



# Long-term Monitoring of Texas Tortoises on National Park Lands: Use and Suitability of Available Habitats

Jane Carlson, Jeff Bracewell, Fabiane Barato Speyrer, Billy Finney, Whitney Granger & Martha Segura

Gulf Coast Network Inventory and Monitoring Program, National Park Service, 646 Cajundome Blvd, Lafayette, LA



## Background

The Gulf Coast Network conducts long-term monitoring of Texas tortoises (*Gopherus berlandieri*) as part of a national program that tracks the condition of key natural resources on National Park lands. The Texas tortoise (Fig. 1a) is the smallest and only non-burrower of the four North American tortoise species, and it is seen regularly in only one U.S. National Park unit: Palo Alto Battlefield National Historical Park. The species is protected in the state of Texas due to its small geographic range (Fig. 1b) and shrinking habitat availability. The primary habitats used by Texas tortoises are Tamaulipan thornscrub, other shrublands and the shrub-grassland ecotone. In coastal Texas, the shrublands tortoises use are on low-relief ridges called lomas, where they form semi-isolated subpopulations with limited dispersal. At Palo Alto Battlefield, Texas tortoises are monitored on all major lomas, which are shrub-dominated and have patches of prickly pear (*Opuntia engelmannii*), a preferred food source. These habitats and the adjacent sloping ecotones comprise less than 16% of the park's 696 hectares. Much of the remainder is salt prairie, with large stands of Gulf cordgrass, *Spartina spartinae*.

All seven of the park's major lomas are broadly considered suitable habitats for tortoises, yet they differ in size, elevation, isolation and land use history, which is linked to the current vegetation community. These characteristics could alter the condition and behavior of the tortoises that live there. **This study's objectives were to evaluate the structure, habitat and history of the park's seven major lomas and determine whether the tortoises that inhabited them had different attributes or behaviors.**

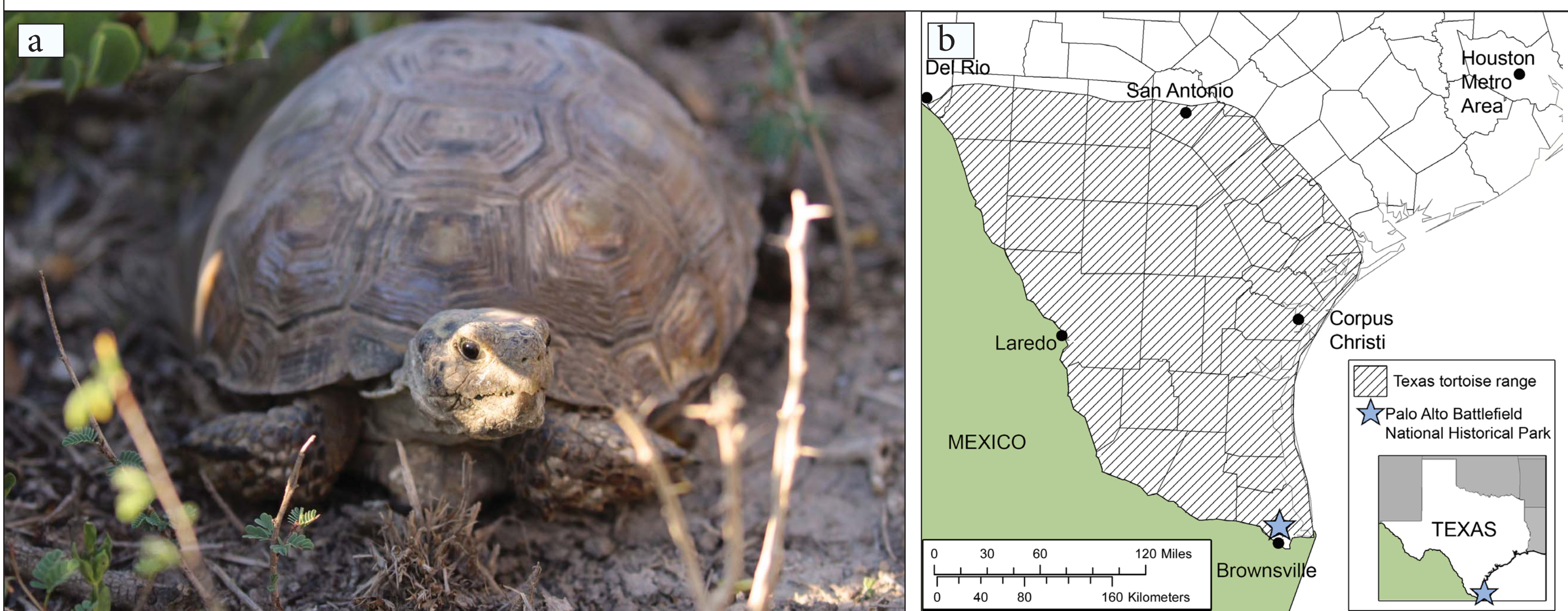
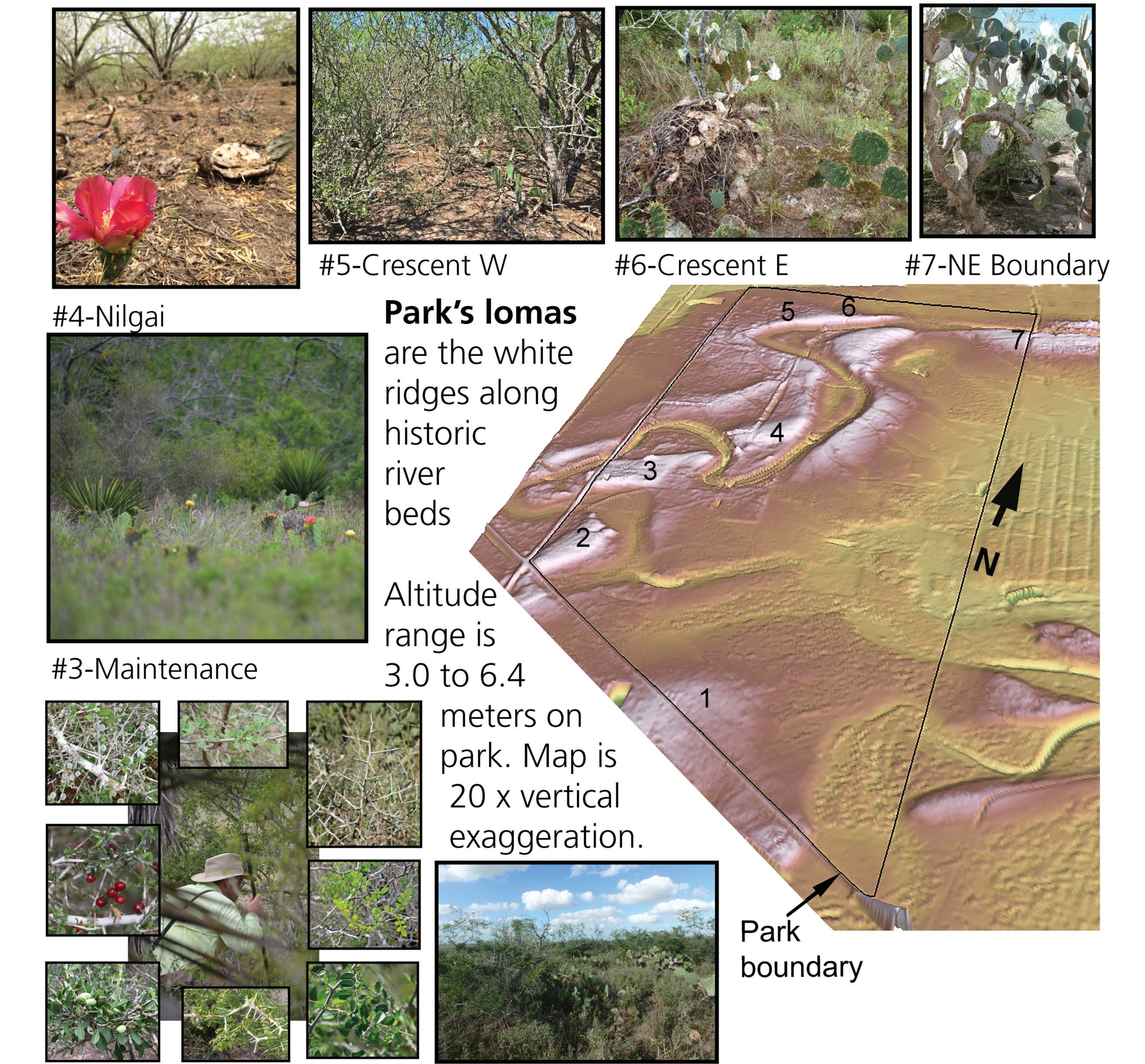


**Figure 1.** (a) Female Texas tortoise at Palo Alto Battlefield. (b) Range of Texas tortoise in the U.S., following Rose and Judd (2014) in *The Texas Tortoise: A Natural History*. (University of Oklahoma Press. Norman, OK.) The species is also recorded in three northern provinces of Mexico.

## Results and Interpretation

**Lomas:** Of the seven lomas, the northern four were higher elevation and had more tall shrubs in and around them (Table 1, Fig. 3). The southern loma, #1, was lower than the rest, had fewer tall shrubs and more surrounding grassland. Only loma #2 had not been cleared in the last century, and its shrubland was dense and diverse. The four northern lomas had repeated clearings, some as late as 1990s, and were dominated by mesquite.



|                                                   | #1-Southside                                                                        | #2-Visitor Center                                        | #3-Maintenance                                                        | #4-Nilgai                                        | #5-Crescent W                                                            | #6-Crescent E                                                  | #7-NE Boundary                                                    |
|---------------------------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------|--------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------|
| Description of habitats                           | Mostly open with prickly pear. Mainly shrub-grassland ecotone, but some tall shrubs | Dense & diverse thornscrub. Some mesquite & prickly pear | Mostly thornscrub but some regrowth mesquite & open with prickly pear | Mostly regrowth mesquite with prickly pear below | Mostly tall regrowth mesquite, but some thornscrub and open prickly pear | Mix of open with prickly pear, regrowth mesquite, & thornscrub | Mostly regrowth mesquite with prickly pear below. Some thornscrub |
| Disturbance history                               | Last clearing was around 1960s, likely pasture                                      | Never cleared, though road added in 2000                 | Parts never cleared, rest last cleared in 1970s, likely pasture       | Last clearing was late 1990s, likely row crops   | Last clearing was in the 1970s, likely row crops                         | First & last clearings were 1970-80s, likely pasture           | First & last clearing was in late 1980s, likely pasture           |
| % shrub-covered, >1.2 m tall (or >3 m tall)       | 73% (36%)                                                                           | 81% (64%)                                                | 99% (72%)                                                             | 100% (58%)                                       | 91% (90%)                                                                | 93% (61%)                                                      | 100% (55%)                                                        |
| % >0.5 m altitude (or >1.2 m alt.)                | 82% (0%)                                                                            | 94% (10%)                                                | 95% (33%)                                                             | 83% (71%)                                        | 99% (52%)                                                                | 97% (53%)                                                      | 89% (51%)                                                         |
| % grass in 100m buffer (or <0.5 m alt. in buffer) | 65% (42%)                                                                           | 53% (69%)                                                | 53% (45%)                                                             | 34% (37%)                                        | 36% (35%)                                                                | 30% (58%)                                                      | 22% (51%)                                                         |

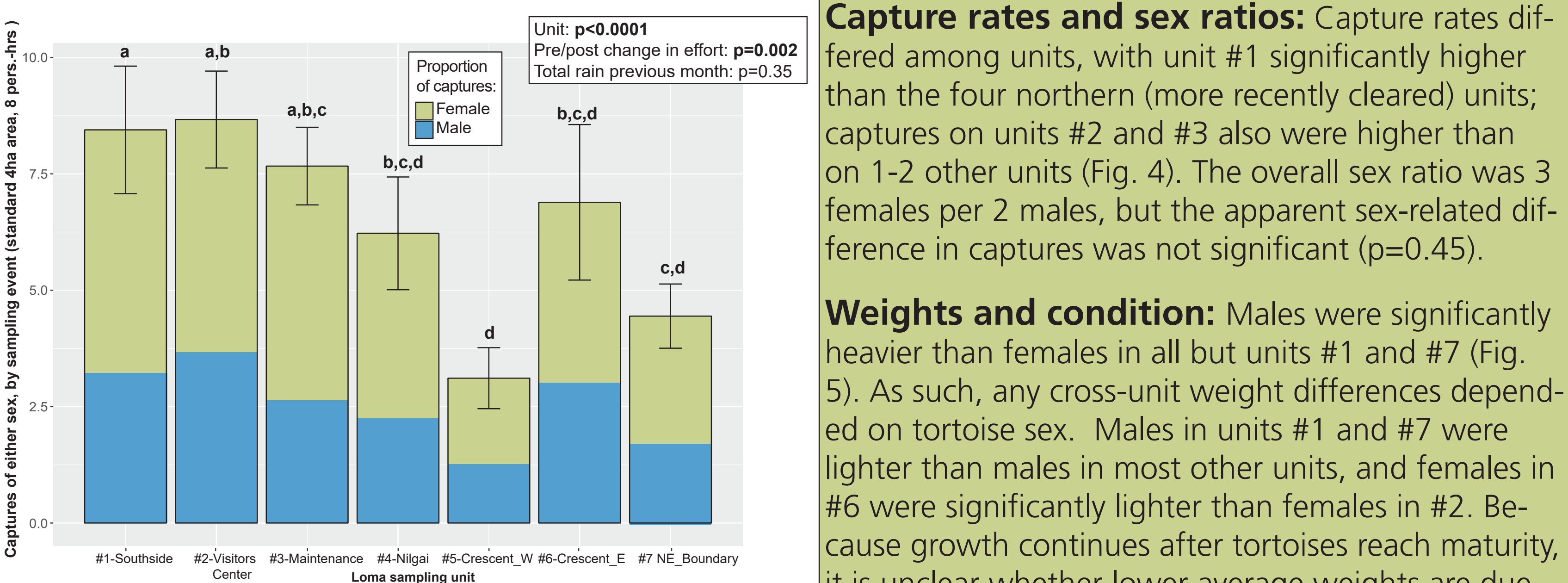


**Figure 4.** Capture rates per unit, averaged over 9 events.

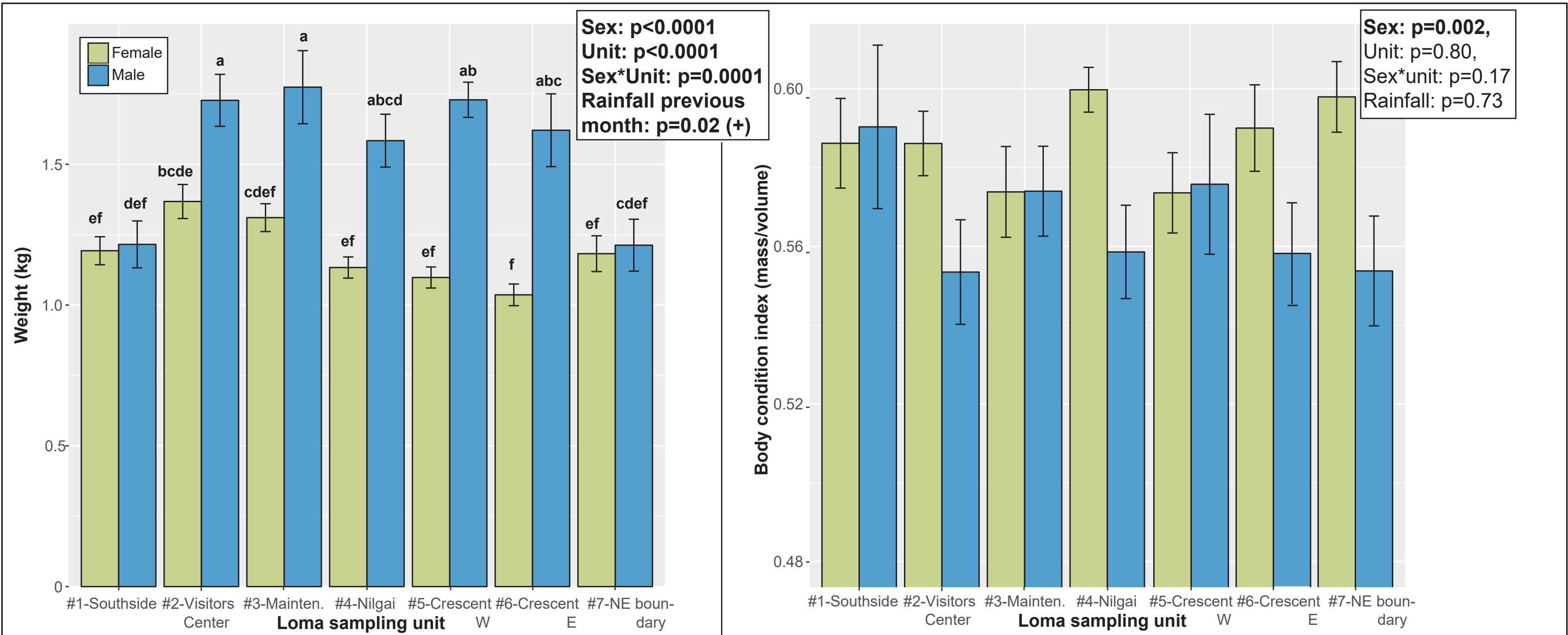


**Figure 5.** Tortoise weight and body condition index by unit and sex.

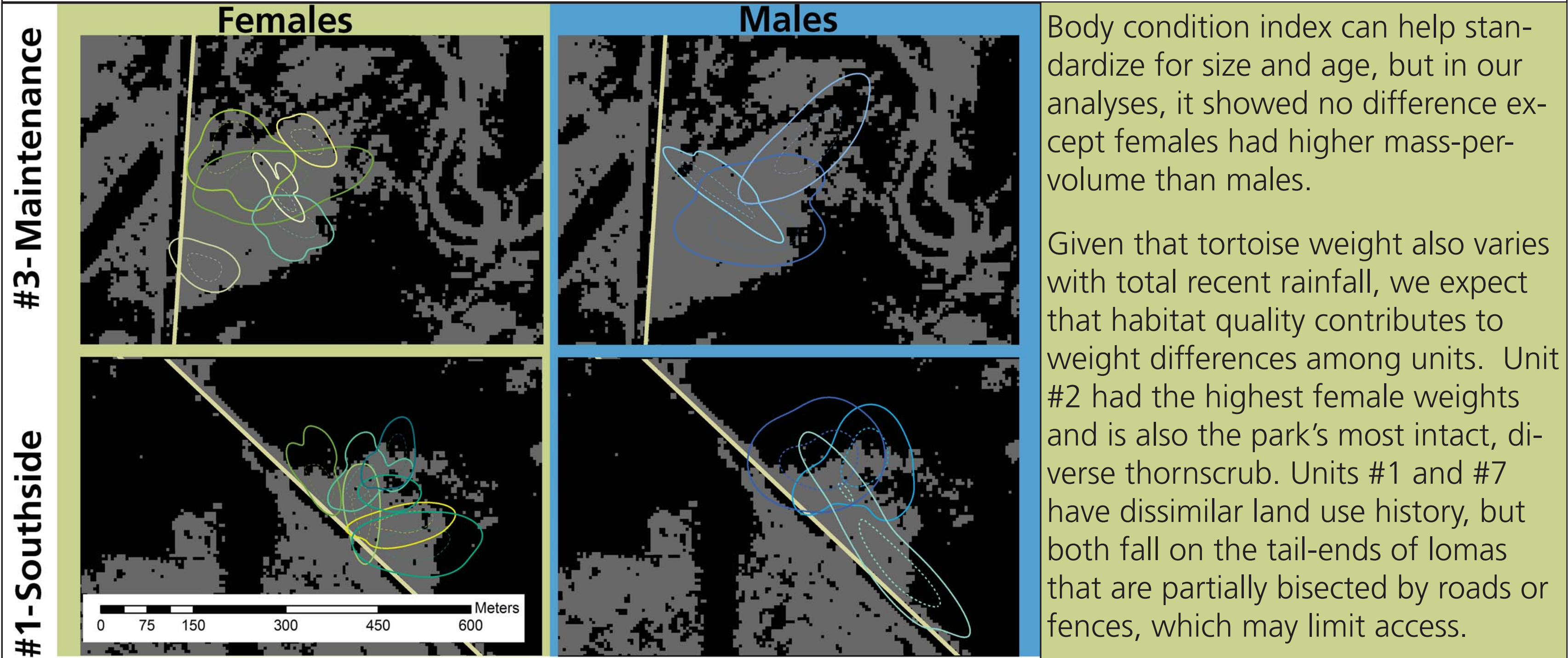


**Figure 6.** 50% (dotted) and 95% (solid) kernel density estimates in two units. Grey is shrubland (>1.5 m tall) and black is grassland.

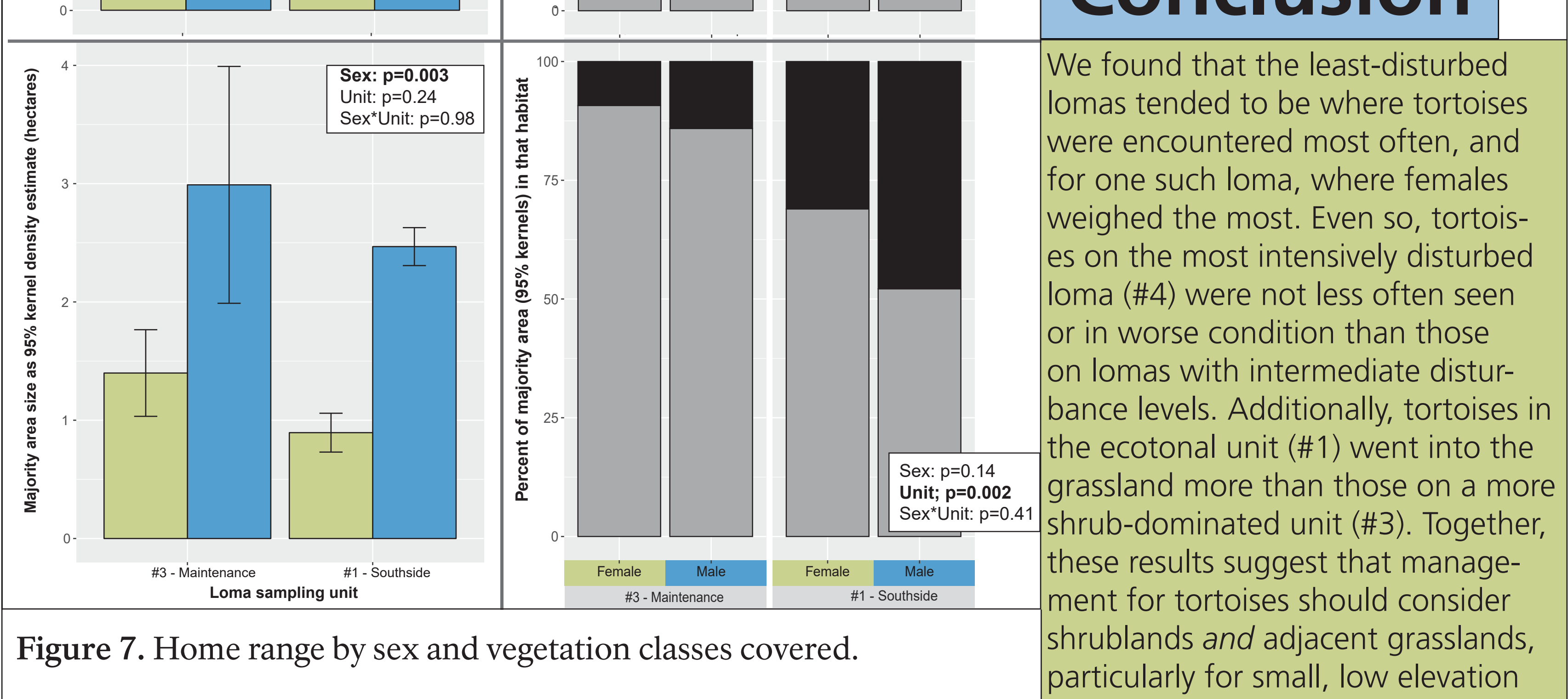
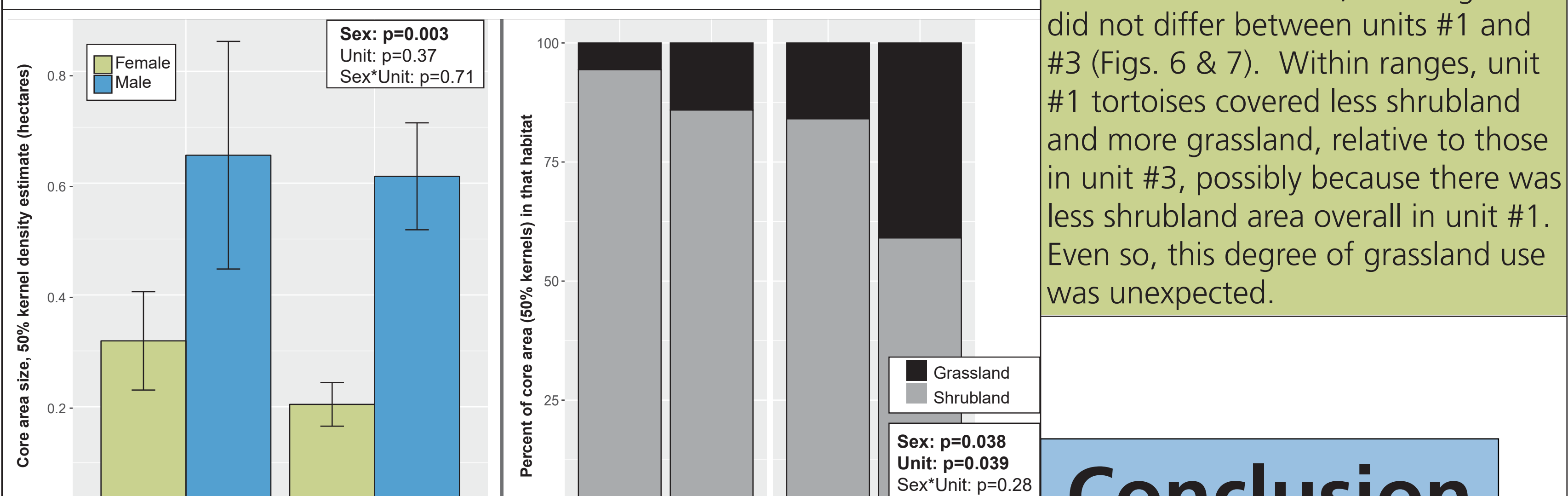


**Figure 7.** Home range by sex and vegetation classes covered.

lomas. Land use history also matters, but as shown previously, tortoises occupy sites recovering from a range of disturbance intensities. Because monitoring is ongoing (including population size estimates), we can assess whether apparent differences among lomas have additional consequences that will be revealed over the long-term.



**Acknowledgements:** We thank Rolando Garza, Kurt Buhlmann and Tracey Tuberville for extensive help developing the monitoring project, completing the radio tracking study, and assisting in the field. We also thank our volunteers for help with fieldwork.

## Methods

Loma study units were characterized in GIS using lidar data from 2005-2006 for bare earth and first surface elevations. History of land-use was determined from aerial images, from 1934 then 1+ per decade from 1950 onward. To describe tortoise subpopulations, field crews collected data twice a year during visual ground searches on each loma. Standardized sampling began in 2014 (Fig. 2), with defined unit boundaries and 8 person-hours per unit.

During each search event, crew members weighed all captured tortoises, measured them for carapace dimensions, permanently marked them and recorded locations with GPS. We compared tortoise counts, sex ratio, and body condition from 2014-2018 among units using mixed models (lmer or glmer in lme4 package in R), with recent rainfall as a covariate. Sampling event and season were random effects, as was pre/post change in search area for the capture model. Sex and sex\*unit were added to body condition models. Post-hoc comparisons were Tukey-adjusted (letters for groupings). We estimated home ranges in units #1 and #3 by radio tracking 18 tortoises for up to a year. Fifty and 95% kernel density estimates were from 8+ encounters, and by overlaying these with vegetation height from lidar, we calculated % of home range in shrubs (>1.5 m tall) or grassland.

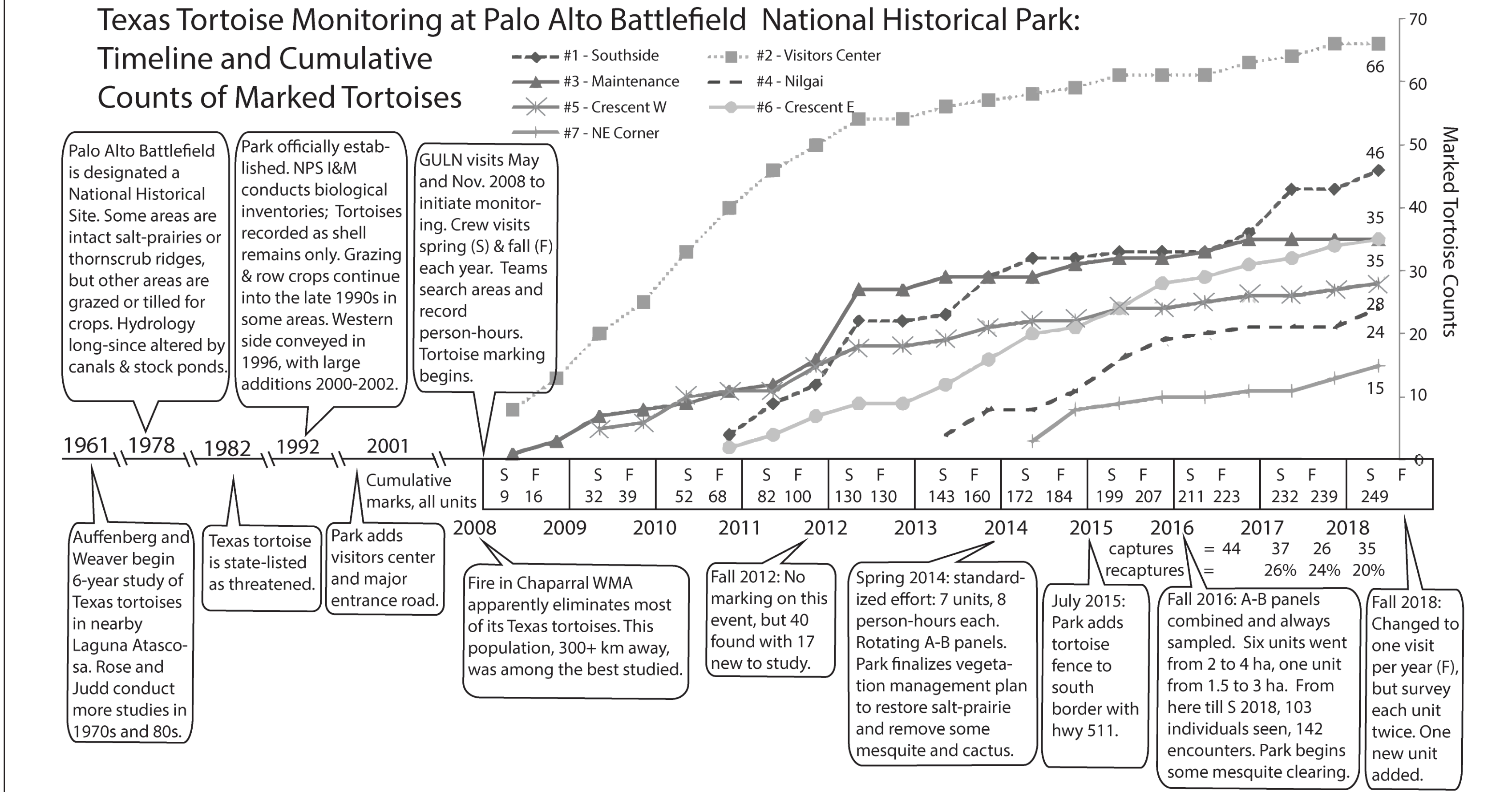


**Figure 2.** Project development timeline at Palo Alto Battlefield, including important dates for the park and for tortoise research in the region. Also shown are cumulative counts of marked tortoises. S=spring visit and F=fall visit.