and to reduce any bias in dispersal distance influenced by early mortality.

I used the attribute statistic function in ArcGIS and data from the distance attribute to calculate minimum distance, maximum distance, mean distance and standard deviation for the remaining bobwhites. I generated a scatter plot in Microsoft Excel (Microsoft inc., Bellevue, WA) depicting the relationship between number of days post-release and distance each bobwhite dispersed from its respective release site.

I used the 2010 National Agriculture Imagery Program Mosaic Map to draw polygons in ArcGIS delineating five different vegetation classes (Mesquite Savannah, Dense Shrubland, Riparian Areas, Un-improved Grasslands, Improved Grasslands) throughout the study area (Fig. 3). I performed a select by attribute function on the bobwhite observation layer for observations obtained after the first 3 days of tracking to allow for acclimation of bobwhites to transmitters and the new environment. I then spatially joined the selected observations with each vegetation classification polygon separately, creating individual layers for observations falling within each vegetation polygon. After separating observations by vegetation class, I performed a two-factor Analysis of Variance in Program R (R Core Working Group) using individual surrogators and vegetation classifications as factors and number of observations in each vegetation class, blocked by surrogator, as the response variable to detect whether differences in bobwhite use of vegetation classes occurred between surrogators and to determine if there was a difference in bobwhite use among the five habitat types.

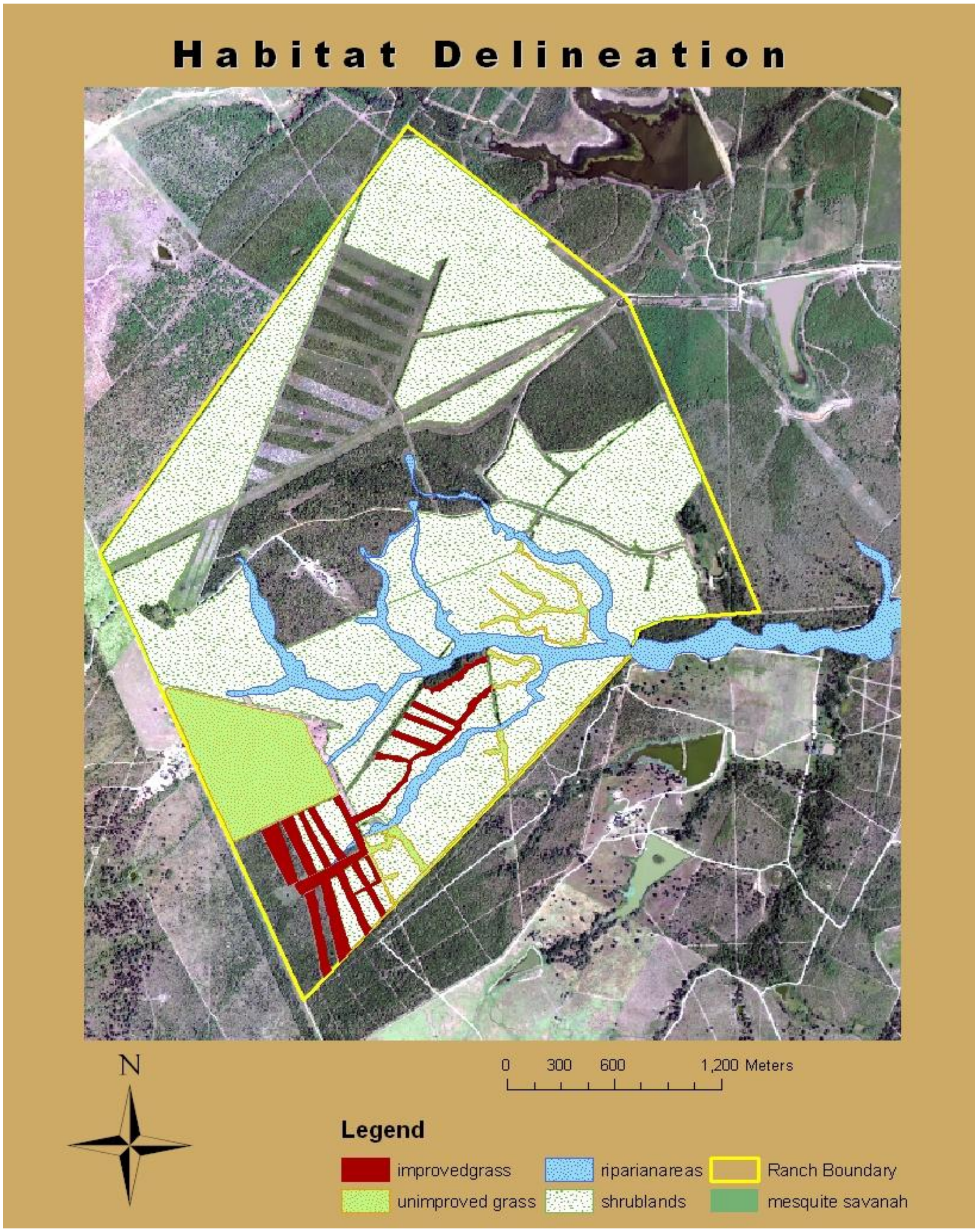

Figure 3. Map of vegetation classifications on the Sheffield Ranch in Wilson County, Texas in 2010.

CHAPTER IV

RESULTS

Predator surveys.---I used the predator survey results to compile a list of potential predators and the number of detections of each (Tables 1 and 2).

Survival.---Mean weekly pre-release bobwhite mortality was 4.0 mortalities per week for both surrogators combined during the first 2009 trial and 9.5 bobwhite mortalities per week for both surrogators combined during the second trial. However, the transmitter attachment method used in 2009 failed. All transmitters failed to adhere to the skin of bobwhites and became displaced within 48 hours post-release. Consequently, no data regarding individual bobwhite movement was recorded. Also, in 2009 bobwhites did not immediately leave the surrogator with some exiting and reentering surrogators more than once. The majority of bobwhites did not disperse from surrogator sites. Instead, bobwhites remained huddled together inside the fence. Also, individuals exhibited signs of cannibalism. They pecked at hanging objects trying to get water. Released bobwhites from surrogator A moved to a nearby brush pile and consumed grasshoppers. Bobwhites from surrogator B vacated the site, produced locating/grouping calls, and then returned to the surrogator site. Dispersal was not reported for trials one and two in 2009 because of transmitter failure.

Table 1. Predator species detected at scent stations on the Sheffield Ranch, Wilson County, Texas.

Common name	Species	Number of detections
Coyote	*Canis latrans*	5
Gray fox	*Urocyon cinereoargenteus*	3
Raccoon	*Procyon lotor*	9
Opossum	*Didelphis virginiana*	3
Skunk	*Mephitis* spp.	15
Feral hog	*Sus scrofa*	22
Armadillo	*Dasypus novemcinctus*	4
Bobcat	*Lynx rufus*	5

Table 2. Avian predator species observed during surveys on the Sheffield Ranch, Wilson County, Texas.

Common name	Scientific name	Number of detections
Crested Caracara	*Polyborus plancus*	31
Red-tailed hawk	*Buteo jamaicensis*	23
Coopers hawk	*Accipiter cooperii*	5
Northern Harrier	*Circus cyaneus*	3
Sharp-shinned hawk	*Accipiter striatus*	7
American Kestrel	*Falco sparverius*	12
Peregrine falcon	*Falco peregrinus*	3

Mean weekly pre-release bobwhite mortality was < 2 mortalities per week for both surrogators combined during the first trial in 2010. Bart and Robson's Maximum Likelihood Estimate of Daily Survival Rates for bobwhites released from surrogators A and B were 0.87 and 0.96, respectively. The 105-day finite survival rate (number of days from release to bobwhite hunting season) for bobwhites was > 0.01 (95% CI = 0 - >0.01) and 0.0167 (95% CI = 0.01-0.08) for surrogators A and B, respectively. The 365-day finite survival rate for bobwhites for surrogator A was 0, and surrogator B > 0.01. The number of live bobwhites declined sharply over time from release to 100% mortality (Figs. 4 and 5).

Mean weekly pre-release bobwhite mortality was 4 mortalities per week for both surrogators combined during the second trial in 2010. Bart and Robson's Maximum Likelihood Estimate of Daily Survival Rates for bobwhites released from surrogators A and B were 0.86 and 0.87, respectively. The 33-day finite survival rate (number of days from release to bobwhite hunting season) for bobwhites was > 0.01 (95% CI = > 0.01-0.01) and 0.01 (95% CI = > 0.01-0.05) for surrogators A and B, respectively. The 365-day finite survival rate of bobwhites for both surrogators was 0.0.

Dispersal.---For 2010, released bobwhites readily moved from the surrogator areas. During the first trial of 2010, the mean dispersal distance by bobwhites from surrogator A was 334.7 m (maximum distance = 1,483.6 m). Mean dispersal distance from surrogator B was 471.6 m (maximum distance = 2,043.2 m; Table 3, Fig. 6). Dispersal was not reported for the second trial of 2010 because of insufficient sample size (n < 2).

Table 3. Individual dispersal distances (meters) of northern bobwhites from surrogators A and B at last live observation on the Sheffield Ranch, Wilson County, Texas in 2010.

Surrogator	Bobwhite	Days Survived	Distance Traveled
A	11	18	630.6
A	13	9	235.1
A	16	32	620.9
A	19	9	118.4
B	22	55	847.4
B	23	17	537.0
B	24	65	2,036.3
B	28	66	1,356.5
B	32	65	2,036.3
B	33	65	2,031.2
B	37	44	1,075.4
B	39	66	1,411.6

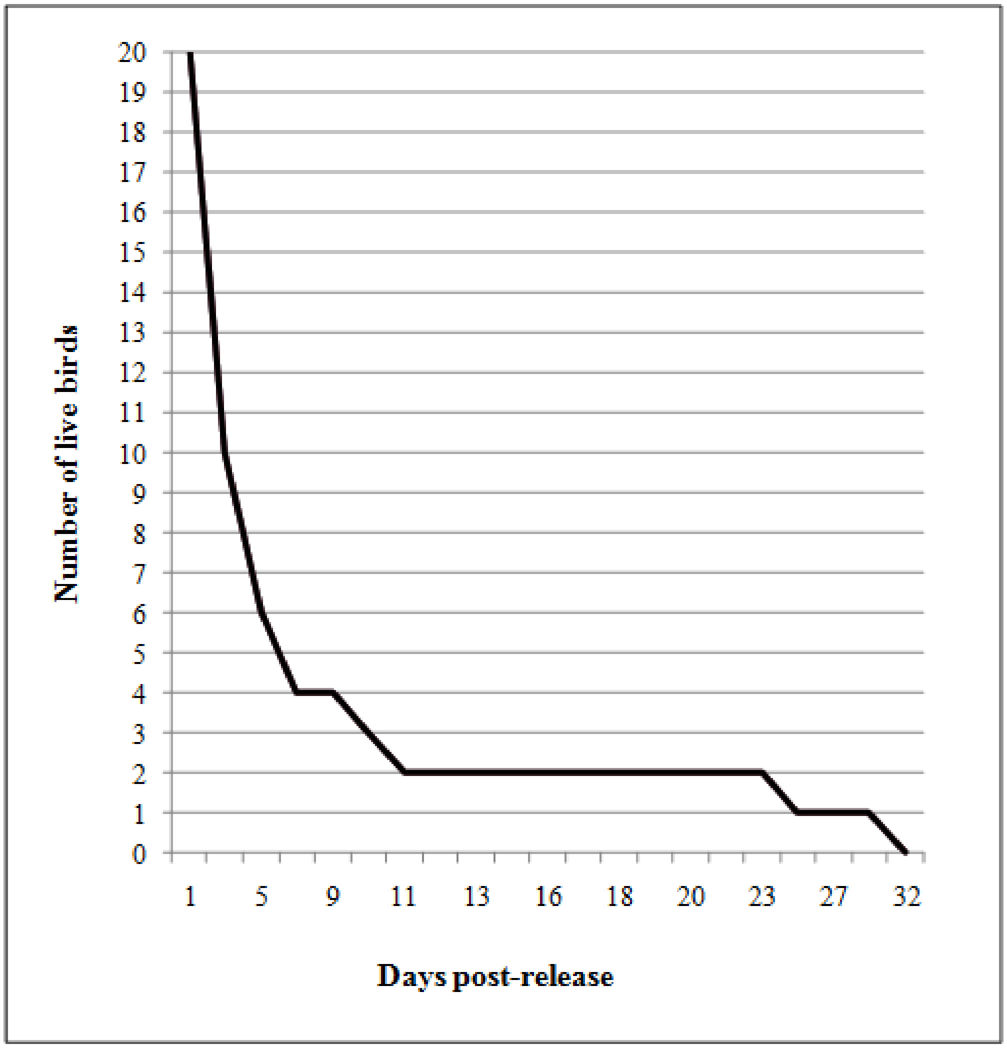

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Figure 4. Post-release survival of northern bobwhites released from surrogator A in 2010 at the Sheffield Ranch, Wilson County, Texas.

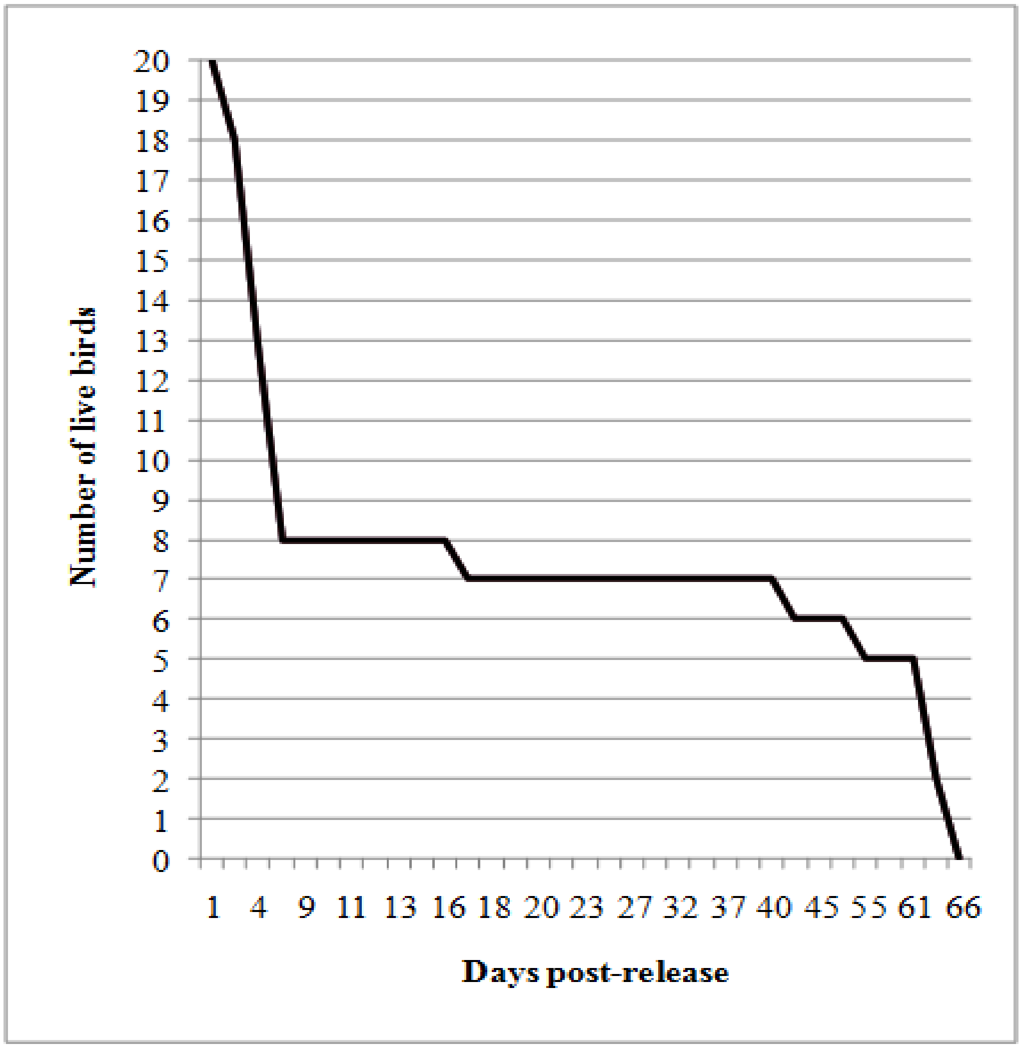

Figure 5. Post-release survival of northern bobwhites released from surrogator B in 2010 at the Sheffield Ranch, Wilson County, Texas.

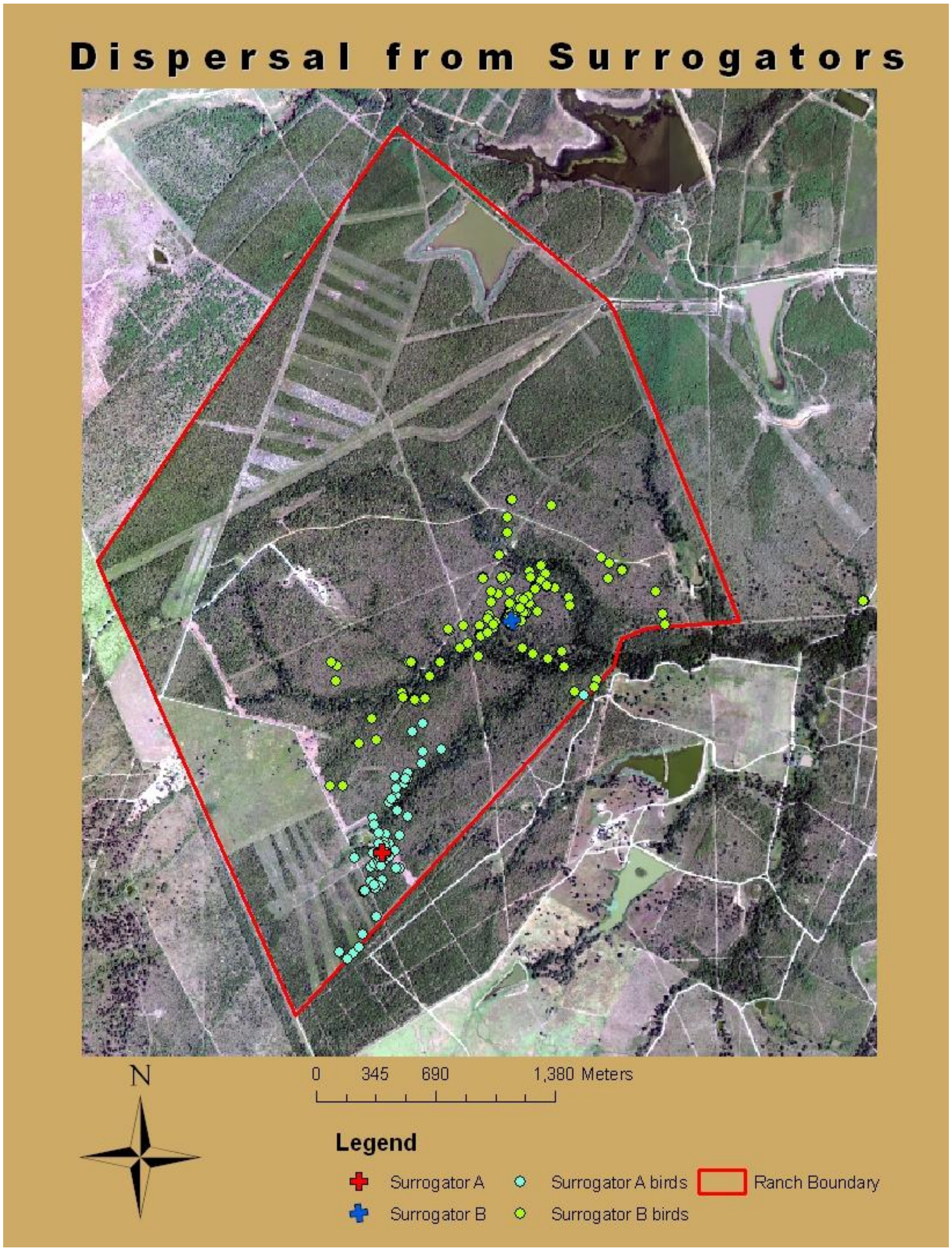

Figure 6. Dispersal map of northern bobwhites released from surrogators A and B during the first trial in 2010 at the Sheffield Ranch, Wilson County, Texas.

Habitat Selection.---There were no differences in habitat use between releases (F_1 = 4.25, P = 0.108) for the first release. There was also no difference in habitat use among vegetation classes (F_4 = 2.385, P = 0.2102). There is no evidence of a statistical interaction between the two releases and habitats in which bobwhites were observed, except for improved grasslands (Fig. 7). Mean cone of vulnerability measurements for surrogators A and B in the first trial of 2010 and surrogator B in the second trial of 2010 were 1,365,074 m^3, 3,297,939 m^3, and 903,574m^3, respectively.

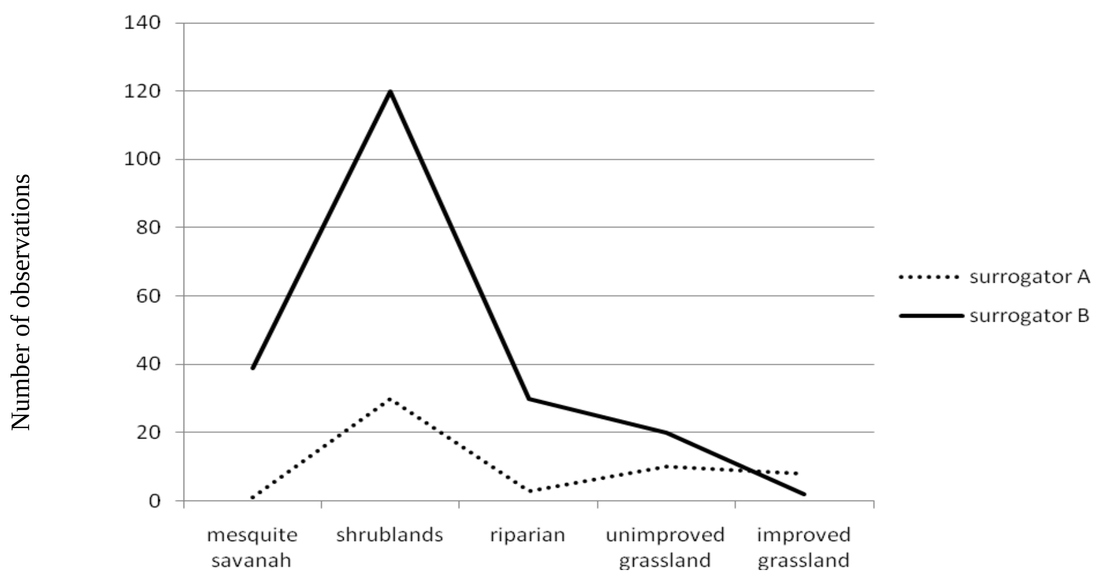

Figure 7. Interaction plot describing the interaction between habitats selected for by northern bobwhites released from surrogators A and B during the first trial in 2010 at the Sheffield Ranch, Wilson County, Texas.

CHAPTER V

DISCUSSION

Wildlife Management Technologies advertised that about 300,000 quail were released from surrogators in 2006 with a mean of 65% survival of the bobwhites to the hunting season. Further, quail released from the surrogators successfully reproduced during the next year's breeding season (Wildlife Management Technologies 2009). However, using the upper level of the 95% confidence interval of survival rates (0.08) calculated for my most successful release and if 100 bobwhites were released, only 8 would survive until the first day of the next bobwhite hunting season. Thus, to acquire a favorable hunting density of 1.25 northern bobwhites per hectare on my 990-ha study site, 152.8 releases of 100 bobwhites per release would need to be conducted simultaneously to establish 1,222.5 live bobwhites available for harvest on opening day. Furthermore, using these survival rates, 2,000,000 bobwhites would have to be released, simultaneously, for there to be 2 survivors during the next breeding season, with only a 50% chance that a surviving pair would be a breeding pair. Maple and Silvy (1988) also had variable survival rates ranging from 1.9% to 58.3% for released pen-raised adult bobwhites in north Texas, depending on the season of release. Krebs (2009) illustrated how single birds have a greater probability of predation than birds in a group. This was evident in my study by the lack of cohesiveness, and lower survival, among bobwhites for the second release of 2010. The bobwhites from the aforementioned release did not form cohesive coveys, as did the bobwhites from the first release in 2010.

Another claim of WMT was that properly raised bobwhites in surrogator units are instilled with home range behavior and will imprint on the property where released. Again, the results of my study did not support assertions of the manufacturers. Although the majority of my observations were on the study area, I observed the longest surviving northern bobwhites at great distances from release sites, including observations on neighboring ranches (Table 1, Fig. 6) and at distances much greater than mean home range size for bobwhites (Brennan 1999).

The wider range of dispersal distribution of bobwhites from surrogator B may be explained by the difference in number of observations, (surrogator A = 43, surrogator B = 203), and the increase in length of survival of bobwhites from surrogator B compared to surrogator A (4 weeks and 10 weeks, respectively). As number of days post-release increased, so did the dispersal distance of each bobwhite from respective surrogators (Table 1, Fig. 8).

The lack of habitat preference displayed by bobwhites in this study is not characteristic of wild bobwhites. The surrogator sites were selected based on quality of habitat to support a bobwhite population. Post-release dispersal could have been minimal in order for bobwhites to encounter habitat containing adequate resources to support the entire population of released bobwhites. A lack of innate habitat recognition based on environmental cues are only acquired by interacting with wild bobwhites could explain the lack of habitat preference exhibited by the bobwhites in my study. There was a difference in use of improved grasslands between bobwhites from the two surrogators (Fig.7). This can be explained by the lack of access to this vegetation class to for surrogator B bobwhites. The lack of habitat preference coupled with the large area covered by the dense shrubland vegetation class explains the large number of observations within that vegetation class and also makes this population of bobwhites essentially unavailable for harvest.

The wide range in mean cone of vulnerability measurements likely reflects the wide range in observations made between the 3 releases (surrogator A = 43, surrogator B = 203 in trial 1, and surrogator B = 14 in trial 2), as well as the number of individual bobwhites observed per trial (surrogator A = 3, surrogator B = 9 in trial 1, and surrogator B = 1 in trial 2).

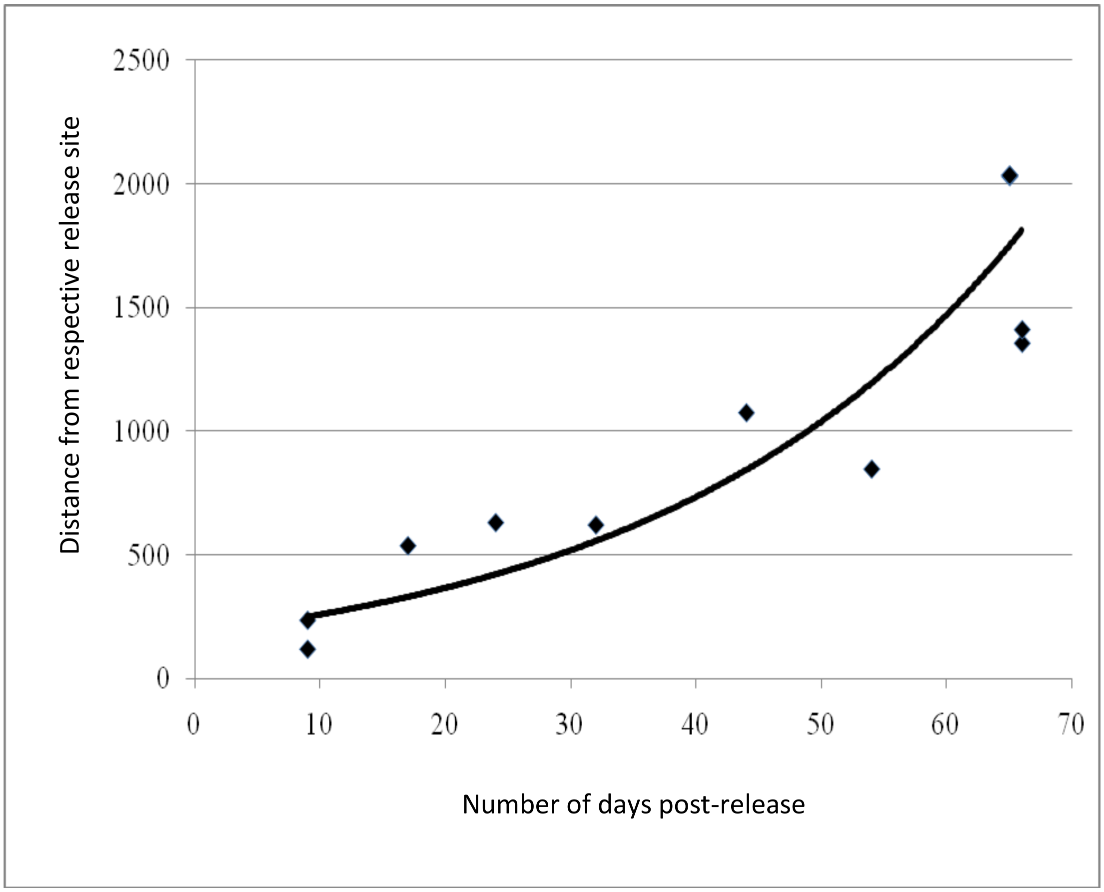

Figure 8. Relationship between survival and dispersal distance of northern bobwhites released from surrogators in this study.

CHAPTER VI

MANAGEMENT IMPLICATION

I rejected my hypothesis that the surrogator is an effective method for supplementing populations of wild bobwhites in south-central Texas. The objective of my study was to test surrogators following guidelines of the manufacturer as a means for producing viable populations of bobwhites. I did not necessarily seek to prove or disprove claims of the manufacturer. Since the surrogator has become a tool used by landowners with varying degrees of success, I sought to provide information for landowners and Texas Parks and Wildlife biologists, so an informed decision can be made by landowners in the purchase and potential use of this propagation tool.

Since the early 1900s, a solution has been sought for the periodic decline in bobwhite populations. Many want a "quick fix" for the problem without understanding the ecology of bobwhites. Bobwhite populations exhibit complex dynamics in which biotic components (i.e., demographic and habitat parameters) are intricately interrelated with abiotic components (i.e., precipitation, soil, temperature, topography; Roseberry and Klimstra 1984, DeMaso et al. 2011). This irruptive population behavior in bobwhites has long intrigued and perplexed wildlife biologists and hunters. Bobwhite populations fluctuate so radically in semi-arid environments that these population changes are referred to as boom and bust cycles (Bridges et al. 2001, Hernández et al 2007).

Survival rates recorded in this study do not support the 65%-90% survival to bobwhite hunting season claimed by WMT. Likewise, claims that chicks raised in surrogators imprint to local areas were not supported by my results. The results of the distribution analysis raise questions as to how large a property has to be before bobwhites will truly be imprinted. The claim made by WMT that bobwhites released from surrogators will behave like wild bobwhites was also not supported by my results. Wild populations of bobwhites have specific habitat requirements that were not selected for by bobwhites released in my study. The results of my study indicate surrogators are not an effective propagation tool for the restocking of bobwhite populations in south-central Texas. A best practice for maintaining consistent bobwhite populations is to invest in habitat management by increasing native bunch grasses, controlling overgrazing by livestock, use of prescribed burning, and control for overharvest of the annual production of bobwhites.

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VITA

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