Final Report

Population Status and Habitat Selection of an inland alligator (*Alligator mississippiensis*) population at the Fort Worth Nature Center and Refuge

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PROJECT SUMMARY

American alligator (*Alligator mississippiensis*) populations declined severely due to over hunting and wetland conversion, leading to listing of the species as endangered in 1967 and subsequently under the Endangered Species Act (ESA) of

1973. Since its original listing under the ESA, conservation efforts have increased populations of American alligators across their distribution range leading to the removal of the species from the Endangered Species List in 1987. The removal of the American alligator from the Endangered Species List resulted in the resumption of legal harvest in most states where they occur, including Texas. While American alligators have been widely studied in coastal ecosystems, there is currently little information available on the demographic rates, population abundance, and habitat use of alligator populations in inland wetland ecosystems. Without data collected on alligator populations occupying inland areas state and federal agencies often base management plans on data collected on coastal populations. However, recent research has shown that inland populations differ significantly from coastal populations in individual growth rates, body condition, demographic rates, and habitat use. Therefore, in order to develop sustainable harvest objectives and sound management strategies for inland alligator populations, state and federal wildlife management agencies need data on the abundance, population demography, and habitat use collected specifically from inland alligator populations. This research project will contribute some much needed data that will allow managers to make more informed decisions regarding the management of alligators from inland populations.

Project Objectives

We conducted research on the abundance and habitat selection patterns of an inland alligator population. The goal of this study is to determine the population status and habitat use of an urban, inland alligator population at the Fort Worth Nature Center and Refuge. Our specific objectives were to: 1) develop standardized survey methodology for the long-term monitoring of alligator population trends; 2) collect baseline data on alligator abundance; and 3) estimate home range area and assess diel (i.e., day vs. night) habitat selection patterns.

Results

During the 2010 season, we captured 7 alligators (3 males, 3 females, 1 unknown sex) during 203 trap nights, 5 of which (2 male and 3 female) were fitted with VHF transmitters (Table 1); two additional alligators were too small to be fitted with transmitters. In 2011, we captured 7 alligators (2 males, 3 females, 2 unknown sex) during 213 trap nights; 4 (2 males, 2 females) were fitted with the VHF transmitters (Table 1). One of the males was a recapture from the previous year and had a separate home range from the first season. The second female that was captured was tagged at the very end of the season while she was on a nest. For the remainder of the season she never left the nest and will be excluded from this analysis.

Alligator Abundance

Throughout the two field seasons, there were ten surveys conducted to estimate the population size, four in 2010 and six during the 2011 field season.

During the two years, the estimated population size was 8.28 alligators (95% CI 7.07 - 30.61). In GIS, 680.6 ha of aquatic and shoreline habitats were determined to be potential alligator habitat. It is assumed that this area is available to the alligators making the density 0.012 alligators/ha; based on 95% confidence intervals for the population abundance, this would translate to alligator densities ranging from 0.01 to 0.045 alligators/ha.

Home Range

Mean home range (95% kernel) for all the alligators combined for both years was 56.9 ha (range 27.9 ha - 110.6 ha) and mean core area (50% kernel) was 16.1 ha (range 4.7 ha - 47.3 ha). Mean home range decreased from 67 ha in 2010 to 43.4 ha in 2011. Average female home range (95% kernel; *n* = 3) was 40.9 ha (range 27.9 ha - 64.7 ha) while mean home range for males (*n* = 4) was 68.9 ha (range 33.9 ha - 110.6 ha). Mean core area (50% kernel) for female alligators (*n* = 3) was 10.1 ha (range 5.3 ha - 17.6 ha) whereas average core areas for males (*n* = 4) was 20.6 ha (range 4.7 ha - 47.3 ha; Table 2).

Table 2. Home Range (95% kernel and 50% core area) size (ha) for each radio-transmitted American alligators on the Fort Worth Nature Center and Refuge, Texas, 2010-2011.

Alligator ID	Sex	Year	95% Home Range	50% Core Area
51	F	2010	27.9	7.4
53	F	2010	64.75	17.6
43	M	2010	64.9	15.5
38 (2010)	M	2010	110.6	47.3
38 (2011)	M	2011	33.9	4.7
39	M	2011	66.1	14.8
11	F	2011	30.1	5.3

Selection Ratios

Second order selection ratios. (Study Area Level) --- Alligators that had the highest selection ratio for open canopy shoreline (selection ratio range 9.1 – 24.8) were 11, 43, 38, and 39 (Fig. 6). Alligators 53 (0.101; 95% CL -0.011 – 0.31) and 51 (0.101; 95% CL -0.174 - 0.38), selected against open canopy shoreline. All alligators with the exception of alligator 51 also selected for stream/river channel (selection ratio range 1.8 - 5.4). All of the alligators selected for floating vegetation (selection ratio range 3.3 - 147). Two alligators (Alligators 51 and 38) had the highest selection for emergent vegetation (selection ratio range 2.9 – 4.6), where as alligators 11 (.01; 95% CL -0.012 – 0.033), 43 (0.43; 95 % CL 0.2 - 0.66), and 39 (0.01; 95% CL -0.02 – 0.04) selected against emergent vegetation. Alligator 53 had no selection for or against emergent vegetation but was the only individual that selected for shrub land (1.94; 95% CL 1.02 – 2.85).

Third order selection ratios. (Home Range Level) --- Four of the alligators selected for open canopy shoreline (alligators 11, 43, 38 from the 2011 season and 39; selection ratio range 3.5 – 10.7). Alligator 53 selected against open canopy shoreline (0.05; 95% CL -0.093 – 0.193). Alligator 51 and 38 from the 2010 season did not select for or against open canopy shoreline. Four of the alligators (11, 53, 38 from the 2011 season and 39) selected for stream/river channel (selection ratio range 1.5 – 5.8). Alligator 38 from the 2010 season selected against stream/river channel (0.1; 95% CL -0.158 – 0.358) and alligators 53 and 51 had no selection for or against stream/river channel. Alligators 51 and 38 (from both seasons) had the highest selection ratios for emergent vegetation (selection ratio range 3.5 – 18.5). Alligator 11 selected against emergent vegetation (0.1; 95% CI 0.03 – 0.168) and

alligators 53, 43, and 39 had no selection for or against emergent vegetation. Floating vegetation was selected for by alligators 43 and 39 (selection ratio range 1.9 – 29.4). Alligator 38 from the 2011 season selected against floating vegetation (0.007; 95% CL -0.034 – 0.049) and alligators 11, 53, 51, and 38 from the 2010 season had no selection for or against floating vegetation.

Diel Habitat Selection

During nighttime , water depth was an average 0.4 m ± 0.08 (SE) deeper in used locations than at available locations ($t_{(0.05),\,2,\,155} = -4.487$, $P = 0.0001$; Fig. 1). Mean surface water temperature ($t_{(0.05),\,2,\,94} = 0.912$, $P = 0.364$; Fig. 2) and distance to nearest vegetation ($t_{(0.05),\,2,\,216} = -0.647$, $P = 0.518$) did not differ between used and available locations (Fig. 3). The percent canopy cover of the used plots was 15.4% lower than in available plots ($t_{(0.05),\,2,\,146} = 5.67$, $P = 0.0001$; Fig 4).

For the daytime locations, the mean water depth was 0.6 m ± 0.059 (SE) deeper in used locations that at available locations ($t_{(0.05),\,2,\,236} = -10.02$, $P = .0001$). Mean surface water temperature was 0.6° C lower ($t_{(0.05),\,2,\,257} = 2.038$, $P = 0.043$) and distance to nearest vegetation was 2.5 m closer ($t_{(0.05),\,2,\,276} = 2.695$, $P = 0.007$) in used plots than in available plots. The percent canopy cover of the used plots was 26.7% lower when compared to the percent canopy cover of the available plots ($t_{(0.05),\,2,\,352} = 7.5$, $P = 0.0001$).

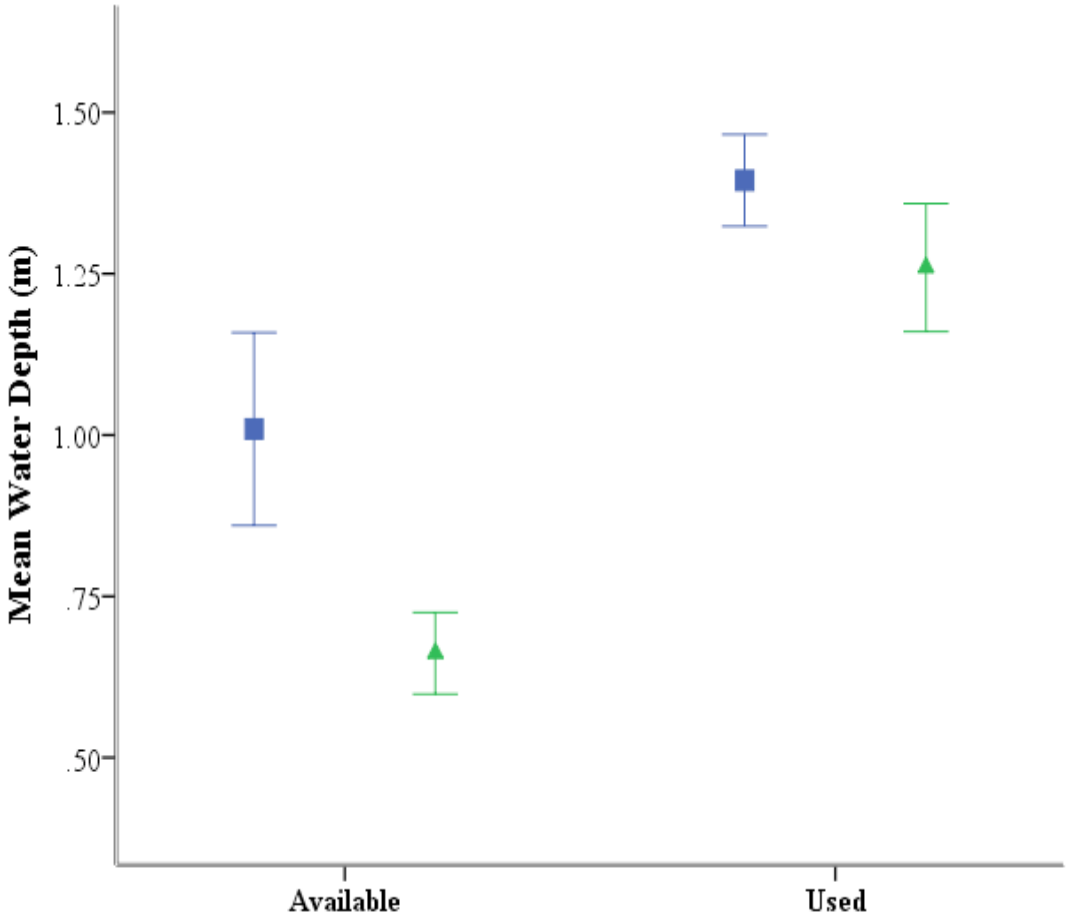


Figure 1. Mean and 95% confidence intervals for water depth of used and available locations for diel habitat selection of alligators at the Fort Worth Nature Center and Refuge, Texas, 2010-2011. Squares depict locations for alligators during the nighttime locations and triangles represent daytime locations.

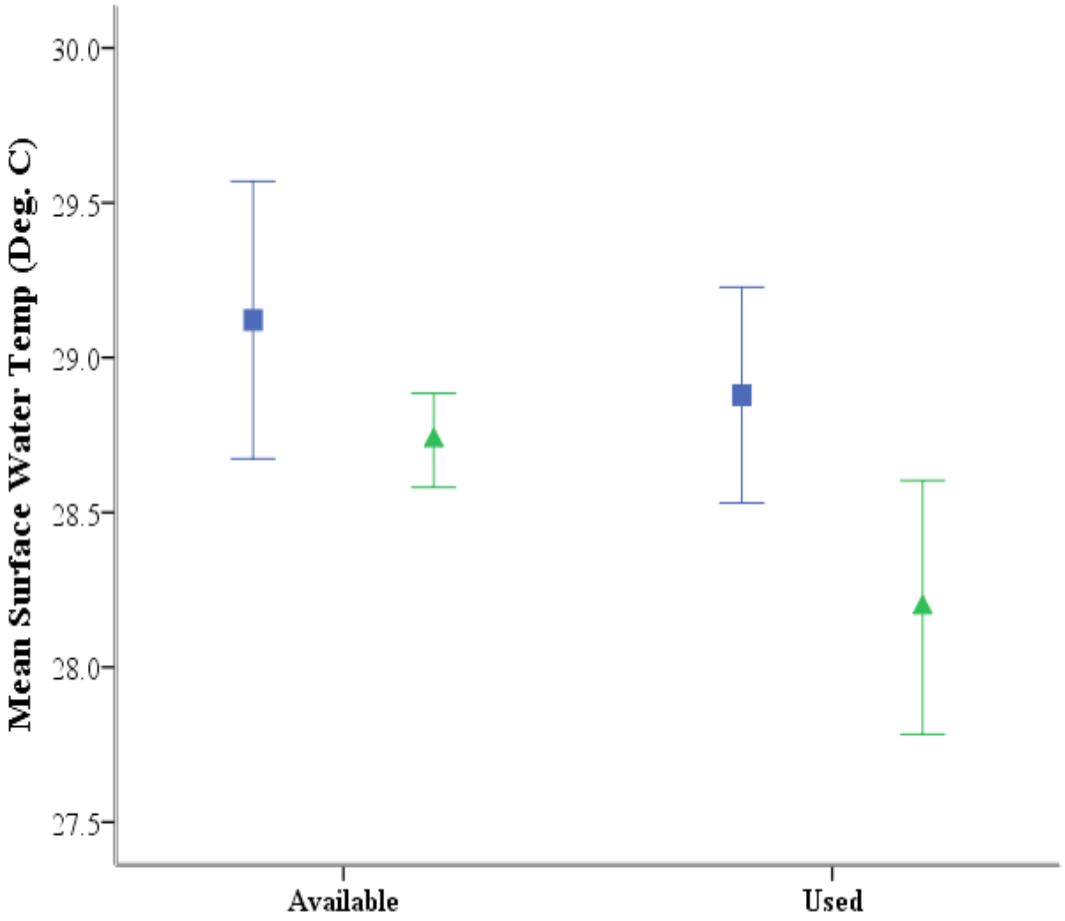


Figure 2. Mean and 95% confidence intervals for surface water temperature of used and available locations for diel habitat selection of alligators at the Fort Worth Nature Center and Refuge, Texas, 2010-2011. Squares depict locations for alligators during the nighttime locations and triangles represent daytime locations.

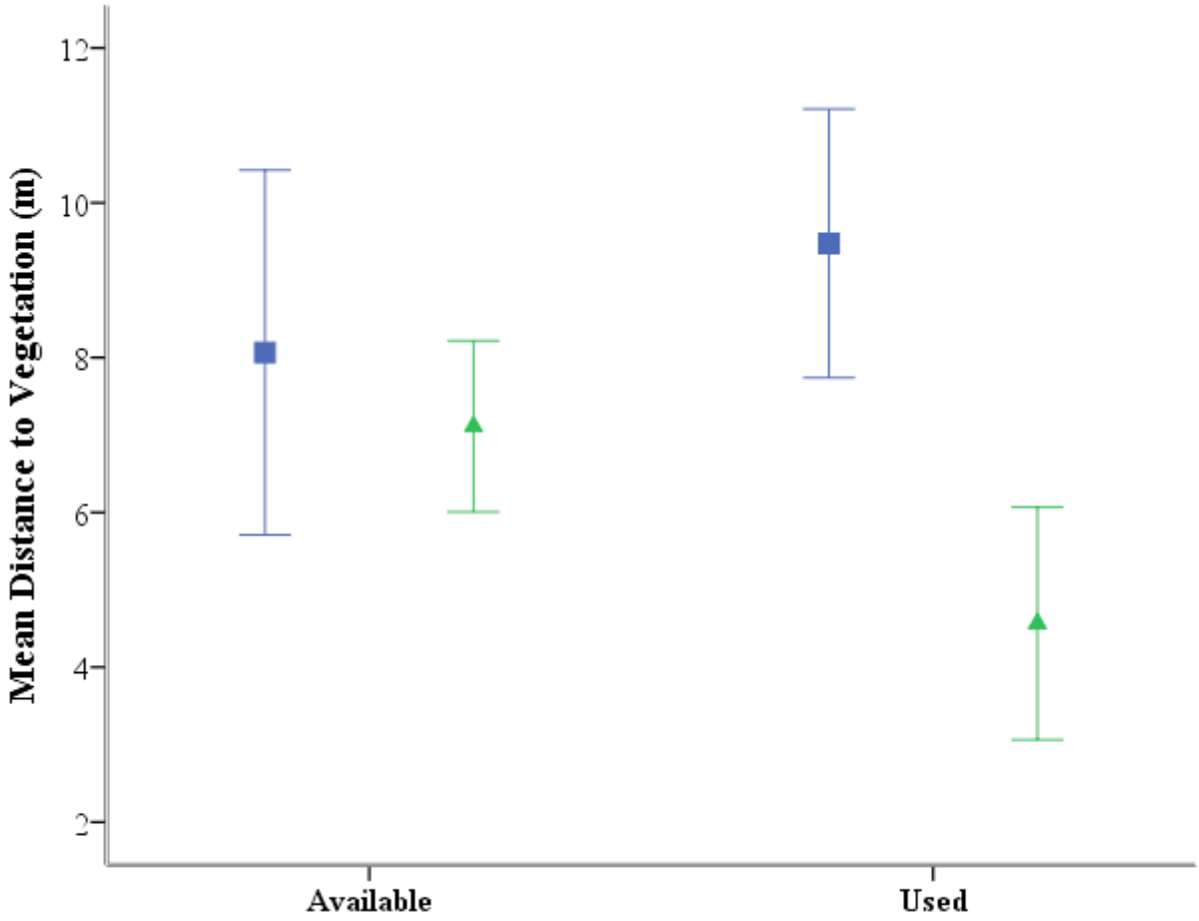


Figure 3. Mean and 95% confidence intervals for distance to vegetation of used and available locations for diel habitat selection of alligators at the Fort Worth Nature Center and Refuge, Texas, 2010-2011. Squares depict locations for alligators during the nighttime locations and triangles represent daytime locations.

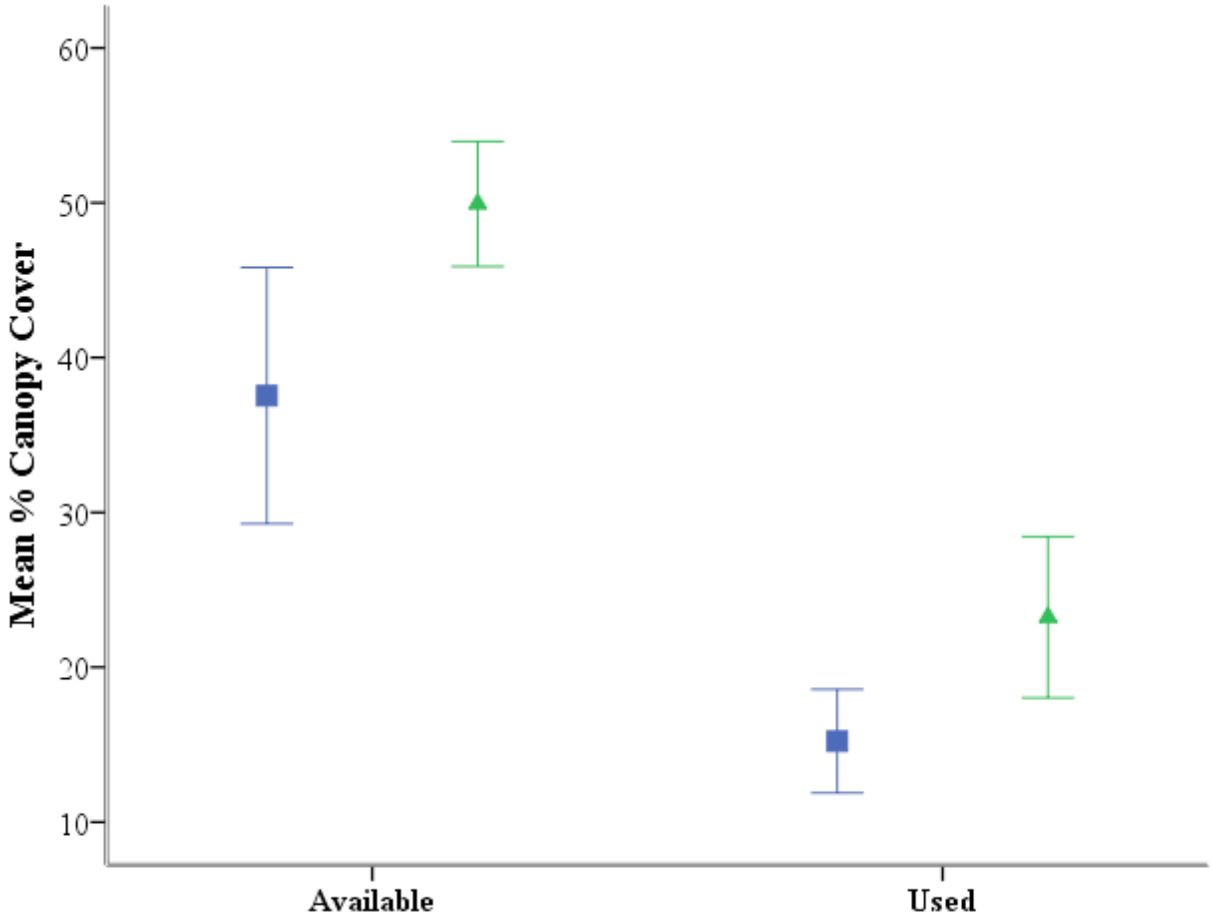


Figure 4. Mean and 95% confidence intervals for percent canopy cover of used and available locations for diel habitat selection of alligators at the Fort Worth Nature Center and Refuge, Texas, 2010-2011. Squares depict locations for alligators during the nighttime locations and triangles represent daytime locations.

Logistic Regression

Nighttime Locations.--- The best model for predicting nighttime habitat use included habitat type and the logit transformed percent canopy cover ($\chi^2_{0.05, 6}$ = 151.45, $P \leq 0.0001$). This model correctly classified 66.7% of available sites and 95% of used sites with an overall correct classification rate of 84.7%. The probability of use was 2.8 times higher for emergent vegetation, 62 times higher for stream/channel and 28.3 times higher for open canopy shoreline than for open water. After accounting for the influence of habitat type, the probability of use decreased by approximately 24% for every 1% increase in canopy cover.

Daytime Locations.---The best model for predicting daytime habitat use also included habitat and the transformed percent canopy cover ($\chi^2_{0.05, 6}$ = 249.22, $P \leq 0.0001$). This model correctly classified 92.6% of the available sites and 65.3% of the used sites with an overall correct classification rate of 87.6%. The probability of use of emergent vegetation was 8.7 times higher, stream/river channel was 13.3 times higher, floating vegetation was 14.3 and open canopy shoreline was 39.8 times higher than for open water. The probability of use for the combined terrestrial habitats was 98% lower than for open water and the probability of use increased by approximately 16% for every 1% increase in canopy cover.

Combined Locations.---When predicting day and nighttime habitat use combined, the model only included habitat type ($\chi^2_{0.05, 6}$ = 408.5, $P \leq 0.0001$). This model correctly classified 87.5% of the available sites and 63.2% of the used sites with an overall correct classification rate of 79.4%. The probability of use of emergent vegetation was 2 times higher than for open water. The probability of use of stream/river channel was 7 times higher, floating vegetation was 3 times higher, and open canopy shoreline was 15 times higher than for open water. The probability of use for the combined terrestrial habitats was 94% lower than for open water.

Discussion

The estimated density of alligators at the Fort Worth Nature Center and Refuge (0.012 alligators/ha) was much lower than the estimated density of inland alligator populations in east Texas (0.12 - 0.31 alligators/ha; Webb 2005, Lutterschmidt and Wasko 2006) and lower than the 1.29 alligators/ha reported in coastal Louisiana (Taylor et al. 1991) and 0.22 - 0.7 alligators/ha in Florida (Woodward et al. 1996). The lower density observed during this study could be a result of this population being at the very edge of its known range where there is more variability in growing season length, resource availability, and habitat quality compared to inland populations closer to the core range. Geographic variation in alligator food habits has generally been attributed to the geographic differences in the availability of prey species. Diets of adult alligators in southwestern Louisiana are more likely to contain fish and reptile remains and less likely to contain crustacean remains than alligators found in coastal southeastern Louisiana (Gabrey 2010). Also, geographic variation has an important influence on both growth rates and condition. Although alligator density is lower for this population compared to other less disturbed populations in the core of the distribution range, we observed the first reproductive event in which two hatchling alligators were marked and sampled.

Home range size and daily movement of adult alligators varies according to gender, temperature, reproductive efforts, habitat, and water level. In a study conducted by Joanen and McNease (1989), the average home range for four adult

females in Louisiana was 8.4 ha (range 2.6 – 16.4 ha). In Florida, the mean home range was 12.7 ha for five females (Goodwin and Marion 1979). This was significantly lower than the home ranges of the three females from my study (40.9 ha, range 27.9 - 64.7 ha). The average minimum range size for five adult males in Louisiana was 328 ha (Joanen and McNease, 1989) and 95.4 ha for four tagged males in Florida (Goodwin and Marion 1979), this was larger than the average home range size for four adult males from my study (68.9 ha, range 33.9 - 110.6 ha). Territorial defense was not witnessed during either year despite the fact that there was a considerable amount of range overlap between the tagged alligators.

Male alligators are known to have larger home ranges and higher levels of movement compared to females. Mean home range for the alligators of this study confirm these results. Morea et al. (2000) reported that Everglades alligators have relatively small home ranges and are more or less bound to their ranges with infrequent emigration. This inland alligator population saw frequent movement within the home range and also some movement between regions of the study area. One adult male (Alligator 38) traveled approximately 9.6 km between the two field seasons, with distinct home ranges in each season. The differences in home range sizes could be explained by the habitat types within the home range. Alligators located in the natural marsh, where extended travel was relatively difficult due to thick vegetation, restricted movement and home range size; where-as alligators located in deep water canals, which offered convenient and unimpeded travel lanes, tended to have larger home range size. Adult size may have a positive influence on the size of home ranges as well. The mean home range for male alligators decreased from 87.7 ha in 2010 to 50 ha in 2011. The mean home range for females also decreased from 46.3 ha in 2010 to 30.1 ha in 2011. This could be explained by the changes in water level between the two years. In 2010, flood conditions were experienced throughout the entire season while in 2011, it was drought.

The differences between day and nighttime habitat selection was highly variable. Mean daytime water depth was deeper in both the used and available locations compared to the nighttime locations. This is similar to Webb (2005) where alligators were routinely observed in water depths of 1.0-2.0 m due to the encroachment of emergent vegetation and mats of floating vegetation in the late summer months resulting from decreasing water levels. Mean difference in surface water temperature and distance to the nearest vegetation was not significantly different between the used or the available locations during the nighttime. The nighttime model was better at predicting used sites than the daytime model (95% vs. 65%), likely because the majority of alligator activity occurs at night. During the daytime, mean difference in surface water temperature and distance to the nearest vegetation was significant between the used and available locations. Alligators were often observed in relatively close proximity to vegetation during daytime hours; this may be associated with open canopy shorelines or emergent vegetation and also lower water temperatures due to shading. The percent canopy cover was lower during both day and nighttime between used and available locations.

Changes in water levels may influence the extent of alligator habitat. Water levels in inland reservoirs and associated wetlands rapidly change, often unpredictably, during summer, due to natural (i.e., flooding) and man-made (i.e. withdraw) causes. During the spring months of 2010, a high amount of rainfall resulted in flooding of much of the FWNCR which may have displaced alligators from their normal home ranges. The flood displaced one adult male from the refuge out

onto Lake Worth. During this time, there was an increased current, high amount of floating debris, and lower water temperature. In the summer of 2011, east Texas was in a drought and water levels in Lake Worth dropped by 0.9 meters. Most of the effects of the decline in water level on the refuge were at the north end of the lake where the marsh was shallowest. Although temporary, such fluctuations seemed to concentrate the alligators into remaining suitable areas and reduce the size of their home range.

Alligators were most strongly associated with particular habitat types (stream/river channel, open canopy shoreline, and emergent vegetation) during the nighttime locations, whereas during the daytime, locations occurred within all the habitat types (e.g. emergent vegetation, stream/river channel, floating vegetation, open canopy shoreline, and "other" terrestrial habitats). The top two habitats with consistently highest odds ratios and selection ratios were stream/river channel and open canopy shoreline at the study area level. This was consistent with Joanen and McNease (1989) in that the majority of locations were in deep water canals, however this differed from Goodwin and Marion (1979) where the highest proportions of male and female alligators preferred lake or open water habitat and lower proportions of swamp habitat in a north-central Florida Lake. Emergent vegetation was equally selected for and against by adult alligators. Open water wasn't selected for at all at the study area level. This differed from the results of Webb et al. (2009), in which adults occupied deeper, less vegetated open water habitats. Alligator habitat selection within the home range (i.e., third order selection) was similar to that at the level of the study area (i.e., second order selection). Open canopy shoreline, stream/river channel and emergent vegetation were selected for most often. There were 2 adult males that did select for floating vegetation when it was present within the home range.

It is unclear why open water wasn't selected for at either the study area level or within the home range, however, there is a lot of recreation on both Lake Worth and the FWNCR throughout the entire day. These pressures may be forcing the alligators to spend less time out in open water and instead seek out the areas where human disturbance is lower. A study on spectacled caiman (*Caiman crocodiles fuscus*) in the Tortuguero region of Costa Rica found that increasing boat traffic associated with ecotourism, recreation and a rapidly expanding local community increased the vulnerability of this species to injury and population reduction (Grant and Lewis 2010). Furthermore, alligators in this part of Texas are very uncommon, therefore, when they are observed by the public (especially while from a boat) they are often approached; much more so than in areas where sightings of alligators are more common.

Although alligator harvest regulations should control the unwarranted or illegal taking of animals, wherever human access is not physically excluded, poaching activities have undoubtedly had some effect on local populations. Although there is a high amount of human disturbance, this population seems to be reasonably sustainable. For example, in the reproductive event documented during this study, a large female chose to place her nest approximately 16 m from a very popular hiking trail on the FWNCR. Goodwin and Marion (1978) stated that although it is a popular belief that nesting female alligators are among the most aggressive of all animals, their observations did not support that belief. This event that was witnessed confirms this conclusion. Since nest and pod searches were not a component of this study, it is unclear whether or not there were more females on the FWNCR that successfully reproduced. Reproductive success and the ecology of these

populations are important factors for management strategies and should be examined further.

These results and the results from past studies suggest that the American alligator is a generalist when it comes to habitat selection. It has been documented that there are many differences in coastal and inland populations but little information exists for populations at the edge of their distribution range and those inhabiting an urban setting. Changes in the biotic and abiotic parameters at range edges make ecological processes more variable than in the core of the distribution range. Also, expansion in the urban population in Texas increases the potential for disturbance on the populations that inhabit these areas.

Management Implications

Alligator populations across their range have responded well to management and have recovered rapidly. Practically all harvested wildlife is managed based on demography and recruitment, and alligators are no different. Although there is little data describing these characteristics for inland alligator populations, Texas currently permits and regulates public harvest of inland populations. Understanding the pattern of alligator presence and abundance in isolated, seasonal wetlands is critical to developing appropriate management strategies for alligators in this habitat and for understanding the ecological role of alligators in these systems.

Due to the low density of this population at the edge of its distribution range, with limited reproduction and immigration, harvesting from this population would be ill advised. However since it is an urban population and there is potential for alligator-human conflict, the need may arise for wildlife officials to remove an individual or individuals. More effort needs to be dedicated to educating and raising the awareness of the potential of this animal as a predator with members of the public sharing recreational areas. Also, in reservoirs where the water levels are managed, an early warning system could be employed during high water events to inform the public that there may be the potential for alligators being displaced from their normal home ranges. Additional monitoring of alligator populations in all habitat types might provide comparative data for the sustainability of these populations in areas with high amounts human disturbance. Crocodilian species can sustain life history functions critical for population stability in man-made reservoirs as long as thought is given to the potential impacts arising from various management activities.

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