

A Pilot Study: Report on the gopher tortoise foraging preferences at Barefoot Beach County Preserve during the summer of 2017

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Abstract

Gopher tortoise populations have recently been on the decline, in part due to the disturbance of natural processes, such as wildfires. Since many preserves do not mandate burning as an appropriate habitat management practice, we propose a solution that could both be safe for humans and improve habitats for gopher tortoises. We tested whether areas within the preserve that were treated with understory cutting were more preferable to gopher tortoises than those uncut. We observed foraging behaviors within cut and uncut areas, and predicted that the site with the most recent cutting would be preferred by tortoises over all other sites. Gopher tortoises were found to consume five various plant groups within the four research sites. The groupings were as follows: weeds and grasses, prickly pear, flowers, ragweed, and other species that were not identified. Weeds and grasses underwent the highest amount of foraging behavior by gopher tortoises, followed by ragweed, flowers, prickly pear, then other species. In descending order, foraging behavior was most commonly observed at the parking lot, then at the treatment, control, and mound sites. Finally, there were several instances when tortoises were found foraging in an area that was outside of the vicinity of their burrow site. The data suggests that gopher tortoises prefer sites with significant weed-covered ground, and prefer weed species over all other plant groupings. To better understand the flora that has been utilized by the gopher tortoises in this pilot study, it is advised that a local botanist is contacted to identify the specific plant species observed in this study. Since gopher tortoises seem to prefer foraging in the parking lot area, it may prove wise to take measures to restore areas that provide optimal foraging habitat away from human and vehicle traffic.

Introduction

Gopher tortoises (*Gopherus polyphemus*) are an important occupant of Florida's great and diverse habitats; these animals can reside in a range of sandy uplands, including sandhills, scrub, pine flatwoods and coastal dunes (McCoy et al. 2006). *G. polyphemus* burrows are an indispensable resource for many species including rattlesnakes, mice, and burrowing owls, making them a keystone species on which vertebrates and invertebrates alike depend (Breining et al. 1991). Therefore, it is no wonder why many national, state, and county preserves are looking to protect gopher tortoises on their lands.

Gopher tortoise populations have recently been on the decline, primarily due to the increase in land development and the disturbance of natural processes, such as wildfires (Ashton et al. 2008). Fire in the natural environment promotes community succession, and the small-statured, herbaceous species which gopher tortoises depend on for foraging are found in early successional stages, which thrive after burning events (Ashton et al. 2008). It has been observed that gopher tortoises are significantly more common in areas of recent burning than in areas that are undergoing fire suppression (Ashton et al. 2008), most likely because burned areas are characterized by lower canopy density and increased areas of open ground.

Since many preserves do not mandate burning as an appropriate habitat management practice because of the dangers to nearby human populations, we propose a solution that could be both safe for humans and improve habitats for gopher tortoises. Cutting and removal of understory species has been used to restore gopher tortoise habitats in areas where fire burning is not permitted (Diemer 1986). However, the effects of understory cutting on gopher tortoise foraging behavior is still uncertain.

In this review, we test the possibility of using understory cutting to promote small herbaceous species on which gopher tortoise depend. This study observed the behavior of gopher tortoises at Barefoot Beach County Preserve in Bonita Springs, Florida to help better understand the foraging preferences of this species in managed and unmanaged habitats. We tested whether areas within the preserve that had undergone understory cutting were more preferable to gopher tortoises than those uncut by observing foraging behaviors within cut and uncut areas, and predicted that the site with the most recent cutting would be preferred over all other sites.

Methods

Understory cutting was conducted on two areas within Barefoot Beach County Preserve: a sand dune on the south side of the second parking lot within the Preserve (referred to as the mound), and an area between parking lot #2 and the beach (referred to as the treatment site). It is important to note that, even though the mound had undergone understory cutting in the past, the majority of this site had reverted back to its original, overgrown condition, and was, therefore, very similar to untreated sites and was treated in this review as such. The behavior of gopher tortoises was observed in these areas as well as two other sites that had

never undergone cutting: an area directly east of the boardwalk between the Preserve's first parking lot and parking lot #2 (referred to as the control site), and the weed-covered median between parking lot #2 and the Preserve's main road (referred to as the parking lot).

Understory cutting was conducted in June 2014 on the mound and in October of 2015 at the treatment site. To simulate changes that could be caused by a burning event, Colloquium students from Florida Gulf Coast University conducted understory cutting under the guidance of Dr. Nora Demers and the Friends of Barefoot Beach Preserve. Student volunteers pruned back sea grapes, removed ragweed, and raked up dead sea grape leaves to promote the growth of other flora species. Photographs were taken of these areas before and after understory cutting, and can be seen in Appendix I along with photographs of the control site and parking lot #2.

Behavioral observations were collected to obtain data on the foraging preferences of gopher tortoises within Barefoot Beach Preserve. Continuous focal animal samples were conducted by a single observer during the summer of 2017 from June through August. The researcher observed the behavior of an individual tortoise for a continuous period. Tortoises were observed in the morning hours between 09:30 and 11:30, as this was the time frame when the most gopher tortoise activity seemed to occur. The researcher would arrive at the Preserve and select one of the four research sites (the mound, treatment, control, or parking lot) to begin observations. The first tortoise seen was the chosen focal animal, and the observer would follow this individual until it became out of site, either by entering a burrow or entering areas where human traffic was prohibited. At that point, another individual was sought for further observation.

The observer used an ethogram of behaviors (Appendix II) constructed for this project from a behavioral inventory of desert tortoises (a closely related species) that was developed by Ruby and Niblick (1994). The behavior of the focal individual was recorded for every change in behavior, as well as (if the animal was foraging) the plant species the tortoise was utilizing. The date, time, weather, temperature, location, and humidity were recorded for each observation as well. Tortoises were identified using an identification coding system that included three characters symbolizing the location of their burrow, the relative order the individual was observed over the study, and the individual's age class.

Data was collected in the field using paper data sheets, and then transferred into Google Sheets for long-term records and data analysis. The data was analyzed using Google Sheets' graphing software.

Results

Of the identifiable individuals, five of the gopher tortoises observed had burrows in the treatment site, two in the parking lot, eight in the mound, three in the control, and four from outside the research sites. At least seven other individuals of unknown origin were also observed. Gopher tortoises displaying foraging behavior for a total of four hours and two minutes over the study's observation period. During this time, forty-eight minutes was spent foraging at the control site, forty-four at the mound, twenty-eight at the treatment, and one-hundred and twenty-four minutes was spent foraging at the parking lot.

Gopher tortoises were found to consume five various plant groups within the four research sites. Photographs of the plant groups are available in Appendix III. The groupings are as follows: grasses and clover, which include a "weed mix" that possesses several species of weeds and grasses, a short grass species, and a tall grass species; prickly pear; the flowers of several grasses and clovers (flowers); ragweed; and other species that could not be placed into these other groupings. It is important to note that none of the species have been identified by a professional, and, therefore, it was decided that these groupings would allow for more accurate interpretations of the data until identification was possible.

The plant group that was foraged on the most by gopher tortoises was the grasses and clover (75.3% of individual foraging behavior observations, Figure 1). After this group, ragweed had the second highest level of foraging behavior (12.4%), followed by flowers (8.2%), prickly pear (2.1%), and other species (2.1%). Foraging behavior was most commonly observed at the parking lot (43.9% of foraging behavior observations), and was observed 21.4% of the time at the treatment site, 19.4% at the control, 15.3% at the mound, and 5.1% at the parking lot (Figure 2).

Different plant groups were utilized by gopher tortoises at each research site (Figure 3). Grasses and clover were by far the group most foraged on at the treatment (95% of foraging behavior was on weeds and grasses), parking lot (81.1%), and mound (80%), but ragweed was foraged on the most at the control site (42%). However, grasses and clover came in a close second possessing 36.8% of foraging behavior instances at the control site.

Even though foraging behavior was observed for ragweed, the specific behavior that was observed for the majority (66.6%) of foraging time spent on this plant was "biting only", with only 33.3% of foraging behavior on ragweed being actual consumption, or

both biting and chewing (Figure 4). Biting only behavior was observed for the ragweed group only, and never for any of the other plant groups. Six out of the eight total instances of this “biting only” behavior was observed at the control site.

Finally, there were several instances when tortoises were found foraging in an area that was outside of the vicinity of their burrow site. Four tortoises from the mound were observed foraging at the parking lot site for a total of 19 instances; one tortoise from the treatment site was observed foraging at the mound site four times and at the parking lot site twice; another tortoise from the treatment site was observed foraging at the parking lot five times; and a tortoise from outside any of the research sites (specifically, right off the boardwalk in the wooded natural area close to the parking lot) was observed foraging in the parking lot during six instances (Figure 5).

Fig 1. The number of times each plant species was consumed by *G. polyphemus* throughout the study.

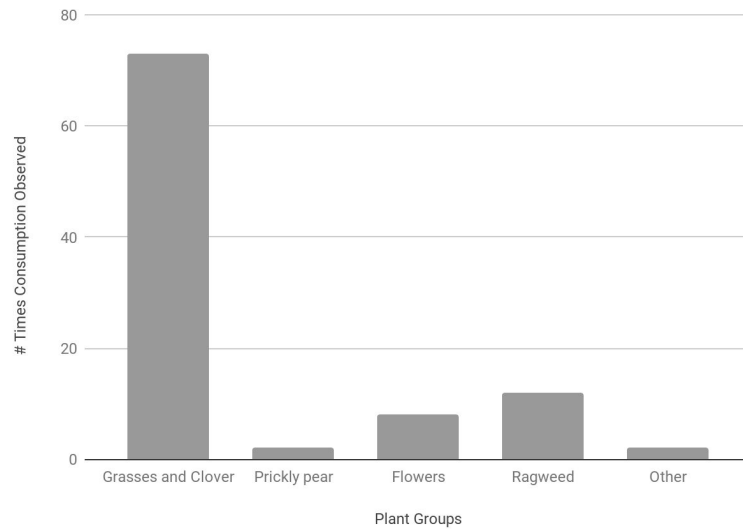


Figure 1. The number of times each plant species was consumed by *G. polyphemus* throughout the study.

Fig 2. Total number of foraging behavior observations at each research site.

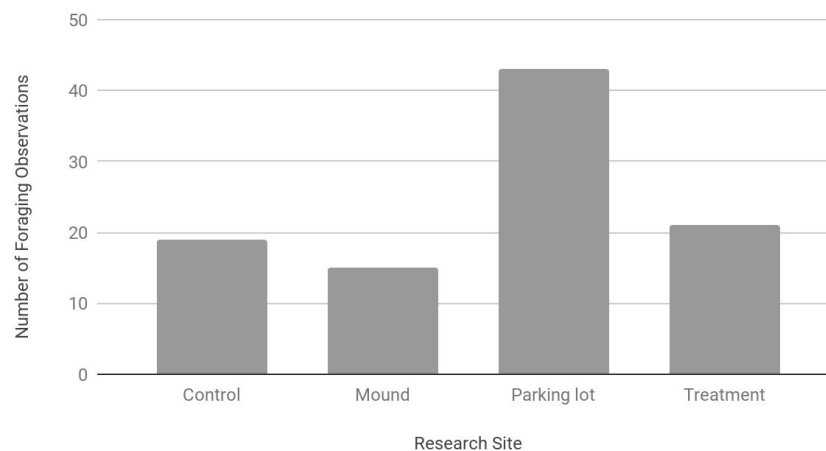


Figure 2. Total number of foraging behavior observations at each research site.

Fig 3a. The number of times foraging behavior was observed for each floral grouping at the control site.

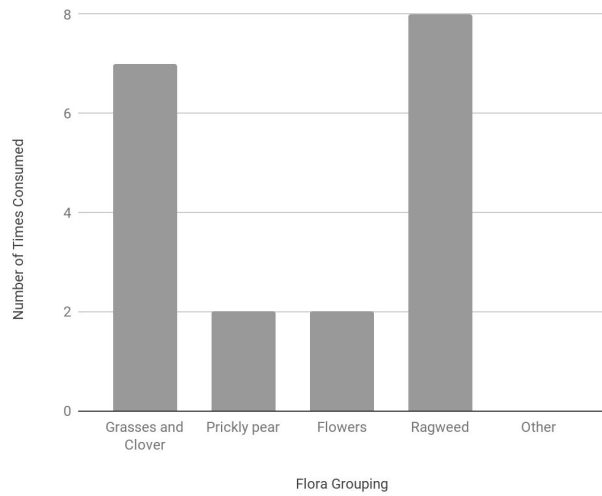


Fig 3b. The number of times foraging behavior was observed for each floral grouping at the mound.

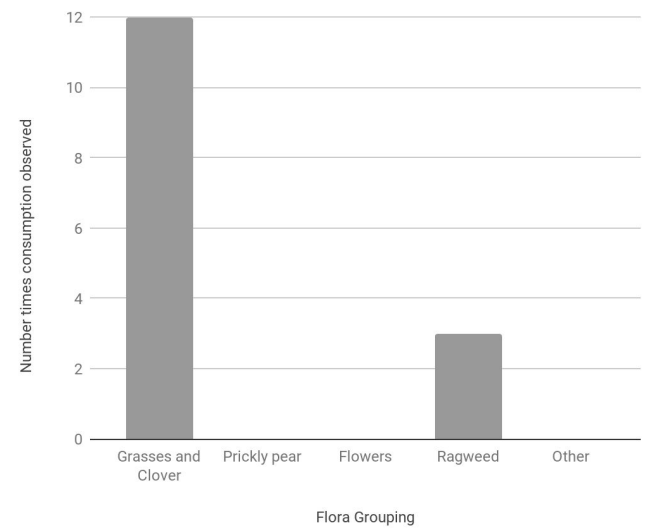


Figure 3a. The number of times foraging behavior was observed for each floral grouping at the control site.

Figure 3b. The number of times foraging behavior was observed for each floral grouping at the mound.

Fig 3c. The number of times foraging behavior was observed for each floral grouping at the parking lot.

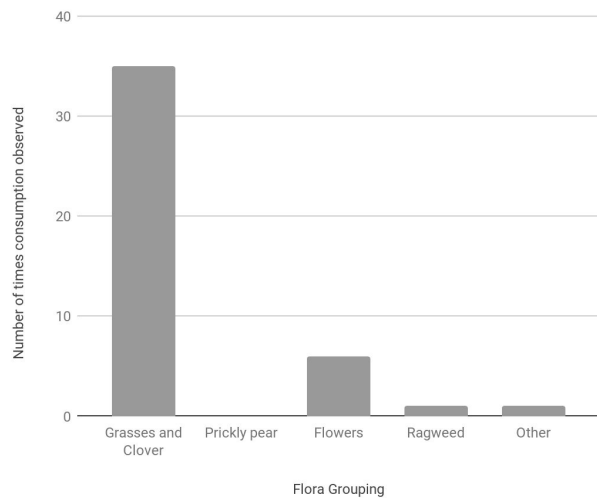


Fig 3d. The number of times foraging behavior was observed for each floral grouping at the treatment site.

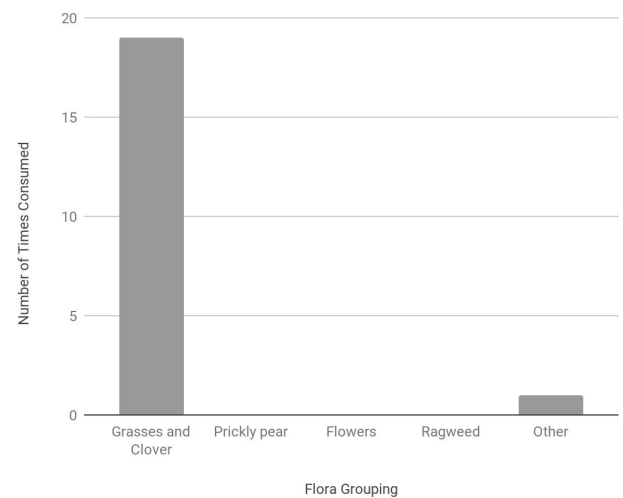
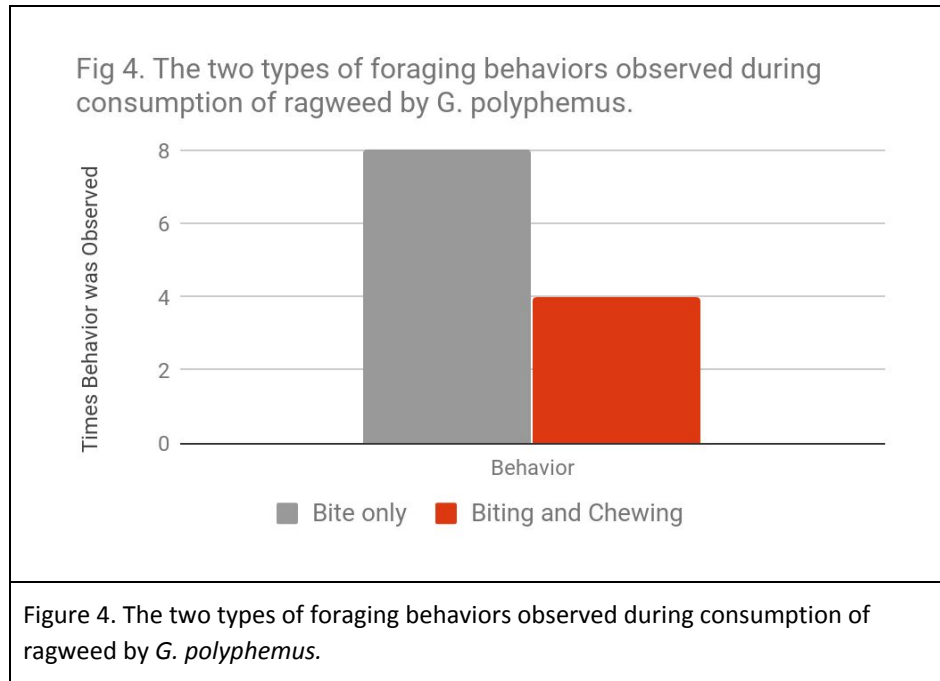


Figure 3c. The number of times foraging behavior was observed for each floral grouping at the parking lot.

Figure 3d. The number of times foraging behavior was observed for each floral grouping at the treatment site.



Individual (ID #)	Foraging Location	
	Mound	Parking Lot
M1A	-	2
M2A	-	6
M4A	-	4
M5A	-	7
T1A	4	2
T2A	-	5

Figure 5. The number of times identifiable individuals were observed foraging outside of their burrow site. Tortoises were only observed to forage in the mound and parking lot locations when not foraging at their burrow site.

Discussion

Overall, the data show a high propensity of gopher tortoises to consume grasses and clover over any other plant group. Not only did they consume grasses and clover during 75.3% of all foraging behavior instances, but also did so for over 80% of foraging observations within three of the four research sites. Grasses and clover are plants that are easily accessed due to their small stature and these species tend to be effortlessly bitten off due to their lack of rigid structural support, characteristics that may contribute to gopher tortoises seeming to specifically targeted these species. As seen above, gopher tortoises were most likely to exhibit foraging behavior at the parking lot. It could be deduced that, since grasses and clover may be sought-out species, the area possessing the highest concentration of grasses and clover, the parking lot, would possess the greatest amount of foraging behavior instances observed. Therefore, gopher tortoises may specifically be seeking out areas similar to the parking lot for their foraging needs. In fact, tortoises from all over the Preserve were found foraging in the parking lot, including three individuals from the treatment area, five individuals from the mound, and several other individuals that were outside any of the research sites.

The percentage of all foraging behavior was only 2% higher at the treatment site than at the control site (21.4% versus 19.4%, respectively). These contradicting results may have been generated because the majority of the data collected at the control site was collected within the first two weeks of observation. Therefore, since observer error is highest during early periods of

observation, the data may not accurately represent foraging behavior within this region. Furthermore, the lack of variance of foraging behavior between the treatment and control sites could be due to the inclusion of the “bite only” behavior. Biting was observed for eight out of the nineteen foraging behaviors at the control site, while the behavior was not seen a single time at the treatment site. Gopher tortoises did not consume during this behavior, but rather tactilely investigated the plant. When removing the “bite only” behavior from the calculation, the percentage of all consumption behavior instances recorded that were observed at the control site decreased to 16%, but increased to 22.3% at the treatment site. This increased disparity may be a more accurate representation of foraging preferences of gopher tortoises at the two sites.

Contradictorily, it was also observed that gopher tortoises spent more time in foraging behavior at the control site than in the treatment site (48 versus 28 minutes, respectively). However, the majority of the time spent foraging at the control site was when a tortoise was consuming prickly pear, which may take a significantly longer time to consume than leafy plants because of the need to maneuver around the plant’s thorns and because tortoises may need to compensate the species’ bulky composition with increased mastication. This would be a question for further analysis.

It is important to note that all eight “bite only” behaviors observed during this study were of gopher tortoises foraging on ragweed. None of the other plant groups were only bitten during observations, always being consumed fully (biting and chewing). Therefore, gopher tortoises fully consumed ragweed only four out of the twelve instances of foraging behavior on ragweed. Furthermore, even though ragweed was consumed twice at the mound and another two times at the control site, both of these areas have considerably higher ragweed cover than the parking lot and treatment sites and lack large areas of weed cover. Therefore, it may be that gopher tortoises are only foraging on ragweed because of the lack of other, more preferable species available, and the plant is most likely avoided the majority of the time. This may also give reason as to why gopher tortoises spent a significant amount of time consuming prickly pear at the control site, since there was a lack of weed availability and significant concentration of ragweed.

Following this logic, this foraging preference may help explain why gopher tortoises preferred the parking lot and treatment sites over the control and mound sites. As seen in the photographs in Appendix I, open ground that is not veiled by ragweed and is available for the colonization of grass and clover species can be found in large quantities in the parking lot and treatment sites but in low quantities in the control and mound sites. This large amount of grass/clover-covered ground may be why the treatment and parking lot sites have the highest amount of foraging behavior observed, while the control and mound sites have very little foraging behavior observed.

This idea is also supported by several of the tortoises leaving the site of their burrows to forage in areas with more open ground. Several of the tortoises from the mound and treatment sites were observed travelling to the parking lot for foraging purposes, and none of the individuals already located in the parking lot travelled to any other site to forage. Furthermore, it was noticed by the researcher that several of the tortoises that were from an unknown location would leave the parking lot after foraging and walk back into the woods towards the control site. Since it was impossible to determine the actual burrow location of individuals after they were no longer visible, and, therefore, no longer able to be tracked, it may be useful to develop a protocol to track such individuals in order to identify their burrow location. Nonetheless, gopher tortoises were observed travelling relatively long distances from their burrows to their preferred foraging sites in order to reach areas that had an increased area of open ground and grass/clover availability. Therefore, these areas seem to be of vital importance to gopher tortoise foraging needs as a whole.

Proposed Future Steps

To better understand the flora that has been utilized by the gopher tortoises in this pilot study, it is advised that a local botanist is contacted to identify the specific plant species observed in this study. Furthermore, observations of gopher tortoise foraging behavior should continue in order to determine if understory cutting is a viable option for gopher tortoise habitat management. The species composition of the cut and uncut areas should be determined, and continued understory cutting of the treatment and mound sites should commence in order to assist with this research endeavor. This is especially true for the mound site, since it has reverted back to its original, untreated state and seems to no longer be prime foraging ground for the gopher tortoises. If it is determined that understory cutting is a useful method for optimal habitat management, then cutting should be conducted regularly within certain areas of Barefoot Beach Preserve.

Specifically, since gopher tortoises seem to prefer foraging in the parking lot area, it may prove wise to take measures to restore areas that provide open habitat away from human and vehicle traffic. Several tortoises were seen with severe carapace cracks and damage that were most likely caused by vehicular collisions, and guests at the Preserve often approached or even pick up the tortoises in the parking lot area. Therefore, restoring more suitable, secluded habitat space within the Preserve could assist species conservation initiatives and allow this species to thrive at Barefoot Beach.

To continue this research, it is advised that a protocol be developed to track tortoises that travel through wooded areas that are inaccessible to human observers. It may also be useful to identify each burrow with its own identification code before conducting observations in order to make the system more feasible and accommodating for large-scale observations.

Acknowledgements

We would like to thank the staff at Barefoot Beach County Preserve for allowing us to use their land as a research site for this project. We also would like to thank Margaret Winn and the Friends of Barefoot Beach for their continual assistance with gopher tortoise conservation at the Preserve, and for assisting us with several research endeavors.

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Appendices

I. Photographs of research sites: the mound, treatment A, control A, and parking lot #2

The Mound	
Pre-Understory cutting (April 2014): The mound is dominated by ragweed.	Post-Understory cutting (August 2014): The mound has a significantly higher biodiversity.



Treatment A

May 2017: Bare ground, made available by understory cutting in 2015.



August 2017: Increased weed population.



Control A

May 2017: Area dominated by ragweed, presence of prickly pear as well.



August 2017: No significant change in vegetation.



II. Gopher Tortoise Ethogram

Category	Behavior	Definition
Maintenance	Resting	Legs and head only partially pulled in, eyes open
	Sitting	Shell resting on ground with legs out
	Standing	Animal on extended legs
	Scanning	While sitting, looking around with head motions, head elevated
	Alert	Animal on four extended legs, active in some way
	Defecate	Elimination of wastes, tail raised
Foraging	Substrate sniff	Head oriented down, nostril open
	Explore	Head extension to investigate food source
	Tactile Investigation	Bites food source, but does not consume.
	Bite and Chewing	Reach out, bite, and pull to snap off food source, then mastication with food in mouth

	Drink	Submerges mouth or snout into puddle of water
Defensive/ anti-predator	All Defensive	Head and all limbs pulled in tightly, can be awake or sleeping
	Head defensive	Only head pulled in slightly
	Freeze	Suddenly stops action and holds position
	Quick lie down	Rapid settling from alert to all defensive
	Back up	Moves backwards further into burrow in response to intrusion
	Wedging	Animal in burrow resists being extracted by pressing shell against top of burrow
	Quick retreat	Move away quickly from perceived threat, usually back into direction of burrow
Thermoregulatory	Basking	Shell on ground, legs sprawled with posterior/broadside sun orientation
Locomotor	Slow walking	Slowest gait
	Normal walk	Typical gait when moving and foraging
	Fast walk	Gait when moving purposefully
	Running	Fastest gait possible. When being chased, leaving conspecific encounter, or going to a burrow at end of activity period
	Climb	One or both feet on an object higher than surface, head extended
	Yawn	Opens mouth wide, often followed by a move
Social	Exploratory sniff	Sniff limb or cloaca of other tortoise
	Throat pump	Gular breathing; if head is high, may be a display
	High stand	Alert posture with animal on lifted legs
	Marking	Rub nose or chin on own forelimb
	Chin rub	Male rests chin on back of female's shell
	Sniff face to face	One animal directly in front of another, sniffs other animal's face
	Turn head away	Submissive response to approach by another tortoise doing rapid head bobs
	Turn body away	Submissive response to another tortoise approaching
	Head bobs	Quick side to side motions of the head, seen in courtship and aggression
	Gape	Animal threatens with open mouth
	Nip	Biting shell or limb of other tortoise, withdraws immediately
	Hold bite	Bites and holds at least momentarily
	Approach	Walks closer to another tortoise
	Trailing	One tortoise follows closely behind another tortoise moving away
	Side-display	One animal during an interaction with another tortoise moves sideways
	Soliciting	Animal turns 270 degrees in front of another animal, keeps side in front of other animal and presents rear in front of other animal
	Tail wag	Swing tail back and forth
	Rotate	Female turns on a pivot while trying to avoid a courting male
	Circling	Male walks around female who rotates away
	Stroke	Male strokes female's legs with front claws
	Shell scratch	Male scratches back of shell of female while mounting
	Mount	Male stands behind female in copulatory-ready position
	Head in and out	Female extends head straight out and back in
	Head swinging	During mounting, female does side to side swing of the head
	Hop	While mounting, male moves up and down simultaneously on both rear legs in order to

		remain with female who moves underneath him
	Copulation	Male behind female on rear legs, tails and cloaca together
	Walk away	Female walks away from courting male to end courtship or mount
	Aggressive climb	Tortoise tried to climb on another tortoise
	Front ram	Tortoises butt one another face to face, gular projections connect
	Side ram	One tortoise butts another tortoise on its side
	Rear ram	Animal rams and lifts up opponent from the rear using epiplastral projection
	Prop up	Both animals locked together in a front ram, front of each animal raised off the ground
	Back up	Submissively backing up
	Shell drop	Edge of carapace lowered to ground where other animal butts or attempts to mount
	Flip	One animal is thrown on its back
	Fall over	Pushing animal flips itself if other animal retreats from ram
	Foot bite	Animal bites foot of flipped animal
	Neck extension	When flipped on back, the animal reaches back to make contact with substrate, pivots body and uses legs to flip back over
	Foot waves	While flipped on back, tortoise rapidly flips foreleg to make contact with ground or shift balance
	Retreat	Tortoise runs away from another tortoise after aggressive encounter
Nesting	Dig	Digging motions in dirt, one leg at a time
	Egg lay	Egg laying motions
	Nest cover	Female pushes dirt over nest and urinates on it
Vocalizations	Hiss	Noise made by expelling air from lungs, often heard when tortoise is picked up
	Grunt	Deep, short sound
	Moan	Low, prolonged sound
Human Interaction	Touched	Being stroked, poked, or touched by a person, but not displaced
	Displaced	Being physically displaced (picked up, pushed, etc.) by a person.

III. “weed mix” - several species present. Included in the weed group.





IV. Unknown B. Included in the other group.



V. Unknown C. Included in the other group.



VI. Short grass Species. Included in the weeds and grasses group.



VII. White flower specimen. Included in the flowers group.





VI. Purple flower specimen. Included in the flowers group.



VII. Tall grass specimen. Included in the weeds and grasses group.

