

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

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10 ABSTRACT

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

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

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

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

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) (fig.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. As shown on the map (fig.1), 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. It was hypothesized that there may be a different Sonoran Desert communities within this single basin. The experiment was designed and conducted 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* present a relationship influenced by soil, pH and rainfall caused by the high temperatures and the low precipitation. The presence of desert plants is impressed by their physical environment; however, it may also be influenced by soil structure and nutrient availability.

MATERIALS AND METHODS

This experiment was designed to find the differences, if any, that existed between NMP and CGMP, relating to the plant life that live at NMP. The project began by initiating the use of three transects to record the vegetation that lives at NMP. The transects would consist of three transits that were to be tested by the four authors, (GG, SG, XR, BC), standing ~three metres apart, with orientation provided by a corresponding author, (RG).

1 Environmental data, such as temperature and weather, were gathered on arrival at the transects sites, using
2 a Casio Commando phone (Casio_a, Japan), running the Android operating system (Google). Temperature was
3 recorded using the application G'Zone Thermometer (Casio_b). GPS data, such as latitude, longitude and elevation,
4 were collected using the application Backcountry Navigator Pro (CrittterMap Software), before beginning the
5 transits. Soil pH was measured using a commercially available SoilMaster moisture, light, and pH meter (Mosser
6 Lee Co., Millston, WI) using factory instructions. Data output on the analog dial was estimated to the nearest tenth.

7 The plant data was recorded by the authors on the plants at NMP that were at least 30 centimeters in height,
8 (excluding woody plants with heights at maturity less than this threshold). This metric was applied to ensure only
9 permanent established members of the Parks' respective communities were sampled.

10 To know what areas of the park that were to be studied, the authors selected three representative points
11 from commercially available overhead imagery (Google Maps). The transects were conducted from November 12 to
12 November 26, 2013. Data collected by previous surveys (Zheng et al. 2013) were field-checked on November 27th,
13 2013, at CGMP.

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

18 RESULTS

19 The following data was collected in Transect One which was sampled multiple times: *Larrea tridentata*
20 (n=2048), *Ambrosia deltoidea* (n=356), *Krameria erecta* (n=88), *Echinocereus engelmannii* (n=37), *Ferocactus*
21 *wislizeni* (n=10), *Ambrosia dumosa* (n=10), *P. microphylla* (n=5), *Cylindropuntia acanthocarpa* (n=3), *Ferocactus*
22 *cylindraceus* (n=2), *Carnegiea gigantea* (n=2), and *Opuntia leptocaulis* (n=1). The per-transit average counts for
23 Transect One are: *Larrea tridentata*: 682.67, *A. deltoidea*: 118.67, *Krameria erecta*: 29.3, *Echinocereus*
24 *engelmannii*: 12.3, *Ferocactus wislizeni*: 3.3, *A.dumosa*: 3.3, *P. microphylla*: 1.67, *Cylindropuntia acanthocarpa*: 1,
25 *Ferocactus cylindraceus*: 0.67, *C. gigantea*: 0.67, *Opuntia leptocaulis*: 0.3.

26 Transect Two: *Larrea tridentata* (n=1762), *A.deltoidea* (n=543), *Lycium pallidum* (n=18), *C. gigantea*
27 (n=13), *P. microphylla* (n=13), *Olneya tesota* (n=11), *Fouquieria splendens* (n=3), *Encelia farinosa* (n=2), *M.*
28

1 *grahamii* (n=1). The per-transit average counts for Transect Two are: *Larrea tridentata*: 587.3, *A.deltoidea*: 181,
2 *Lycium pallidum*: 6, *C. gigantea*: 4.3, *P. microphylla*: 4.3, *Olneya tesota*: 3.67, *Fouquieria splendens*: 1, *Encelia*
3 *farinosa*: 0.67, *M. grahamii*: 0.3. The average total of plants recorded on this transect is 782.67.

4 Transect Three: *Larrea tridentata* (n=5646), *A.deltoidea* (n=969), *Krameria erecta* (n=659), *A.dumosa*
5 (n=86), *Fouquieria splendens* (n=41), *P. microphylla* (n=17), *L. pallidum* (n=15), *C. gigantea* (n=14), *Olneya tesota*
6 (n=14), *Phoradendron macrophyllum* (n=4), *Ferocactus wislizeni* (n=4), *Prosopis sp.* (n=1). The per-transit average
7 counts for Transect Three are: *Larrea tridentata*: 16668.5, *A. deltoidea*: 289.25, *Krameria erecta*: 164.75, *A.*
8 *dumosa*: 39.75, *Fouquieria splendens*:12.5, *P. microphylla*: 6, *L. pallidum*: 29.25, *C. gigantea*: 4.5, *Olneya tesota*:
9 3.5, *Phoradendron macrophyllum*: 1, *Ferocactus wislizeni*: 1.25, *Prosopis sp.*: 0.25. The average total of plants
10 recorded for this transect is 2202.5. (fig.4, 5)

11 The pH of soils within the study areas were measured. Sample localities at CGMP yielded an average pH of
12 6.91 while NMP yielded an average soil pH of 6.8.

14 ANALYSIS

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

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

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

5 pH values were shown to be significantly different across the range of several Sonoran Desert taxa sampled
6 in this study by Medeiros and Drezner (2010). To test the hypothesis that pH was controlling distribution of the taxa
7 found soil pH was sampled at two localities at CGMP and two localities at NMP (Table 3). A Grubb's test was
8 performed to determine if the range of values recorded were significantly different. The test shows that all values
9 fall within the same statistical range and any deviation is not significant (mean=6.9, SD=0.60, Z=2.4).

11 DISCUSSION

12 It was hypothesized that a community composition difference between the Casa Grande Mountain Park
13 and North Mountain Park existed but was not statistically or biologically significant. The experiment was performed
14 through a series of transects, which were sampled by observers multiple times. The data collected did not correlate
15 with the hypothesis, and revealed a significant difference in the flora of North Mountain Park when compared to the
16 Casa Grande Mountains. The expected values differed by 22% which contradicts our stated hypothesis.

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

24 According to Medeiros and Drezner (2010) the presence of *Larrea tridentata* is significant because it
25 reflects a tolerance to climate and soil-related stress. They also found that soil calcium and pH was significantly
26 related to *Ambrosia* in the Sonoran Desert. Soil pH was tested at NMP and CGMP to test this hypothesis. Values
27 found were within normal variation and not significant. This indicates that pH is not a controlling factor in the
28 distribution of taxa observed. As soil calcium was not measured it cannot be assessed. It is notable, however, that

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

7 Hamerlynck, McAuliffe, and Smith (2000), mentions that *A. dumosa* is constantly in competition with
8 *Larrea tridentata* for water. Under drought conditions *L. tridentata* is able to acquire more water, especially in
9 sandy soils. In wetter conditions *A. dumosa* is able to competitively exclude *L. tridentata*. A significant difference
10 between the abundance of these two taxa was noted in sampling and can likely be attributed in part to *L. tridentata*
11 affinity to sandy soil horizons. Further testing within the Casa Grande Valley may shed light on whether soil
12 calcium is playing the role predicted or if another factor or combination of factors is limiting the distribution of
13 characteristic Sonoran Desert plants. The soil at NMP was definitely more sandy than the soil that was sampled at
14 CGMP, while the soil at CGMP is not sandy. Any invasive sampling was not aloud, so it was not able to be
15 determined beyond visual surface composition.

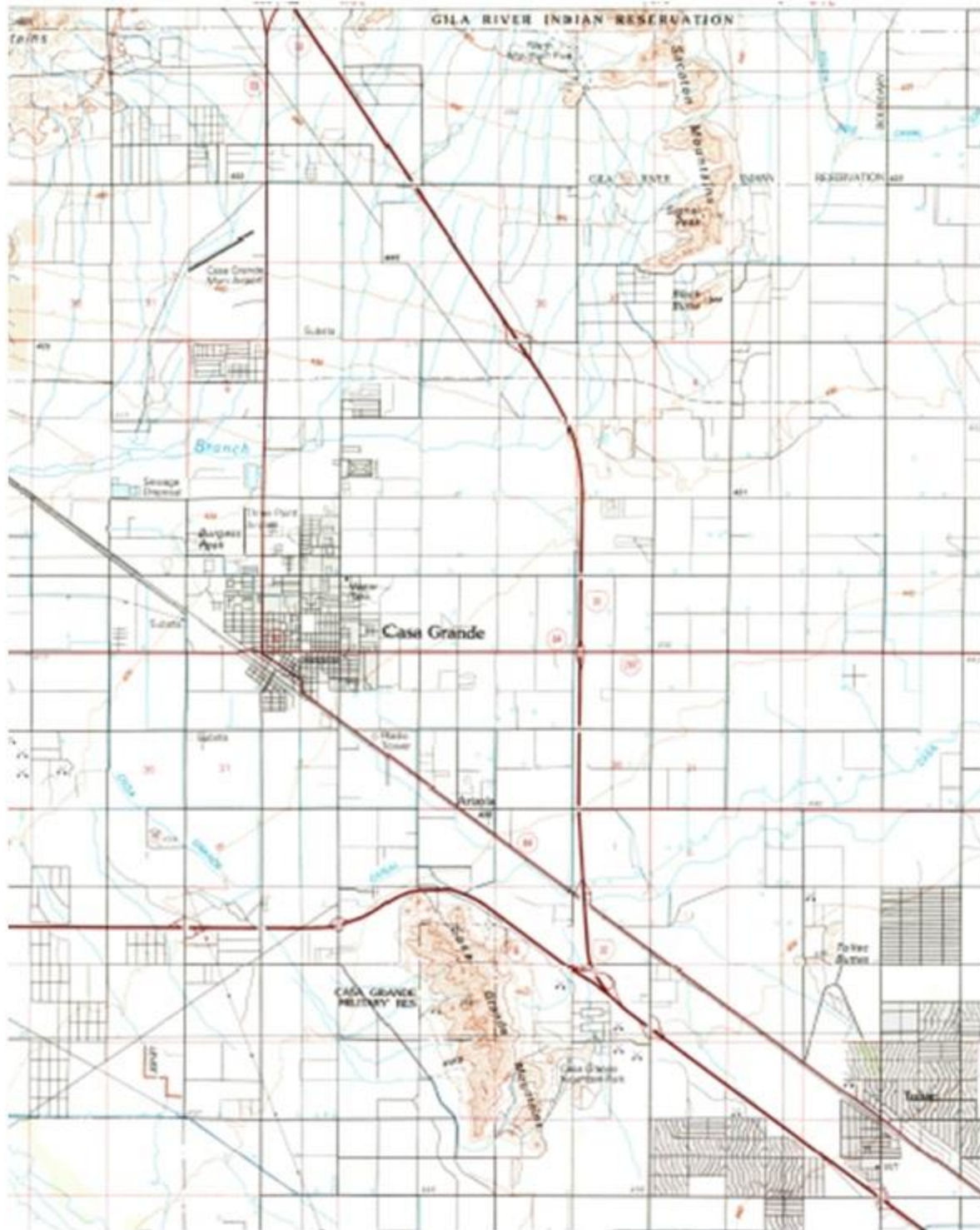
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20 the direction of this study.

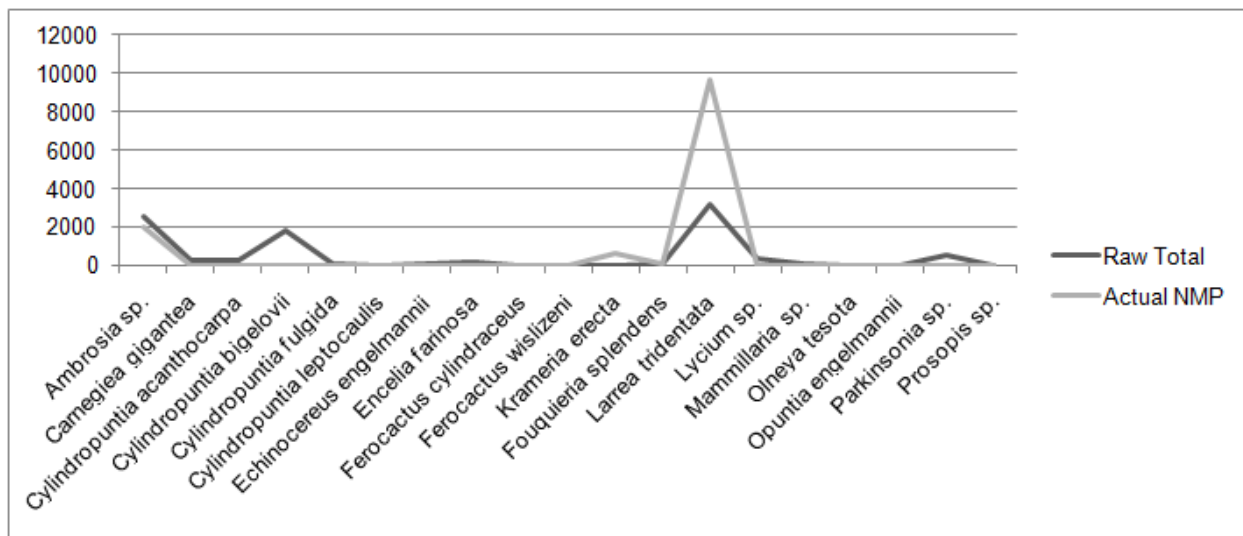
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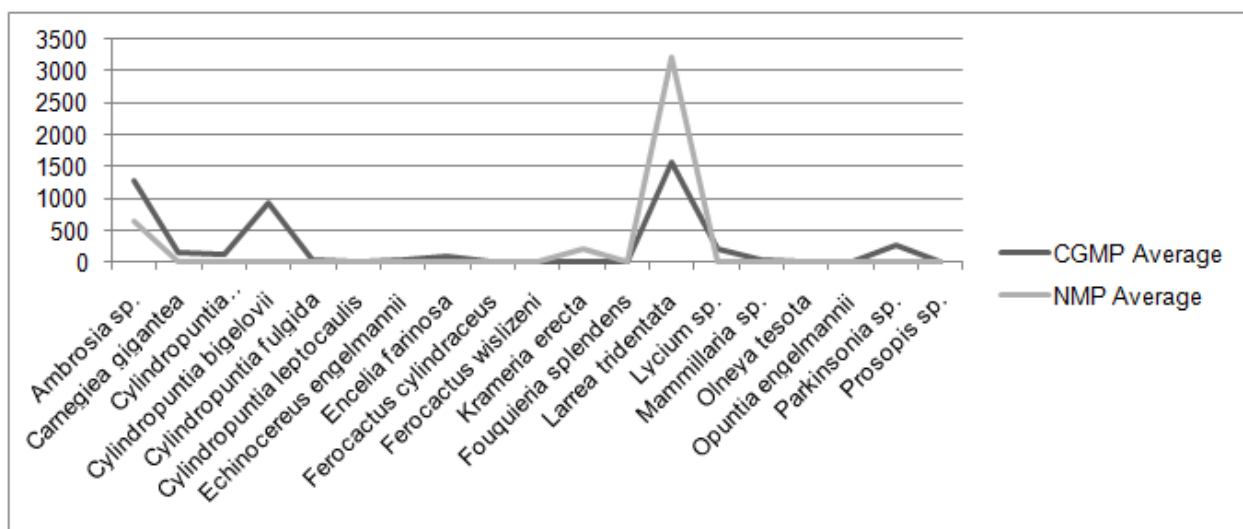
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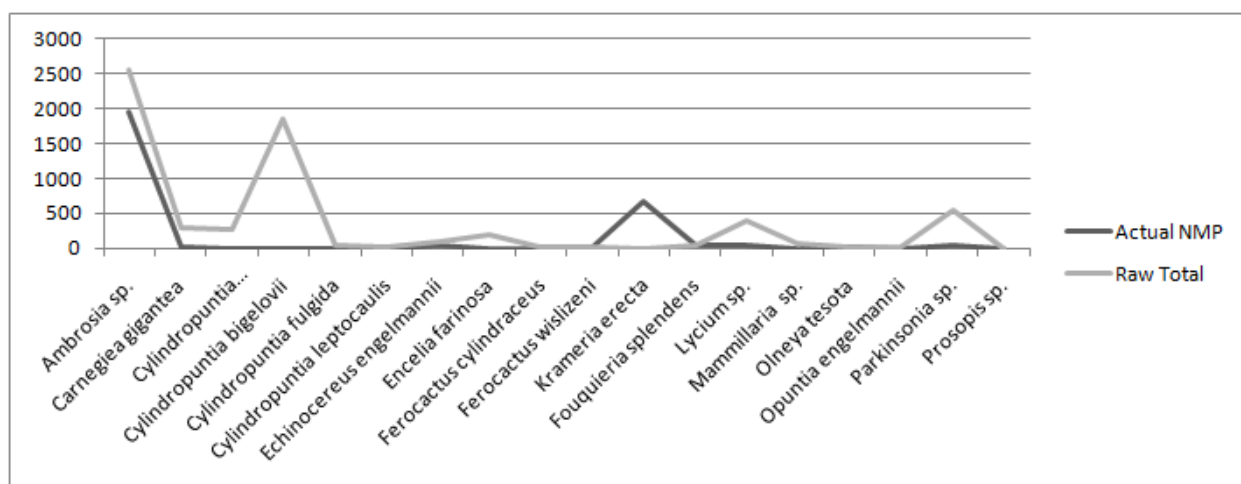
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2 Figure 1. Casa Grande Mountain Park (A; longitude: -111.7179903; latitude: 32.83279) and North Mountain Park
3 (B; longitude: -112.07237; latitude: 33.058532). Map Source: USGS Casa Grande 30' Topographic Map.
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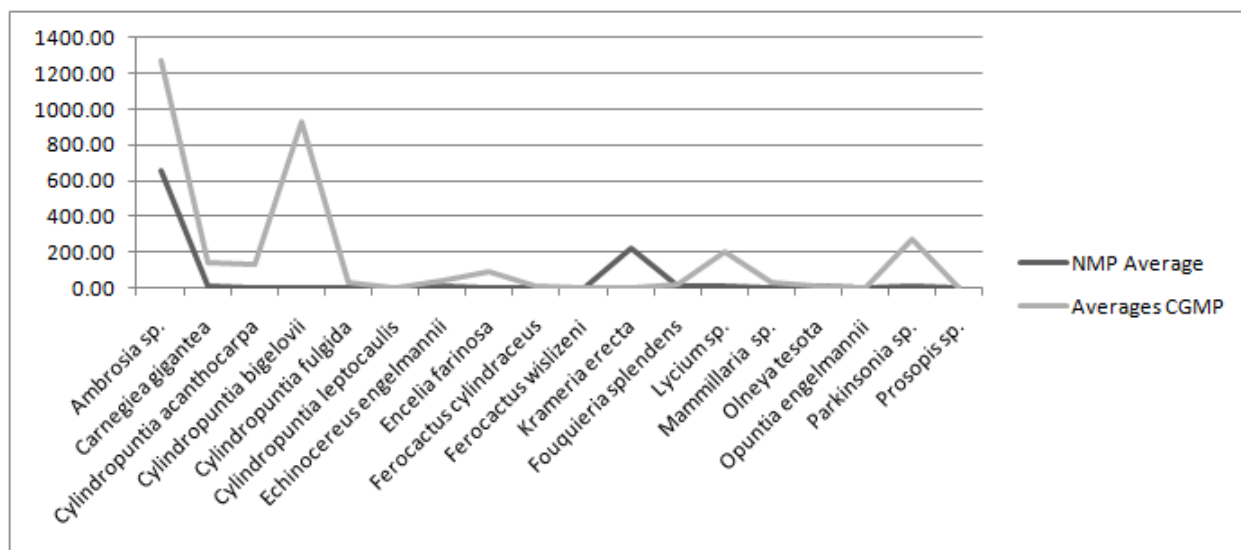
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2 Figure 2. Total number per taxon recorded at North Mountain Park and Casa Grande Mountain Park. Values for
3 CGMP from Zheng et al. (2013).



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



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



4
5 Figure 5. Average number per taxon recorded at North Mountain Park and Casa Grande Mountain Park excluding
6 *Larrea tridentata*. The differences between NMP and CGMP become more obvious when *L. tridentata* is excluded.

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Taxon	Raw Count	Average for Transect
<i>Ambrosia deltoidea</i>	356	118.67
<i>Ambrosia dumosa</i>	10	33.3
<i>Carnegiea gigantea</i>	2	0.67
<i>Cylindropuntia acanthocarpa</i>	3	1
<i>Echinocereus englemannii</i>	37	12.33
<i>Ferocactus cylindraceus</i>	2	0.67
<i>Ferocactus wislizeni</i>	10	3.33

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

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

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

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

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

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

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

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

1 Table 4. Data for all transects, NMP and expected values of CGMP, Pinal County, Arizona. Values for CGMP from

2 Zheng et al. 2013.