Assessment and surveillance of tegu abundance in and around Babcock Webb WMA

Hance Ellington, Assistant Professor, Rangeland Wildlife Ecology
Alex Furst, MSc student, UF Department of Wildlife Ecology and Conservation

The Argentine black and white tegu (*Salvator merianae*; hereafter tegu) is a large, diurnal, active-foraging lizard that was introduced to Florida via the pet trade. Established breeding tegu populations now occur in Miami-Dade and Hillsborough counties (Pernas et al. 2012). Established tegu populations are also present in Charlotte and St. Lucie counties (Dan Quinn, FWC; personal communication; EDDMapS 2022) though there is currently no published research on either of these populations. Indeed, much of Florida and the southeastern United States is potentially suitable tegu habitat (Meshaka et al. 2020, Goetz et al. 2021). Moreover, models produced by Johnson et al. (2017) suggest that tegu population size has a doubling rate of three years. The potential for rapid population growth and its predicted ability to persist across all of Florida make this a highly invasive species. Tegus can potentially cause major disruptions to local ecosystems because they are omnivorous generalists with a diet that includes berries, invertebrates, and vertebrates. In Hillsborough County, tegus were found to consume a wide variety of amphibian, reptilian, avian, and mammalian species, including the eggs of several of these species (Offner et al. 2021). Notably, tegus were found to have consumed young gopher tortoises (*Gopherus polyphemus*), a threatened species in Florida (Offner et al. 2021).

The goals of tegu management in Florida should be both containment and eradication. For either to be successful, there must be efforts focused on early detection and rapid response to potential new populations and removal efforts targeted at populations that are breeding in the wild. Johnson et al. (2017) predicted a harvest rate of > 0.19 across all age classes would be needed to stabilize tegu population growth and suggested that even higher harvest rates would be needed to reduce the population size.

Tegus appear to be reproducing in the wild immediately north of the Babcock-Webb WMA in Charlotte County, FL. Most of the current removal efforts in this area occur along roadsides because disturbed landscapes appear to be preferred by tegus and because a systematic and large-scale removal effort would be logistically difficult due to the high proportion of privately-owned land in this area. There have been more than 270 tegus removed from this area, but the impact of these management actions on tegu population size is currently unknown (Dan Quinn, FWC; personal communication). Furthermore, a few tegus have been removed from inside the Babcock-Webb WMA but the number and spatial extent of tegus in the Babcock-Webb WMA is also unknown. Tegus typically avoid wet landscapes, and the seasonally flooded areas of the Babcock-Webb WMA might act as a barrier to tegu dispersal further into the WMA. The tegu population in Charlotte County has the potential to become a source population for a new invasive front of tegus in Southwest Florida. The FWC recognizes this risk - one of the FWC priorities in 2022 includes the *assessment and surveillance of tegu abundance in Babcock Webb WMA*. We propose to address this need through the following objectives:

- Estimate tegu abundance and response to removal efforts in the area immediately north of the Babcock Webb WMA

- Estimate the spatial extent to which tegus have spread into suitable upland environments in northwestern Babcock Webb WMA

Task 1: Removal effort and estimate of abundance (primarily north of Babcock-Webb WMA)

Methodological background

The FWC has been removing tegus in the area north of Babcock-Webb WMA since 2018. Classic removal models (also called depletion surveys) are a special case of capture-recapture models, where the probability of recapture is constrained to zero (because the individual is removed from the study; Zippin 1956). The classic removal model assumes population closure, consistent capture effort, and equal catchability among individuals. With these assumptions in mind, we can use the rate of decline in number of removed individuals across sampling efforts to estimate initial population abundance and the subsequent impact of removal efforts. These types of models are the ideal method for estimating population abundances of invasive species because preferred management actions (i.e., removal) coincide with the methods of population estimation (Davis et al 2016). Recent advances in removal models, including the use of Bayesian approaches and hierarchical models, have allowed for more complex data situations to be modeled (Royle and Dorazio 2006, Davis et al 2016; Zhou et al. 2019). These newer Bayesian-based approaches allow for hierarchical primary and secondary sampling events and importantly, the relaxation of the classic assumptions of consistent capture effort (Davis et al. 2016), population closure (Matechou 2016, Zhou et al. 2019), and equal catchability among individuals (Mäntyniemi et al 2005). These newer approaches can be used to generate estimates of population abundance, but the accuracy and precision of these estimates can vary depending on data quality. Davis et al. (2016) found that higher effective removal rates (# individuals removed across all effort/total population size) produce more accurate estimates of population abundance, especially when total population size is small. For example, if the total population size of the area sampled is 50 individuals, accurate population estimates would only occur when the effective removal rates were 40% or higher. Conversely, if the total population size of the area sampled is 1000 individuals, accurate population estimates can be calculated when effective removal rates are 20% or higher. Importantly, simulations by Davis et al. (2016) also found that inaccurate estimates of population abundance are more likely to be underestimates than overestimates.

Methodological approach

We have deployed traps with a hexagon grid (Figure 1) that seeks to minimize violations to inconsistent capture effort and maximizes effective removal rates so that we can adequately model violations to population closure (birth of tegus occurs from May-August) and equal catchability (tegu catchability is likely higher from April-August due to individual variability in brumation timing and dispersal activity). Trapping will continue until at least September 15th. Traps are baited with chicken eggs and checked. Traps are placed in microsites with characteristics that maximize trap success and minimize trap by-catch, while also minimizing the stress to captured animals by providing shade. Removal models can also benefit from auxiliary data (Huggins and Yip 1997), such as basic demographic data. Thus, we will collect measurements on captured tegus, including sex, age, and reproductive status. We will also collect physical metrics including total length, snout-vent length, and mass.

Task 2: Initial index of tegu abundance in Babcock-Webb WMA

Methodological background

A few tegus have been removed from Babcock-Webb WMA but the spatial extent of tegu presence within the WMA is unknown. Given the small number of tegus previously removed from Babcock-Webb WMA in the past, a large-scale removal effort and subsequent population model might not produce reliable abundance estimates (time and financial resources expended might not be justified). However, camera trap networks require substantially less time and financial resources than removal efforts, and camera traps can reveal the spatial extent of tegu presence in northwestern Babcock-Webb WMA. Furthermore, with sufficient detections, broad indices of tegu abundance can be generated over time (increasing, decreasing, stable; Engeman 2005). Anecdotal evidence and previous studies have suggested that tegus are more likely to be detected in dry, disturbed landscapes, along habitat edges, and in areas with relatively little understory (Klug et al. 2015). Thus, cameras placed in sites with these characteristics will likely have higher detection probability. Tegus enter brumation in the fall (Sept-Oct) and are relatively inactive until early to mid-February. Thus, detectability during this time will be relatively low (and perhaps zero). Keeping camera traps active during these shoulder periods, however, allows for the detection of individual variability in brumation timing.

Methodological approach

We have deployed a camera trapping grid across northwestern Babcock-Webb WMA consisting of 36 cameras that will be rotated throughout the study area every 7 weeks, thus covering a 36 km^2 study area over the course of the tegu activity season. Within sample cells, the cameras were placed in areas that maximize detection probability (i.e., areas most suitable for tegus, higher elevation, habitat edges, and open understory). To improve detection probability, we used bait (chicken eggs) protected by bait cages at our camera sites. Images captured by trail cameras will be collated into image bursts (time between images < 60 seconds) and then bursts will be screened for tegus.

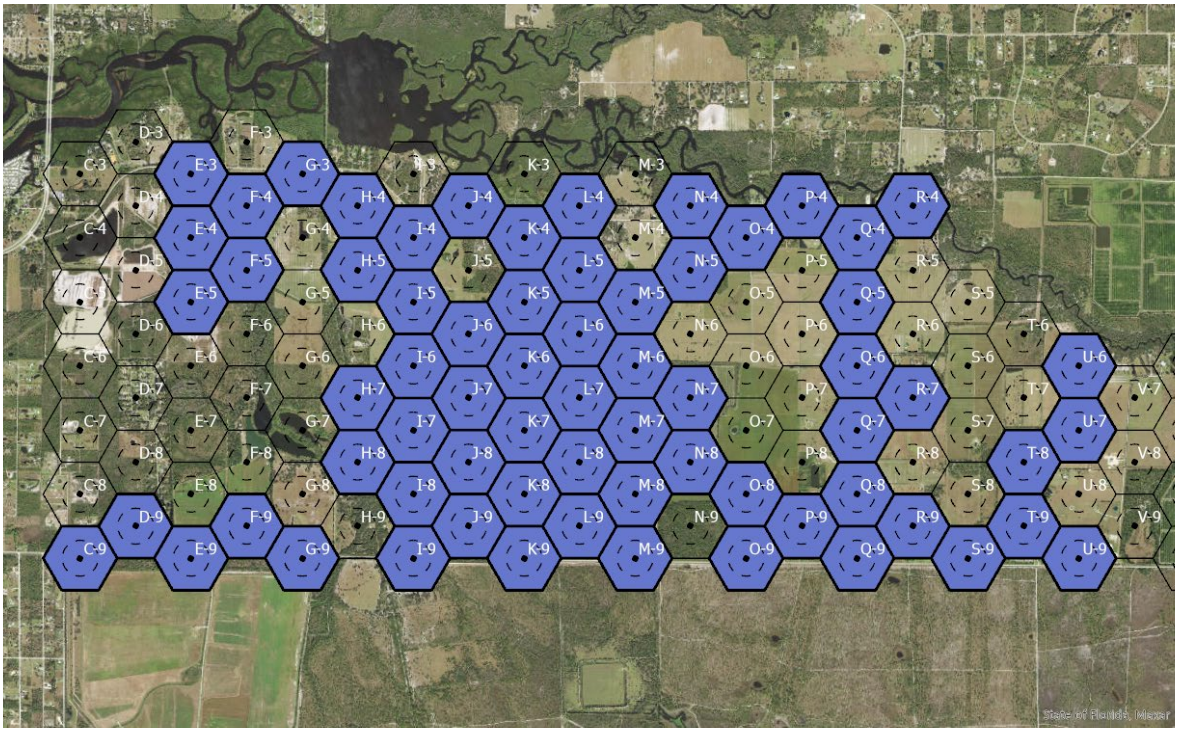

Figure 1. Tegu trap hexagon grid for core area. Blue cells currently have traps deployed. Trap placement in remaining cells is limited by access to private land. We continue to try to gain access to these unoccupied cells.

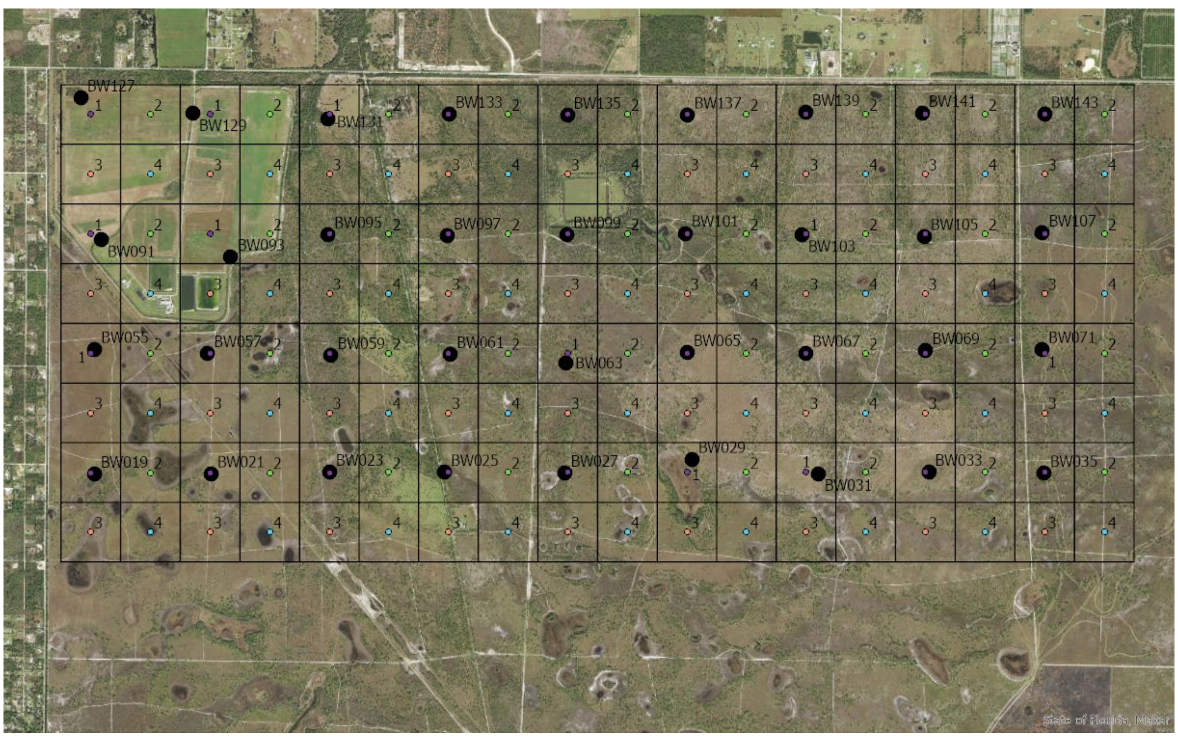

Figure 2. Tegu camera grid for peripheral area. Large black dots are deployed cameras. Cameras will rotate every 6 weeks through neighboring grid cells. Cameras are currently placed in cell 1, then will rotate to cell 2, cell 4, and finally cell 3 (multicolored dots).

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