Intrabasin Floral Differences in the Sonoran Desert; a case study from the Casa Grande Valley

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ABSTRACT

Background: The purpose of this study was to determine what floral differences exist in North Mountain Park and Casa Grande Mountain Park which are both located on opposite sides of the Casa Grande Valley, Pinal County, Arizona and to attempt to explain any measured differences. Previous authors have proposed several explanations for floral variation within the Sonoran Desert including elevation, soil pH, and mineral content. This study explicitly tests several of these proposed mechanisms for determining community composition.

Methods: The floral composition was measured in both North Mountain Park and Casa Grande Mountain Park through a series of transects which were sampled by multiple times in 2012 and 2013. Elevation data soil pH were also sampled.

Results: The data recovered from North Mountain Park differed from the expected values in Casa Grande Mountain Park by 22%. This indicates a significant difference in the flora between these two localities that was not predicted by earlier studies. Elevation and soil pH differences between sampled localities were not significant. This suggests that mineral composition of the soil may play an important role within this basin in determining community composition.

Discussion: Many factors that have been proposed in prior studies do not appear to play a significant role within the Casa Grande Valley in determining community composition. This indicates that the composition of a community is influenced by different factors in different locations within the Sonoran Desert. This makes determining overall controlling factors across an ecosystem difficult.

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INTRODUCTION

The City of Casa Grande, in central Pinal County, Arizona owns and manages two parks which preserve mountain environments in a semi-pristine state; Casa Grande Mountain Park (CGMP) and North Mountain Park (NMP) (Figure 1). CGMP borders private lands on the north, east, and the south. The Bureau of Land Management administers some lands on the southern border of the park while the Department of Defense owns and manages lands on the west side of the Casa Grande Mountains, including lands that border CGMP. CGMP preserves a total of 1,114 acres of Sonoran Desert habitat while NMP borders the Gila River Indian Community (GRIC) on the north and the east, Arizona State Trust Land (STL) on the west and privately-held properties on the south and protects 321 acres of desert land. The two locations are situated on opposite sides of the Casa Grande Valley. There are different trails within the parks; the trails are currently used for activities such as hiking or mountain biking (City of Casa Grande).

Previous surveys conducted at CGMP by one of the authors (RG) (Zheng et al., 2013; Minjares et al., in review) have shown a diverse community with typical Sonoran Desert floral components. An informal survey by one author (RG) in 2012 at NMP noted apparent differences between the two locations. We hypothesized that two different floral communities may exist within this single basin. The current experiment was designed and conducted by the authors to compare the floral community composition of CGMP to NMP, quantify the intra basin difference, and attempt to explain the origin of the different communities.

According to Medeiros and Drezner (2010) *Carnegiea gigantea* and other plants such as *Larrea tridentata, Ambrosia dumosa, Parkinsonia microphylla* (*Cercidium microphyllum* of Medeiros and Drezner), *Ambrosia dumosa, Prosopis spp.* and *Olneya tesota* occur in a relationship influenced by soil, pH and rainfall. The composition of desert floral communities is impressed by their physical environment; however, it may also be influenced by soil structure and nutrient availability.

MATERIALS AND METHODS

The authors used standard transect sampling methodology to determine the floral composition of NMP. Each transect was transited by four of the authors, (GG, SG, XR, BC), standing ~three meters apart (varying with ground conditions), with orientation provided by the corresponding author (RG). In order to determine which areas of the park were to be studied the authors selected three representative points from commercially available overhead

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imagery (Google Maps). The transects were surveyed from November 12 to November 26, 2013. Data collected by previous surveys (Zheng et al. 2013) were field-checked by the authors on November 27th, 2013 at CGMP.

Environmental data such as temperature and weather were gathered on arrival at the transects sites by the authors, using a Casio Commando phone ($Casio_a$, Japan), running the Android operating system (Google). Temperature was recorded using the application G'Zone Thermometer ($Casio_b$, Japan). GIS data, such as latitude, longitude and elevation, were collected using the application Backcountry Navigator Pro (CritterMap Software), before beginning the transits. One author (RG) was responsible for soil pH which was measured with a commercially available SoilMaster moisture, light, and pH meter (Mosser Lee Co., Millston, WI) using factory instructions (data output on the analog dial was estimated to the nearest tenth).

The data were recorded by the authors on the plants at NMP that were at least 30 centimeters in height, (excluding woody plants with heights at maturity less than this threshold). This metric was applied to ensure only permanent established members of the Parks' respective communities were sampled. This metric allowed consistent comparison to Zheng et al. (2013) who used the same metric.

Statistical analyses were performed in the program Excel (Microsoft) and the web application GraphPad (GraphPad Software). Zheng et al. employed more observers (n=10) than the current study (n=4). All values reported by Zheng et al. (2013) were reduced to 40% of their original level to account for reduced observers. This is indicated in all tables where both original values and expected (40%) values are reported for Zheng et al. (2013).

RESULTS

The most common plant in Transect One was *Larrea tridentata* (n_t=2048, n_a=682.67), followed by *Ambrosia deltoidea* (n_t=356, n_a=118.67) (Table 1). The same was true in Transect Two: *L. tridentata* dominated (n_t=1762, n_a=587.3), with *A.deltoidea* being the second most common (n_t=543, n_a=181) (Table 2). Transect Three showed the same pattern. The highest total count of *Larrea tridentata* (n=5646, n=1882) occurred in Transect Three, along with the greatest number of *A.deltoidea* (n_t=969, n_a=289.25) (Table 3). A summary of all taxa sampled at NMP is displayed in Table 4 alongside previous data from Zheng et al. (2013).

The pH of soils within the study areas were sampled by one of the authors (RG). Sample localities at CGMP yielded an average pH of 6.91 while NMP yielded an average soil pH of 6.8.

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ANALYSIS

In order to confirm the data gathered in earlier studies (Zheng et al. 2013) the authors performed a sample transit of one transect sampled previously by Zheng et al. Species level identification was problematic in several taxa in the earlier study so several taxa were assessed at the genus level. This included the two species of Barrel Cactus identified; *Ferocactus wislizeni* and *F. cylindraceus*. These were simplified as *F. spp.* for the analysis. As both studies occasionally had difficulties correctly differentiating between *C. bigelovii* and *C. fulgida* they were combined into a single OTU. Observers were able to differentiate between cholla with short, numerous, thin light spines and easily detached pads and those cholla with sparse needles and elongate, firmly attached pads. *C. acanthocarpa* remains a separate OTU in this analysis (Table 2) since the confidence in identification of this taxon is higher.

A comparison of the expected and actual values at the CGMP transect from Zheng et al. (2013) shows less than 2% deviation between the two. This reproducibility of the data from Zheng et al. (2013) allows us to have confidence in the genus-level taxonomy reported, the numbers reported, and the methodology employed by both the Zheng et al. survey and the current study.

The authors performed a Chi-squared test on the distribution of taxa between NMP and CGMP with CGMP data as expected values and NMP values as observed data. Taxa not recorded at CGMP were excluded from the analysis. The Chi-squared test produced a value of 106.970 with 16 degrees of freedom. This results in a P value of <0.0001. This indicates that the difference in the floral communities found within the Casa Grande Valley is statistically very significant.

Medieros and Drezner (2010) found pH to vary significantly across the range of several Sonoran Desert taxa that we also sampled. To test the hypothesis that pH was controlling distribution of the taxa soil pH was sampled at two localities at CGMP and two localities at NMP. We performed a Grubb's test to determine if the range of values recorded were significantly different. The test shows that all values fall within the same statistical range and any deviation is not significant (mean=6.9, SD=0.60, Z=2.4).

DISCUSSION

We intially hypothesized that a community composition difference between the Casa Grande Mountain Park and North Mountain Park existed but was not statistically or biologically significant. Our data do not support

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this hypothesis; instead the data revealed a significant difference in the flora of North Mountain Park when compared to the Casa Grande Mountains. The sampled data differ from the Zheng et al. (2013) data by 22%.

There were significant differences between our expected and actual values recovered in the data. *Larrea tridentata* had the most prominent difference; it was expected to compose 32.85% of the population. The actual percentage was 77.05% (Figures 2, 3). *Carnegiea gigantea* had an expected value of 3.03% and an actual value of 0.23%. *Ambrosia sp.* had the third greatest difference in the data with an expected value of 26.62% and an actual value of 15.70%. Additional surveys could refine these figures by using additional observers and sampling additional transects. Mechanically enforced spacing between observers may yield increased accuracy per transit but is unlikely to influence transect averages presented above.

According to Medeiros and Drezner (2010) the presence of *Larrea tridentata* is significant because it reflects a tolerance to climate and soil-related stress. They also found that soil calcium and pH was significantly related to *Ambrosia* in the Sonoran Desert. Soil pH values found at CGMP and NMP were within normal variation and not significant. This indicates that pH is not a controlling factor in the observed distribution of taxa. As soil calcium was not measured it cannot be assessed. It is notable, however, that granite does not contain calcium while some types of phyllite do, and phyllite is the main component of the Casa Grande Mountains while the Sacaton Mountains are granitic (Arizona Geological Survey, 2014). Geochemical sampling, which the authors were unable to perform, may help answer this question.

Stromberg (2007) noted that water and elevation may play a role in the distribution of taxa in the Sonoran Desert. Soil moisture was not measured in this study, but considering that both localities are within the same basin at the same altitude, it is unlikely that either rainfall or elevation are significantly different between CGMP and NMP. At this time the only hypothesis suggested in prior literature that explains the intrabasin floral difference as documented by this study is that of Medeiros and Drezner (2010) dealing with calcium in the soil.

Hamerlynck, McAuliffe, and Smith (2000), mentions that *A. dumosa* is constantly in competition with *Larrea tridentata* for water. Under drought conditions *L. tridentata* is able to acquire more water, especially in sandy soils. In wetter conditions *A. dumosa* is able to competitively exclude *L. tridentata*. A significant difference between the abundance of these two taxa was noted in sampling and can likely be attributed in part to *L. tridentata* affinity to sandy soil horizons as the granitic Sacaton Mountains weather to produce sandy soils.

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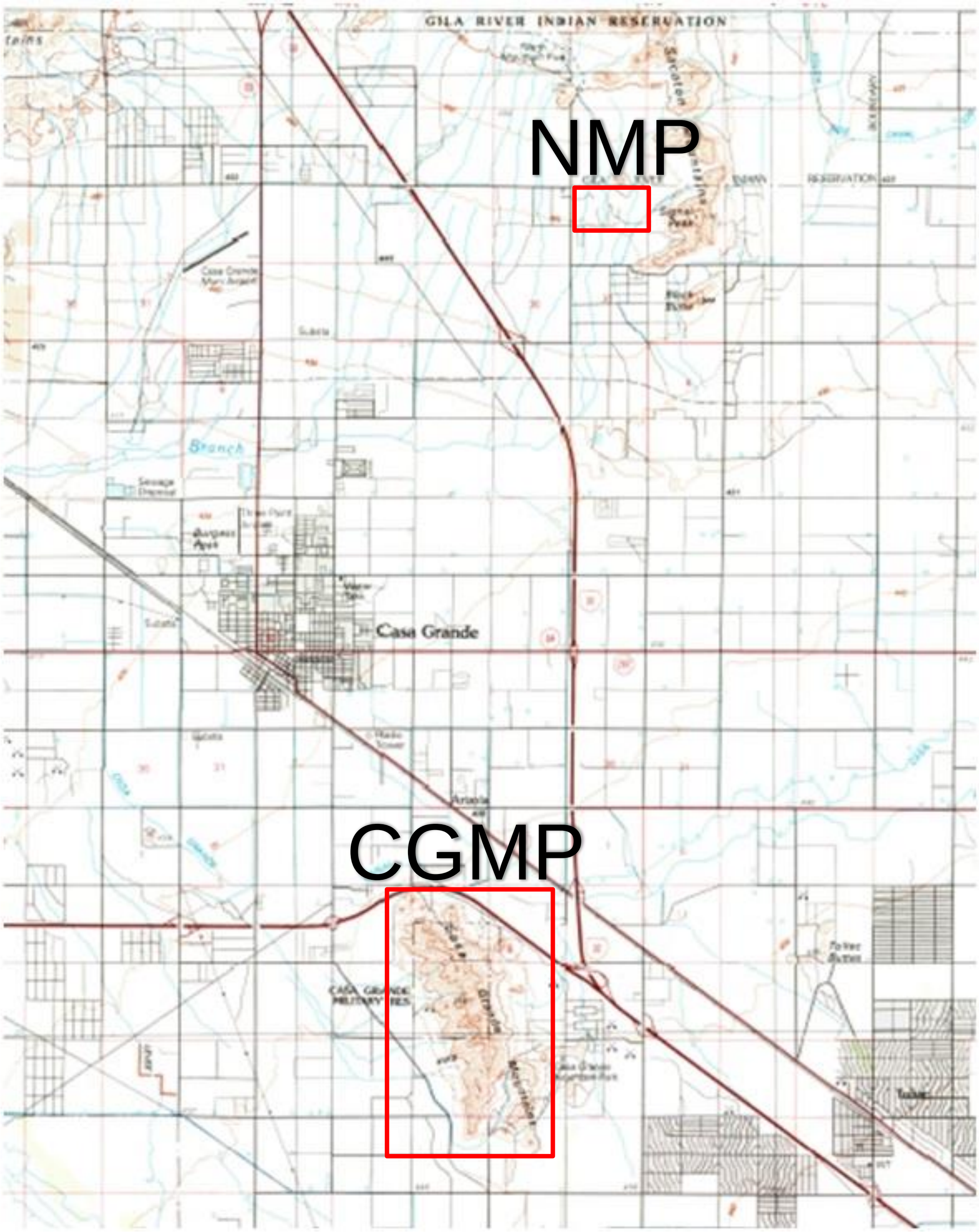

Figure 1. Casa Grande Mountain Park (longitude: -111.7179903; latitude: 32.83279) and North Mountain Park (longitude: -112.07237; latitude: 33.058532). Map Source: USGS Casa Grande 30' Topographic Map.

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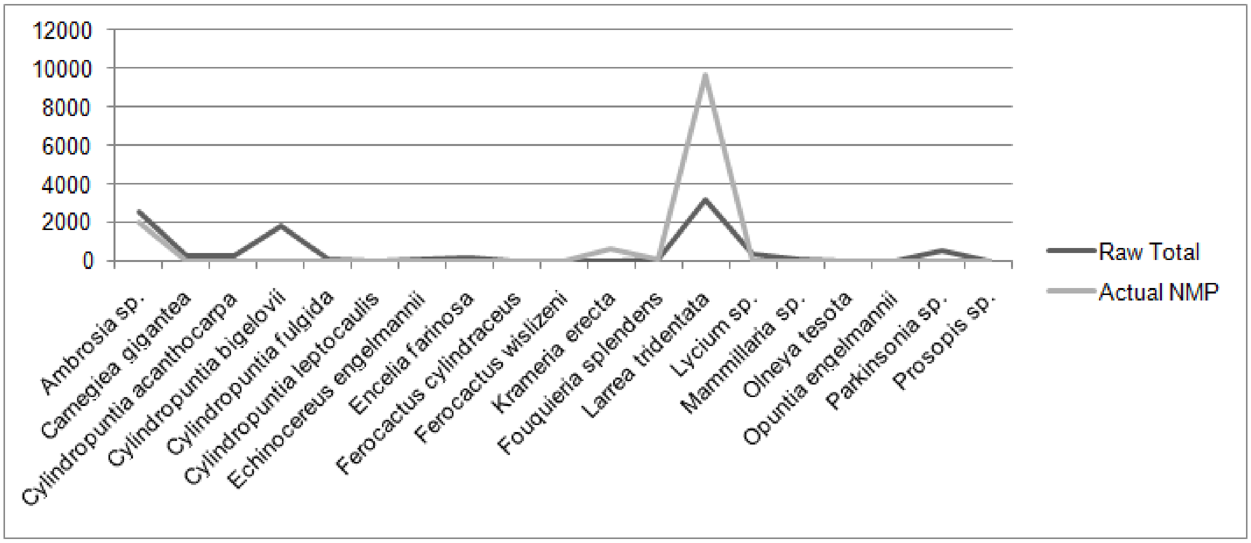

Figure 2. Total number per taxon recorded at North Mountain Park and Casa Grande Mountain Park. Values for CGMP from Zheng et al. (2013).

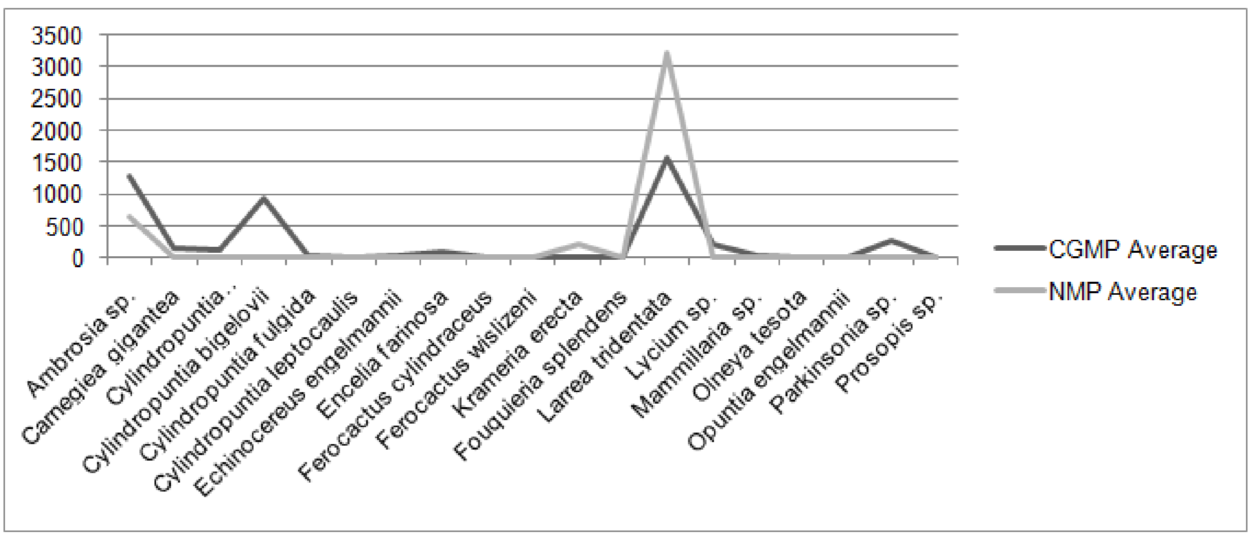

Figure 3. Average number of taxa recorded at North Mountain Park vs. Expected percentage of taxa based on Zheng et al. (2013) sampling at Casa Grande Mountain Park.

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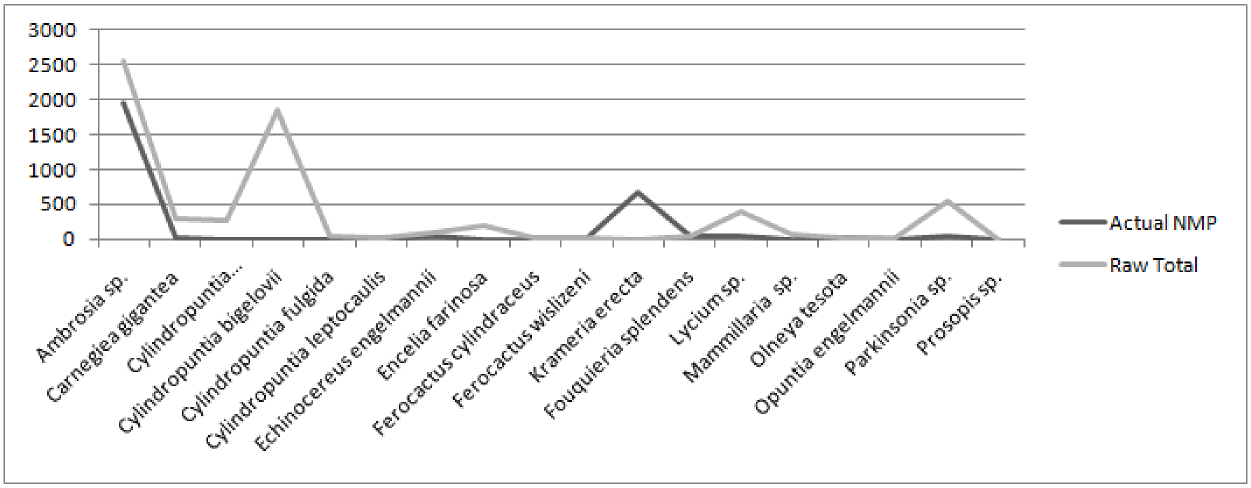

Figure 4. Total number per taxon recorded at North Mountain Park and Casa Grande Mountain Park excluding *Larrea tridentata*. The differences between NMP and CGMP become more obvious when *L. tridentata* is excluded.

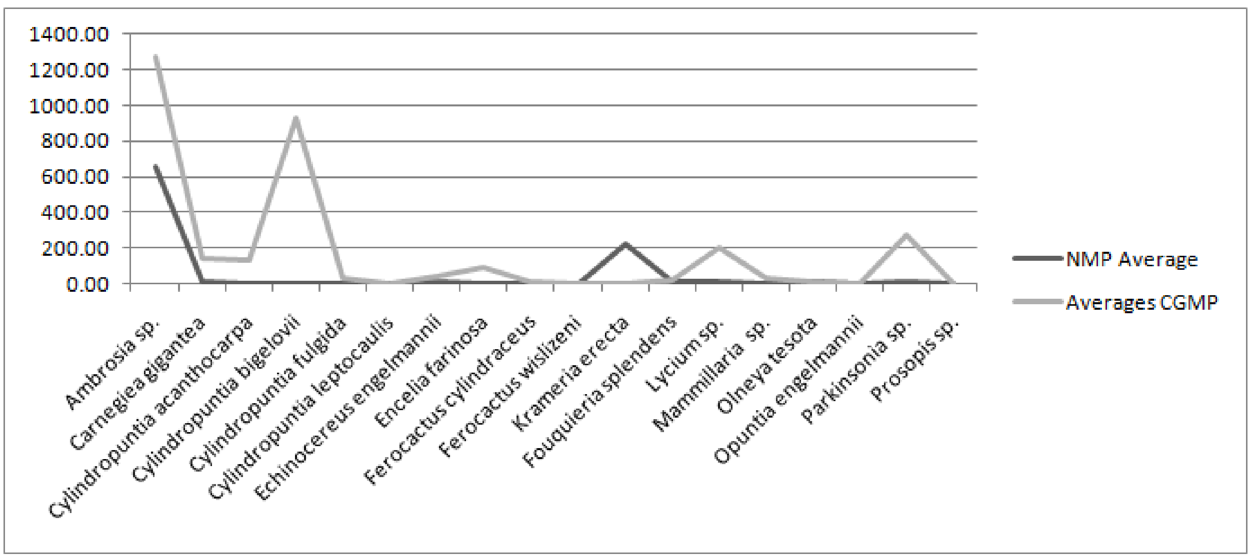

Figure 5. Average number per taxon recorded at North Mountain Park and Casa Grande Mountain Park excluding *Larrea tridentata*. The differences between NMP and CGMP become more obvious when *L. tridentata* is excluded.

Taxon	**Total**	**Average for Transect**
Ambrosia deltoidea	356	118.67
Ambrosia dumosa	10	33.3
Carnegia gigantea	2	0.67
Cylindropuntia acanthocarpa	3	1
Echinocereus englemannii	37	12.33
Ferocactus cylindraceus	2	0.67
Ferocactus wislizeni	10	3.33

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Krameria erecta	88	29.33
Larrea tridentata	2048	682.67
Opuntia leptocaulis	1	0.33
Parkinsonia microphylla	5	1.67

Table 1. Transect 1, North Mountain Park, Pinal County, Arizona. Raw data over three transits and average values for Transect 1.

Taxon	Total	Average for Transect
Ambrosia deltoidea	543	181
Carnegiea gigantea	13	4.33
Encelia farinosa	2	0.66
Fouquieria splendens	3	1
Larrea tridentata	1762	587.33
Lycium palidum	18	6
Mammalaira grahamii	1	0.33
Olneya tesota	11	3.66
Parkinsonia microphylla	13	4.33

Table 2. Transect 2, North Mountain Park, Pinal County, Arizona. Raw data over three transits and average values for Transect 2.

Taxon	Total	Average for Transect
Ambrosia deltoidea	969	323
Ambrosia dumosa	86	28.66
Carnegiea gigantea	14	4.66
Ferocactus wislizeni	4	1.33
Fouquieria splendens	41	13.66
Krameria erecta	659	219.66
Larrea tridentata	5646	1882
Lycium palidum	15	5
Olneya tesota	14	4.66
Parkinsonia microphylla	17	5.66
Prosopis sp.	1	0.33
Phoradendron macrophyllum	4	1.33

Table 3. Transect 3, North Mountain Park, Pinal County, Arizona. Raw data over three transits and average values for Transect 3.

Name of Taxon	Raw Total	Averages	Expected (Raw Numerical)	Expected % Pop.	Actual %	Expected Average	NMP Average	Actual NMP
Ambrosia sp.	2550	1275	1020	10.65%	15.70%	510	654.67	1964
Carnegiea gigantea	290	145	116	1.21%	0.23 %	58	9.67	29
Cylindropuntia acanthocarpa	264	132	105.6	1.10%	0.02 %	52.8	1.00	3

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Cylindropuntia bigelovii	1849	924.5	739.6	7.72%	0.00%	369.8	0.00	0
Cylindropuntia fulgida	53	26.5	21.2	0.22%	0.00%	10.6	0.00	0
Cylindropuntia leptocaulis	7	3.5	2.8	0.03%	0.00%	1.4	0.00	0
Echinocereus engelmannii	86	43	34.4	0.36%	0.30%	17.2	12.33	37
Encelia farinosa	186	93	74.4	0.78%	0.02%	37.2	0.67	2
Ferocactus cylindraceus	27	13.5	10.8	0.11%	0.02%	5.4	0.67	2
Ferocactus wislizeni	6	3	2.4	0.03%	0.11%	1.2	4.67	14
Krameria erecta	0	0	0	0.00%	5.41%	0	225.67	677
Fouquieria splendens	46	23	18.4	0.19%	0.35%	9.2	14.67	44
Larrea tridentata	3146	1573	1258.4	13.14%	77.05%	629.2	3213.33	9640
Lycium sp.	405	202.5	162	1.69%	0.26%	81	11.00	33
Mammillaria sp.	65	32.5	26	0.27%	0.01%	13	0.33	1
Olneya tesota	28	14	11.2	0.12%	0.20%	5.6	8.33	25
Opuntia engelmannii	5	2.5	2	0.02%	0.00%	1	0.00	0
Parkinsonia sp.	546	273	218.4	2.28%	0.28%	109.2	11.67	35
Prosopis sp.	0	0	0	0.00%	0.01%	0	0.33	1

Table 4. Data for all transects, NMP and expected values of CGMP, Pinal County, Arizona. Values for CGMP from Zheng et al. 2013.

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