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White-tailed Deer Abundance, Minimum Range Size, and Annual Survival Using Digital Camera Monitoring in the Mississippi River Delta, Louisiana

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Abstract: White-tailed deer (*Odocoileaus virginianus*) at the mouth of the Mississippi River were of historical significance as a major source for restocking in Louisiana. Concerns over potential population declines in white-tailed deer in the Mississippi River Bird-foot Delta led the Louisiana Department of Wildlife and Fisheries (LDWF) to initiate a study to gather baseline population information in the coastal freshwater environment. We captured and individually marked 57 deer on Pass-a-Loutre Wildlife Management Area (PALWMA) 2007–2012. LDWF monitored travel corridors using un-baited trail cameras and recorded all sightings of marked and unmarked individuals until 2014. We estimated abundance from the camera data using an open population mark-resight approach. Mean resighting rate was 0.28 (SE = 0.16) for females and 2.62 (SE = 0.46) for males and estimates of abundance ranged from 8–200 for females and 21–81 for males. Our results indicated that annual survival for female and male white-tailed deer was 0.48 (SE = 0.07) and 0.78 (SE = 0.06), respectively. Recapture probability was best modeled as constant over time and was significantly higher for male white-tailed deer (0.81 (SE = 0.11)) than for female white-tailed deer (0.54 (SE = 0.08)). Overall, relative abundance was lower than expected based on historic estimates of population size, and estimates of female annual survival were low relative to estimates from other population studies. As coastal marsh habitats are important to the overall statewide harvest in Louisiana, our results suggests that population monitoring can be conducted using trail cameras surveys in freshwater coastal marshes.

Key words: camera surveys, coastal marsh, mark-resight, survival white-tailed deer

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Introduction

White-tailed deer (*Odocoileaus virginianus*) at the mouth of the Mississippi River represent a significant resource in Louisiana. Restocking records indicate that white-tailed deer captured at Delta National Wildlife Refuge (DNWR) and Pass-a-Loutre Wildlife Management Area (PALWMA) were regularly translocated to a variety of regions of Louisiana during the 1960's (Louisiana 1964, McDonald et. al. 2004). The primary drivers for use of coastal white-tailed deer for restocking activities were relative abundance and open marsh habitats that simplified capture operations (Smith 1969).

Monitoring data from spotlight surveys on PALWMA after hurricane Katrina suggested that white-tailed deer sightings increased relative to pre-Katrina survey data. In March of 2005, before hurricane Katrina, an average of 5.2 individuals per hour was observed on PALWMA. During 2006, after hurricanes Katrina and Rita, surveys yielded 12.9 deer per hour (LDWF, unpublished data). While pre and post hurricane surveys are not directly comparable due to changing visibility (Collier et al. 2007) after the vegetation damage, our survey data suggests that white-tailed deer did not relocate due to storm events, and that white-tailed deer were likely not decimated due to the hurricanes. The ability of white-tailed deer to weather storms and flooding has been documented previously (Loveless 1959, Labisky et al. 1999, MacDonald-Beyers 2005). For instance, during flooding of the Atchafalaya basin due to opening of the Morganza spillway in 2011, individuals between the spillway levees experienced conditions that would be similar to hurricane storm surges. During the flood, individuals were observed lying on logs and swimming in deep water weeks after the gates were opened (LDWF, unpublished). However, mortality was estimated at nearly 30% in areas where the floodwaters rose the fastest (LDWF, unpublished).

Land loss in coastal Louisiana has been a well-documented and continuing phenomena and it is estimated that approximately 492,098 ha of coastal wetlands have been lost along the Louisiana coast between 1932 and 2000 (Tibbetts 2006). Impacts such as alteration of local hydrology, subsidence, erosion, and vegetation stress in coastal marshes have only been exacerbated by land loss from tropical storms and hurricanes (Camille, Ivan, Katrina, Gustav, and Isaac) in Louisiana. Concomitant with the above land loss, over the past four decades PALWMA management staff has noted a reduction in deer observations and harvest on the WMA. Removal of 100 deer per year for restocking purposes was not uncommon on the

Mississippi River Delta in the 1960s. This practice was considered sustainable and only comprised 30% of the resident herd on DNWR (Smith, 1969).

In the 1990's the average annual deer harvest was 42.7 deer per year on PALWMA, but by 2005 the harvest had declined 65% to an average of 14.8 deer per year (Figure 1). Concerns with reduction in harvest and the perception of declining white-tailed deer abundance caused LDWF to initiate a population dynamics project in order to direct future management activities.

Study Area

PALWMA is located at the extreme southern end of Plaquemines parish, adjacent to Delta National Wildlife Refuge (DNWR), at the mouth of the Mississippi River (Figure 2). PALWMA encompasses 46,540 ha of the Mississippi River delta. It is comprised primarily of fresh marsh with meandering natural passes, bayous, bays, and man-made oil field location canals. The fresh marsh habitat has an elevation of 0.63'NAVD 88 (USGS, unpublished data) and is fringed by intermediate marsh and a series of small beach and barrier island habitats. Approximately 1.5% of the terrestrial habitat can be classified as artificially high elevation areas such as spoil banks and dredged islands. PALWMA terrestrial habitats are dominated by natural bayou and pass shorelines as well as oil field canal banks that are influenced by the freshwater head of the Mississippi River and gulf tides. Dominant vegetation in our study area is *Phragmites australis* (Roseau cane), *Zizaniopsis miliacea* (cut grass), *Salix nigra* (black willow), *Salix exigua* (sandbar willow), *Lantana camara* (lantana), *Sambucus canadensis* (elderberry), *Myriophyllum spicatum* (Eurasian water milfoil), *Potamogetun* spp. (pond weed), *Colocasia esculenta* (elephant ears), and *Sagitaria platyphylla* (duck potato).

Methods

We captured white-tailed deer between 2007 and 2012 during the months of January, February and March of the year using capture methods including 1) spotlighting deer at night and driving them into open water with airboats where they subdued by hand, 2) Coda netguns, and 3) netgunning from a helicopter. Once captured, each deer was weighed, aged, tagged and immediately released without any chemical sedation. Each deer was marked with an extra-large cattle tag in both ears that was 3 inches by 5 inches with a unique engraved numbered color coded tag. Each tag was numbered on the front and back so that the deer could be identified by observations in any direction. In addition, we inserted a 1.5 inch cattle, self-piercing, self-locking metal tag with the same number as the plastic tag at the base of each ear which were considered permanent marks. All four tags contained a LDWF phone number to contact if the deer was harvested or the tag found.

We monitored movements and survival of tagged white-tailed deer via trail cameras placed across PALWMA (Figure 2) in locations such as narrow ridges or natural funnels. Locations were unbaited but placed in areas observed to have regular deer traffic. We maintained between ten and twenty camera sites during our study with the exception of the periods when hurricanes inundated our study area. Cameras were checked every two weeks and all white-tailed deer were counted, identifying tagged and unmarked individuals, and classifying each by sex and age (fawn, non-fawn) when possible.

We calculated minimum home rages (MHR) for tagged white-tailed deer using camera survey locations and any additional recorded observations. We created minimum convex polygons (MCP) for each tagged deer and assigned a buffer of 400 meters around the perimeter of each MCP polygon which we defined as the MHR. We recognize that these MHRs are not the true extent of each individual’s range but rather represent a minimal area that each white-tailed deer could have utilized. We only estimated MHR for tagged white-tailed deer with >3 observed locations.

Next, we used an open population capture-recapture approach to estimate annual population size based on camera survey data 2007–2014. As we had individual marks, yet the number of marked individuals may be unknown due to tag loss or mortality we used a Poisson-log normal mark-resight model (McClintok et al. 2009a) implemented in program MARK (White and Burnham 1999). As we expected considerable heterogeneity in sightings based on camera locations and deer density, we did not evaluate $\sigma_j = 0$ realizing that the approximation of the sighting probability estimate will decline in accuracy as the resighting rate (λ) increases (McClintock et al. 2009). Next, we developed a set of five potential candidate models addressing variation in survival and recapture probabilities of white-tailed deer on PALWMA and used a Cormack-Jolly-Seber (CJS) model to estimate apparent survival and recapture probability in program MARK (Table 1). Our model set ranged from a model wherein survival was constrained to be constant within and between sexes, to a time specific model that included temporal trends in detection for environmental influences (Hurricane Isaac in 2012). We evaluated fit of each candidate model relative to the model set using AIC_c (Burnham and Anderson 2002).

Results

We captured and marked 57 deer, 26 male and 31 females, during the course of our study. Hunter harvest of tagged deer totaled five males and two females reported during the study (12.3% of tagged deer). Over the course of our study, sex ratios from camera surveys were varied, ranging from 6.1 females per male in 2007 to 0.5 females per male in 2012.

We based our survival and recapture analysis on the best fitting model, conditional on our candidate model set (Table 1). Our results indicated that annual survival for female and male white-tailed deer was 0.48 (SE = 0.07) and 0.78 (SE = 0.06), respectively. Recapture (resighting via camera's) probability was best modeled as constant over time and was significantly higher for male white-tailed deer (0.81 (SE = 0.11)) than for female white-tailed deer (0.54 (SE = 0.08)) and was constant over time. Based on our mark-resight model, the mean resighting rate for females was much lower (0.28 (SE = 0.16)) than for males (2.62 (SE = 0.46)). We found evidence of significant resighting heterogeneity for females (2.04 (SE = 0.27)) and much less so for males (0.73 (SE = 0.10)). Mark-resight based abundance estimates were variable annually (Table 2).

During our study three hurricanes impacted PALWMA. Before passage of hurricanes Gustav and Ike in September 2008, 15 deer had been tagged and observed at least once before the hurricanes. After passage, 11 of the 15 tagged deer (73.3%) were resighted on the study area. In the two years before hurricane Isaac, 13 deer had been tagged and observed at least once before the hurricane. After hurricane Isaac, 10 of 13 tagged deer (76.9%) were resighted on the study area.

Of the 57 marked deer, we had requisite information to create 33 (12 females and 21 males) minimum home ranges. Mean MHR for females was 199.1 ha (SE = 92.1 ha) and the mean for males was 433.2 ha (SE = 201.2 ha) with a range of 119 to 1,106 ha for both sexes. Based on camera data, only 1 marked individual~~s~~ traveled outside of a 1,604 ha core area which was comprised of 53% terrestrial land (Figure 2). Twenty-six camera locations outside of the core did not record any tagged deer sightings.

Discussion

Recent harvest statistics from PALWMA suggests that the white-tailed deer herd may be in decline. The sharp decline in harvest rates of 42.7 deer per year in the 1990's to less than 15 deer per year prior to 2005 is a sharp contrast to the number of deer removed from DNWR in the 1960s. The removal of white-tailed deer from DNWR for restocking throughout Louisiana was thought to be a biologically sustainable program for the remaining herd. The restocking program removed 832 deer over a six year period (Smith, 1969) which is an average of 138.7 white-tailed deer annually. PALWMA encompasses 46,540 ha which is more than twice the size of DNWR at 19,830 ha. The size of the property would certainly not explain the apparent decline in herd on the Mississippi River Delta.

While hurricanes and tropical storms certainly cause mortality for deer, our study suggests that, in general, hurricanes likely have not devastated or significantly reduced white-tailed deer density on the PALWMA. Three hurricanes impacted PALWMA during the course of this study. Hurricanes Gustav and Ike struck project area in 2008 and inundated with mash with a tidal surge up to 5.59 feet (Belvin, Kimberlain, 2009) (Berg 2014). Hurricane Isaac had a direct hit on the Mississippi River Delta and pushed a storm surge of 6.69 feet (Berg 2013). After passage of these hurricanes, we estimated that 98.5% of the study area was under water by several feet. However, in contrast to MacDonald-Beyers (2005), our results demonstrated the vast majority (over 70%) of tagged deer remained on the study area, which suggests that hurricanes were not a significant source of mortality for deer in the Mississippi River delta.

Overall, male survival on PALWMA was in line with annual survival of coastal male white-tailed deer (Labisky et al. 1999, MacDonald-Beyers 2005). However, female survival was lower than most previous research in coastal systems (Labisky et al. 1999) and could be a potential limiting factor for white-tailed deer within this region. Abundance estimates were highly variable for females, driven by variation in resighting rate, which, when at the level we found for males, provided fairly consistent estimates of abundance. Additionally, we note that in 2013 a significant number of unmarked females were photographed, potentially leading to the higher than expected estimate for that year (200).

Variable range size in the population of females may be explained by the repositioning of cameras throughout the project. As noted above, the MHR for females was smaller than that of males thus if cameras were positioned into the core area of a few females the potential of getting multiple pictures of her would increase relative to camera placement outside of female home ranges. Thus, our regular repositioning of the cameras could influence range size population estimates. The apparent larger MHR of males suggests increased travel throughout a greater portion of the landscape led to ~~thus~~ increasing capture probability relative to females.

While our work was not able to identify the ultimate driver of population declines of deer on the PALWMA, our work does indicate that relative abundance is substantially lower than those observed in the 1960s. While we can only speculate, changes in the amount of coastal wetlands is likely the driver of changing deer density and distribution. Recent estimates from the Coastal Wetlands Planning Protection and Restoration Act have identified 45,730 ha of land loss on the Mississippi River Delta over the last 60 years (Coastal 2012), and as such, active restoration activities on the Mississippi River Delta may improve conditions for white-tailed deer on the PALWMA and elsewhere along the coast.

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Table 1. Model selection results for estimating annual survival from uniquely marked white-tailed deer at Pass-a-Loutre Wildlife Management Area, Louisiana during 2007-2014.

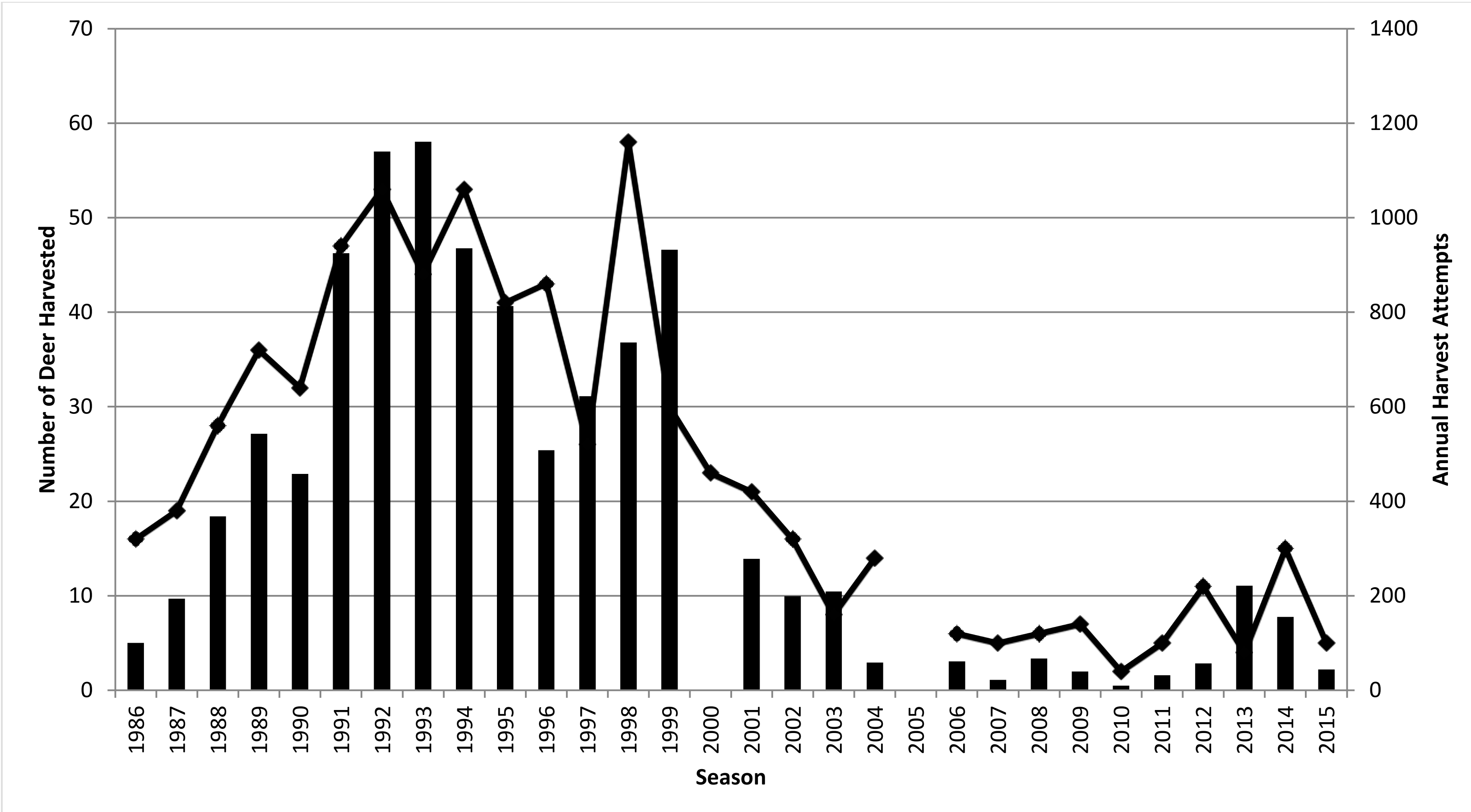
Model	ΔAIC_c	w_i	K	-2 Log Likelihood
Φ(.) p(sex)	0	0.49	4	198.8076
Φ(sex) p(.)	0.5524	0.37	3	201.5292
Φ(sex) p(Hurricane Issac)	3.4821	0.08	5	200.0747
Φ(.) p(.)	5.2174	0.03	2	208.3192
Φ(year) p(sex)	19.65	<0.01	9	206.8972

Table 2. Annual abundance estimates based on mark-resight using camera traps at Pass-a-Loutre Wildlife Management Area, Louisiana during 2007-2014.

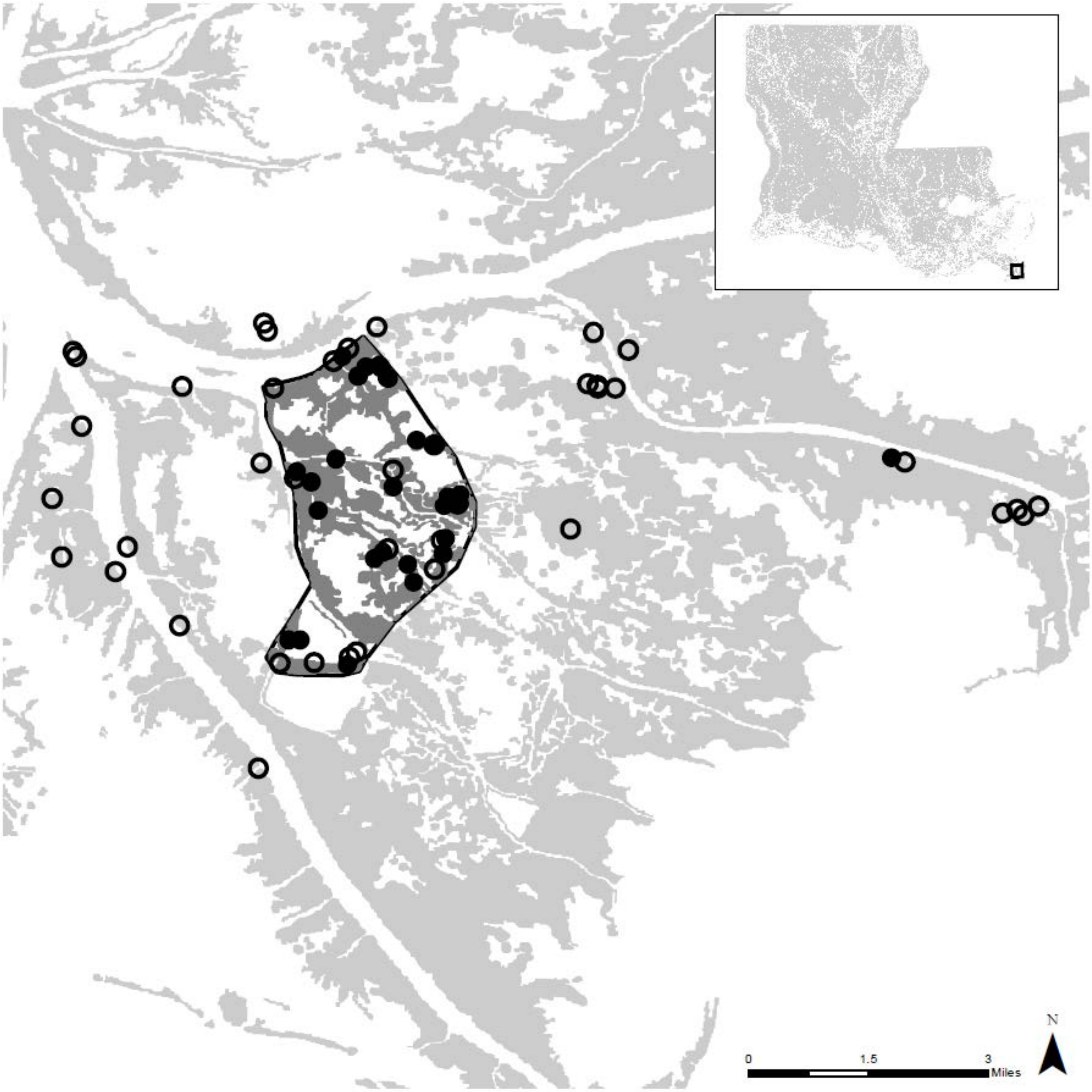
Year	Sex	Estimated Abundance (SE)	95% CI
2007	Male	22 (6.6)	12 –38
2007	Female	9 (8.3)	1 – 42
2008	Male	26 (5.3)	17 – 38
2008	Female	29 (27.9)	6 – 141
2009	Male	39 (6.6)	28 – 54
2009	Female	56 (46.1)	13 – 229
2010	Male	52 (8.5)	37 – 71
2010	Female	33 (28.3)	8 – 141
2011	Male	39 (6.8)	28 – 55
2011	Female	25 (17.8)	7 – 87
2012	Male	68 (10.4)	51 – 92
2012	Female	24 (20.6)	6 – 103
2013	Male	81 (10.5)	63 –105
2013	Female	200 (83.7)	91 – 439
2014	Male	26 (3.9)	20 – 35
2014	Female	21 (3.9)	20 – 35

Figure 1. White-tailed deer harvest (bar plot, left axis) and harvest effort (line plot, right axis) on Pass-a-Loutre Wildlife Management Area from 1986 to 2015, excluding 2000 (lost harvest data) and 2005 (season closure following Hurricane Katrina).

Figure 2. Core area (shaded polygon) where all but one marked deer were observed (1,604 ha) of which only 53% or 844 ha was terrestrial. Unfilled circles were camera locations that did not photograph marked deer while filled circles were camera locations that recorded marked deer.



Number of Deer Harvested
Annual Harvest Attempts
Season
0
10
20
30
40
50
60
70
0
200
400
600
800
1000
1200
1400
1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015


0
1.5
3
Miles
N