Apparent Survival of White-tailed Deer in the Mississippi River Delta of Louisiana

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Abstract: White-tailed deer (*Odocoileus virginianus*) populations located at the mouth of the Mississippi River are of historical significance as they have been a major source for restocking in Louisiana since the 1960s. Apparent population declines of these deer since the 1990s led the Louisiana Department of Wildlife and Fisheries to initiate a study to gather demographic data on white-tailed deer on the 46,540-ha Pass-a-Loutre Wildlife Management Area (PALWMA). We captured and individually marked 57 deer on PALWMA from 2007 to 2012. We monitored travel corridors using un-baited trail cameras and recorded all sightings of marked and unmarked individuals until 2014. We collected 4,325 photographic observations of white-tailed deer with 340 (8%) resightings of individually marked deer. Estimated apparent annual survival for female and male white-tailed deer was 0.48 ± 0.07 and 0.78 ± 0.06, respectively. We found that recapture probability was significantly greater for tagged males (0.81 ± 0.11) than females (0.54 ± 0.08). We found no evidence that white-tailed deer survival was influenced by the three tropical systems that directly impacted our study site. Overall, our estimates of female annual survival were low relative to estimates from other population studies from the southeastern United States. As coastal marsh habitats represent an important component of statewide deer harvest in Louisiana and because environmental studies show coastal habitats are slowly degrading in Louisiana, our results suggest that additional focus on female white-tailed deer demography and harvest rates are necessary in coastal regions of Louisiana.

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

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White-tailed deer (*Odocoileus virginianus*) populations 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 1960s (Louisiana Wildlife and Fisheries Commission 1964, McDonald et al. 2004). The primary drivers for using coastal white-tailed deer for restocking activities were high relative abundance and open marsh habitats that simplified capture operations (Smith 1969).

Land loss in coastal Louisiana is well-documented and is a continuing phenomena; approximately 492,098 ha of coastal wetlands were 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 been exacerbated by land loss from tropical storms and hurricanes (Camille, Ivan, Katrina, Gustav, and Isaac) over the last five decades. As such, one potential limiting factor for coastal white-tailed deer may be the ability to survive storms and flooding (Loveless 1959, Labisky et al. 1999, MacDonald-Beyers and Labisky 2005). For example, during the 2011 second opening of the Morganza Spillway and concomitant rapid flooding of the Atchafalaya Basin, white-tailed deer between the spillway levees experienced conditions that would be similar to hurricane storm surges. Biologists estimated up to 30% potential mortality in deeply flooded areas (LDWF, unpublished data). In Florida, MacDonald-Beyers and Labisky (2005) estimated up to 50% mortality of white-tailed deer during flooding events.

Harvest is generally thought to be the primary source of mortality in Southeastern white-tailed deer herds. Thus population declines concurrent with a decline in hunting effort and/or harvest indicate other potential sources of mortality or reduced recruitment may be influencing population trajectories. Recently, LDWF personnel have noted a reduction in the amount of hunter effort rand harvest on PALWMA. In the 1990s, hunter days averaged 798 annually and the average annual deer harvest was 41.5 deer, but by 2005 hunter days had dropped 77% to an average of 186 days annually and the harvest had declined 57% to an average of 17.8 deer per year (Figure 1). Therefore, with the combined concerns of reductions in harvest and associated perception of declining abun-

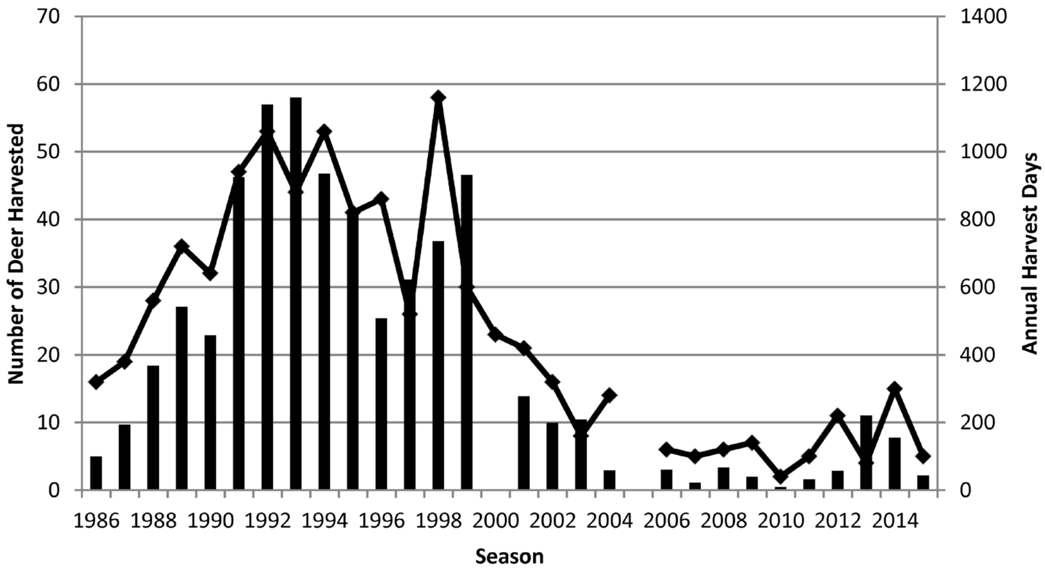

Figure 1. White-tailed deer harvest (bar plot, left axis) and harvest effort (line plot, right axis) on Pass-a-Loutre Wildlife Management Area from 1986 to 2015, excluding 2000 (lost harvest data) and 2005 (season closure following Hurricane Katrina).

dance, we initiated a research project focused on estimating white-tailed deer survival on PALWMA.

Study Area

We conducted our study on the Pass-a-Loutre Wildlife Management Area (PALWMA) located in the extreme southern end of Plaquemines Parish adjacent to Delta National Wildlife Refuge at the mouth of the Mississippi River. Pass-a-Loutre WMA encompasses 46,540 ha of the Mississippi River's terminal "bird-foot delta." It is a tidally influenced coastal fresh marsh, interlaced with meandering natural passes, bayous, bays, and man-made oil field 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. Dominant vegetation in our study area was *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), *Potamogeton* spp. (pond weeds), *Colocasia esculenta* (elephant ears), and *Sagitaria platyphylla* (duck potato). White-tailed deer management strategies on PALWMA are primarily focused on monitoring hunting effort and annual harvest as well as habitat creation and protecting of coastal marsh and terrestrial habitats.

Methods

We captured white-tailed deer January–March 2007–2012 using the following capture methods: 1) spotlighting deer at night and driving them into open water with airboats where they were captured by hand, 2) using netguns (Coda Enterprises, Inc., Mesa, Arizona) from airboats and from a helicopter. Once captured, each deer was physically restrained, weighed, aged based on tooth replacement and wear (Severinghaus 1949), tagged, and immediately released at the capture site. We tagged each deer with color-coded, uniquely numbered, two-sided (7.62 × 12.7 cm) cattle tags in both ears. Additionally, we used self-piercing, self-locking metal tags (3.81 cm) with the same number as the plastic tag at the base of each ear which we considered permanent marks (100% retention rate on harvested individuals, $n = 7$). All tags were engraved with a LDWF contact number if the deer should be harvested or the tag found.

We monitored movements and survival of tagged white-tailed deer using LDWF staff sightings and digital trail cameras (Cuddeback Digital, Green Bay, Wisconsin) placed across a portion of PALWMA (Figure 2a). Cameras were dispersed across the 6,621 ha of the WMA that make up suitable deer habitat on PALWMA. Camera locations were unbaited to ensure unbiased survey data (McCoy et al. 2011), but we placed cameras in areas such as narrow ridges or natural funnels within the marsh where we expected to have regular deer traffic (Figure 2b). We maintained between 10 and 20 camera sites during our study except for 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 them by sex and age (fawn, non-fawn) when possible.

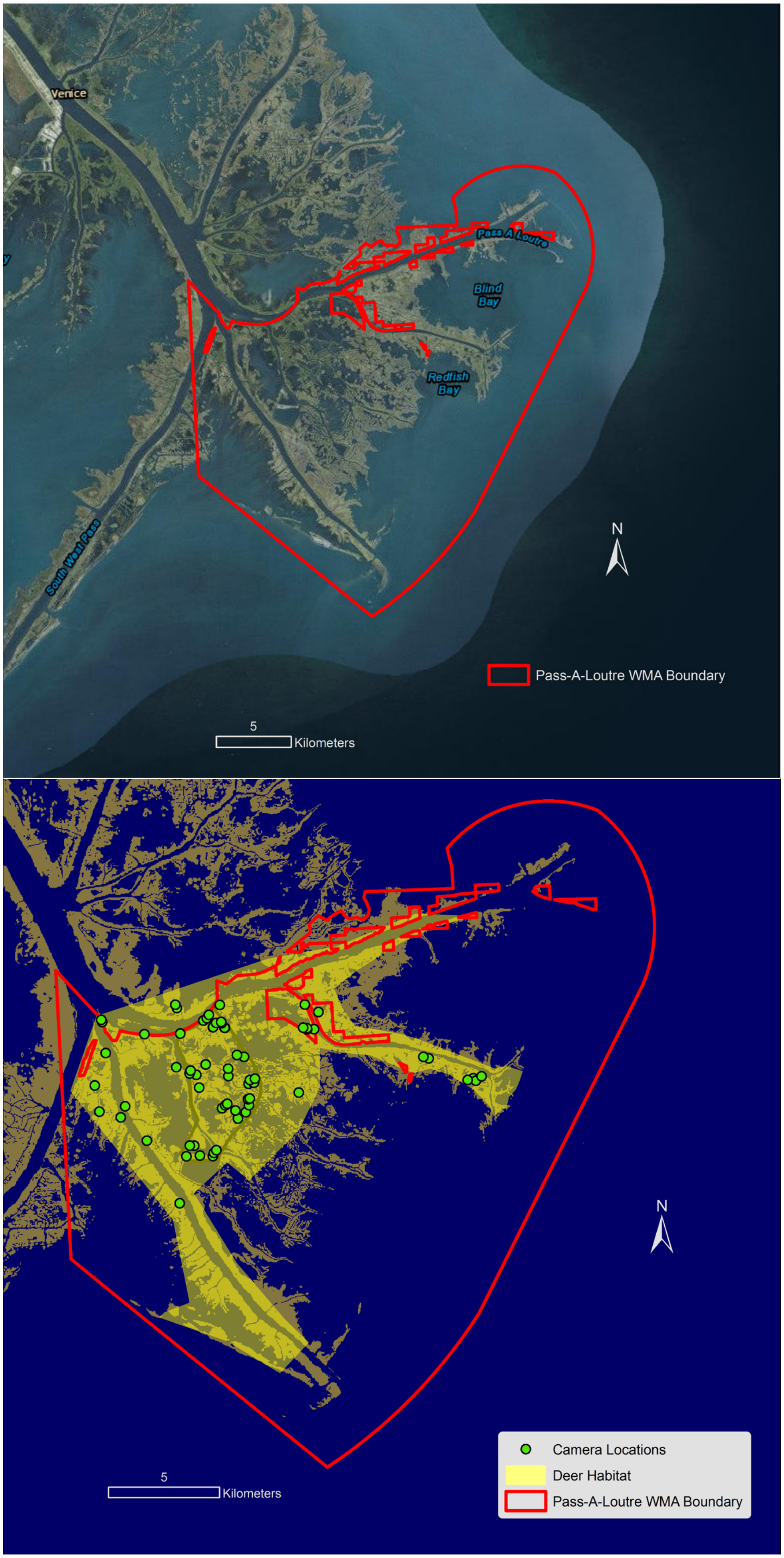

Figure 2. Pass-A-Loutre Wildlife Management Area boundary (a) on the southeast coast of Louisiana. Core area (shaded polygon) represents available deer habitats and filled circles represent camera locations used for our study (b).

Table 1. Candidate models, number of parameters (K), associated model ranks (ΔAIC_c), and model weights (w_i) used to estimate 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(sex) *p*(sex)	0[a]	0.49	4	198.80
Φ(sex) *p*(.)	0.55	0.37	3	201.52
Φ(sex) *p*(Hurricane)	3.48	0.08	5	200.07
Φ(.) *p*(.)	5.21	0.03	2	208.31
Φ(year) *p*(sex)	19.65	<0.01	9	206.89

a. $AIC_c = 207.22$

We used an open population capture-recapture approach to estimate annual apparent survival based on camera survey data in 2007–2014. We developed a set of five potential candidate models (Table 1) addressing variation in survival (Φ) and recapture probabilities (p) of white-tailed deer on PALWMA and used a Cormack-Jolly-Seber (CJS) model to estimate apparent survival and recapture probability in program MARK (White and Burnham 1999). 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 (e.g., 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 males and 31 females) during the course of our study. Hunter days during 2007–2014 averaged 64 days per year which was 92% lower than in the 1990s (=798 days). Hunters harvested a total of seven tagged deer (five males and two females) during the study (12.3% of tagged deer). We collected 4,325 photographic observations of white-tailed deer with a total of 340 (8%) observations of uniquely identifiable tagged deer. During our study three hurricanes made landfall in Louisiana that impacted the study area and may have affected white-tailed deer on PALWMA. Before hurricanes Gustav and Ike in September 2008, we had at least one digital photograph of 15 uniquely identifiable tagged deer and after the hurricanes only 11 of the 15 tagged deer (73.3%) were resighted using digital cameras on PALWMA. In the two years before Hurricane Isaac (26 August–3 September 2012), we had at least one digital photograph of 13 uniquely identifiable tagged deer and after Isaac passed, 10 of these 13 (76.9%) were resighted using digital cameras on PALWMA.

We based our survival and recapture analysis on the best fitting model, conditional on our candidate model set (Table 1). The best fitting model from our analysis indicated that probabilities of recapture and annual survival were lower for female white-tailed deer ($p = 0.54 \pm 0.08$; $\Phi = 0.48 \pm 0.07$) than for male white-tailed deer ($p = 0.81 \pm 0.11$; $\Phi = 0.78 \pm 0.06$).

Discussion

Our results for female white-tailed deer indicated that survival was lower than previous research in coastal systems (Labisky et al. 1999). Male survival on PALWMA was similar to annual survival of other southeastern male white-tailed deer (Labisky et al. 1999, MacDonald-Beyers and Labisky 2005). In addition, our survivorship estimate for females was below 50%, a concern for LDWF as those estimates fall within the range of white-tailed deer populations known to be declining (DePerno et al. 2000). Our survival estimates seem to contrast with the perceived surplus of deer on PALWMA observed in the 1960s when 832 deer were removed from the delta over a six-year period to restock other portions of the state (Smith 1969). Additionally, we have seen both a reduction in deer observations by area managers and a reduction in deer harvest and hunter days within the last 20 years which, when taken together with our survival estimates has compounded our concerns about the status of white-tailed deer in this region of coastal Louisiana. As female survivorship likely underlies population level recruitment in low density populations (DePerno et al. 2000), female mortality should be given greater consideration in harvest management planning. Thus, we concur with Robinson et al. (2014) who lamented the lack of female demography information in general, and we further suggest that deer inhabiting Gulf of Mexico coastal systems represent a significant gap in our knowledge of deer demography.

We note that during our study, three hurricanes impacted PALWMA, and we expected that the impact of hurricanes on apparent survival would be the same regardless of sex. We assumed that hurricanes could significantly influence the resighting rate of tagged white-tailed deer due to the defoliation, abraded vegetation, and in many cases complete vegetation removal. Hurricanes Gustav and Ike impacted the project area in 2008 and inundated the marsh with a tidal surge up to 1.70 m (Belvin and Kimberlain 2009, Berg 2014) while Hurricane Isaac had a direct hit on PALWMA and pushed a storm surge of 2.1 m (Berg 2013). After passage of these hurricanes, we estimated that >98% of the study area was under water. Work in the Florida Everglades by MacDonald-Beyers and Labisky (2005) indicated a low white-tailed deer survival rate during flooding, as did data from LDWF during the opening of the Morganza Spillway. However, our camera monitoring data demonstrated the vast majority (>70%) of tagged deer were resighted alive on the study area post-hurricanes, suggesting that hurricanes may not have substantially reduced white-tailed deer survival on PALWMA. Our mark-recapture analysis bore out this result as the model evaluating the impact of hurricanes on resighting rate was not supported relative to other models in the candidate set.

The observation of surviving deer following major tropical events on the Mississippi River Delta differs from significant mortality found in other flood related studies (MacDonald-Beyers and Labisky 2005, LDWF unpublished data) and has important management implications for managers. Following previous hurricanes such as Hurricane Camille and Hurricane Katrina, managers implemented protective measures to protect deer including cancellation of deer seasons due to perceived concerns of storm related mortality. However, our results suggest that this may have been an unnecessary management strategy. After significant tropical events, habitat conditions in coastal Louisiana are severely degraded, significantly reducing available forage and reducing carrying capacity for up to eight months. Thus, managers are maintaining the same population size on reduced habitat resources. However, it is also important to note that post-tropical events, visibility significantly increases as herbaceous vegetation is abraded and woody vegetation is removed from the linear, narrow land features, which may significantly increase hunter efficiency. Therefore, we recommend that area managers conduct long term monitoring programs that can be replicated after the passage of tropical storms to monitor herd size and inform managers on estimated post event mortality. This data along with habitat surveys should be used to recommend sound harvest strategies in order maintain deer herd health through periods of stressed habitat.

While we were not able to identify the ultimate driver of low annual survival of female deer on PALWMA, this study supports concerns that the population has declined since at least the 1990s. While we can only speculate, changes in the amount of coastal wetlands is potentially one 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 Protection and Restoration Authority of Louisiana 2012). Since 1956 PALWMA has lost 8,577 ha of wetland habitat including 2,123 ha of deer habitat (Barras 2009) 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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