AGAVE SURVEY
OF THE ROSEMONT HOLDINGS AND VICINITY

Prepared for: Rosemont Copper Company
Prepared by: WestLand Resources, Inc.
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WestLand Resources, Inc.
Engineering and Environmental Consultants
4001 E. Paradise Falls Drive
Tucson, Arizona 85712
Ph: (520) 206-9585  Fx: (520) 206-9518

TO: Ms. Bev Everson
United States Dept of Agriculture
Forest Service
300 W. Congress, 6th Floor
Tucson, Arizona 85701

FROM: Brian Lindenlaub

RE: Rosemont Holdings and Vicinity

ATTACHMENTS:

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<td>Lesser Long-Nosed Bat Survey</td>
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cc: Kathy Arnold, Rosemont
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Appendix A. Photos
1. INTRODUCTION

1.1. BACKGROUND

Rosemont Copper Company (Rosemont) proposes to develop an open-pit copper mine, with associated processing facilities and waste disposal sites, on portions of the Rosemont holdings, which encompass patented and unpatented claims and fee lands within privately owned, USDA Forest Service, and Bureau of Land Management lands on the northeast side of the Santa Rita Mountains (Figure 1). Rosemont retained WestLand Resources, Inc. (WestLand) to conduct a variety of biological studies on the Property to gain an understanding of the baseline biological condition of the Property and its potential to support special status species, such as the federally listed lesser long-nosed bat (*Leptonycteris yerbabuenae*).

The Palmer’s agave has been identified as the primary foraging plant for the nectar-feeding lesser long-nosed bat in southeastern Arizona during the summer and early fall (Ober and Steidl 2004; Hayward and Cockrum 1971; Hevly 1979). WestLand conducted various surveys on the Property and regionally to determine the number of agaves that might be impacted by the proposed activities at Rosemont and try to gain an understanding of the importance of the agaves on the Rosemont Property as a foraging resource for the lesser long-nosed bat.

This report summarizes the results of these surveys and is presented in six sections:

*Section 1 (Introduction)* briefly describes the Rosemont Project; describes the habitat requirements, geographic distribution, and relevance of the Rosemont Property to the Palmer’s agave; and identifies the significance of the Palmer’s agave as a foraging species for the endangered lesser long-nosed bat.

*Section 2 (Survey Methods)* describes the methods that were used for Palmer’s agave surveys conducted as part of this effort.

*Section 3 (Results)* describes the results of the agave surveys conducted as part of this effort.

*Section 4 (Discussion)* provides a discussion of the survey results including a discussion of the importance of Palmer’s agave in the Rosemont vicinity to the lesser long-nosed bat.

*Section 5 (Summary and Conclusions)* summarizes WestLand’s findings and discusses the conclusions that were formed during analysis of the survey results.

*Section 6 (References)* provides a list of references that were used for this work.
ROSEMONT PROJECT
Agave Survey
Vicinity Map
Figure 1

ARIZONA

SOUTHEAST PIMA COUNTY

Approximate Scale 1 Inch = 10 Miles

PROJECT LOCATION

Rosemont Holdings
1.2. ROSEMONT PROJECT

The Rosemont Project (the Project) is an open pit copper mining project proposed by Rosemont. The Project is principally a copper mining project, however drilling and metallurgical testing indicate that recoverable quantities of molybdenum and silver are also resident in the deposit. Rosemont has confirmed or identified approximately 600 million tons (MT) of ore and an active mining life of about 19 years. The active mining period will be preceded by a two-year construction period and will be followed by three years of post-closure activities. The total area of disturbance that will result from development of the Project is estimated to be 4,415 ac, with approximately 978 ac on private land, 3,354 on federal lands managed by the Coronado National Forest (CNF), and 82 ac on State Trust Lands.

1.3. HABITAT REQUIREMENTS AND GEOGRAPHIC DISTRIBUTION

Palmer’s agave (*Agave palmeri*) (Appendix A, Photo 1) is a widespread species, with populations in the states of Arizona and New Mexico in the United States, and Sonora and Chihuahua in Mexico (Turner et al. 1995).

Within Arizona, this agave has been reported from Graham, Gila, Pima, Santa Cruz, and Cochise counties, at elevations between 3,500 and 7,500 feet (Kearney and Peebles 1960). Palmer’s agave is generally found on rocky slopes in semidesert grassland, Madrean evergreen woodland, and Madrean montane conifer forest (Turner et al. 1995). Gentry (1982) describes *A. palmeri* as “a widely scattered but characteristic plant of the oak woodland and grama grassland communities at altitudes between 3,000 and 6,000 feet.” Both Turner et al. (1995) and Gentry (1982) refer to the “clumped distribution” or the “scattered colonial nature of the *A. palmeri* distribution.”

Palmer’s agave appears to be tolerant of a wide variety of geologic substrates and soil types within its geographic and elevational limits. It is reported to be particularly abundant on limestone slopes between 4,000 and 5,000 feet in the Patagonia Mountains and on the granite formations of Texas Canyon (Gentry 1982). The Patagonia Mountains are located approximately 25 miles south, and Texas Canyon is located approximately 40 miles northeast of the Rosemont holdings.

1.4. SIGNIFICANCE OF PALMER’S AGAVE TO LESSER LONG-NOSED BAT

The Palmer’s agave has been identified as the primary foraging plant for the nectar-feeding lesser long-nosed bat (*Leptonycteris yerbabuenae*) (Appendix A, Photos 2 and 3) in southeastern Arizona during the summer and early fall (Ober and Steidl 2004; Hayward and Cockrum 1971; Hevly 1979). The lesser long-nosed bat was designated as an endangered species in 1988 and agaves were recognized as providing an important part of their diet (USFWS 1988). In addition, Gentry (1982) observed the different flowering seasons of several species of the agave group Ditepalae across the southwestern United States and Mexico and suggested that these flowering periods might provide food resources for migratory bats. Palmer’s agave is the northernmost representative of the Ditepalae group.
Although the lesser long-nosed bat is dependent on the Palmer’s agave, Palmer’s agave is not necessarily dependent on the lesser long-nosed bat. Gentry (1982) suggested that the timing of the flowering of different species of agave coincides with the migration timing of the bats. However, in a study on the timing of agave flowering in the Chiricahua and Peloncillo Mountains, Scott (2004) found that about 60 percent of the flowering of Palmer’s agaves had been completed before the arrival of significant numbers of lesser long-nosed bats. In a study on the pollination of two chiropterophilous species of agaves (agaves pollinated by bats) in Arizona, Slauson (2000) concluded that the lesser long-nosed bat is not an important pollinator of the golden-flowered agave (Agave chrysantha) because of its geographic distribution and the timing of flowering. Slauson (2000) also found that the lesser long-nosed bat is an effective pollinator for A. palmeri, but numerous other pollinators, both diurnal and nocturnal, appear to be more important than the bat.

1.5. SPECIES OF AGAVE ON THE ROSEMONT PROPERTY

The Property, located on the northeast side of the Santa Rita Mountains (Figure 1), covers an elevation range from about 4,400 to 5,800 feet. The dominant plant communities on the Property are semidesert grassland and Madrean evergreen woodland, as described by Brown (1994). These conditions are appropriate for the Palmer’s agave, as described above, and Palmer’s agave is by far the most common agave species on the Property (Appendix A, Photos 4 and 5). Schott’s agave (Agave schottii) is common on the ridges north of Scholefield Canyon, but it is rare elsewhere on the Property. A few Parry’s agaves (Agave parryi) (Appendix A, Photo 6) were observed on the Property, but they are generally more common at elevations higher than the Property.

Palmer’s agave is the only agave of significance as a nectivorous bat foraging resource on the Property. Schott’s agave is not typically used as a foraging resource by lesser long-nosed bats and this species of agave was largely absent from the proposed Rosemont impact area. Only a few rosettes of Parry’s agave were observed on the Property and no flowering stems of Parry’s agave have been found on the Property.

Unless otherwise specified, all future references to agave in this report will be referring to Palmer’s agave.

2. SURVEY METHODS

2.1. PROPOSED IMPACT AREA

Because of the large size of the Property, a detailed count of all agaves on the Property was not feasible. To obtain a reasonable, defensible estimate of the agaves that would be impacted by the proposed Rosemont Project, it was necessary to sample a random set of plots within the anticipated area of impact, including the mine area, processing facilities, waste disposal, and access road (Figure 2). The entire area of impact was divided into one hectare (ha) units, based on UTM coordinates (NAD 83) giving a total of 1,915 units. From this set of ha units, a random subset of 191 units (10 percent) was selected for sampling, using a computer
algorithm for randomization. Sampling units were located in the field with high resolution aerial imagery overlaid with the unit boundaries and corner coordinates. These photos allowed the recognition of individual trees and shrubs within a sampling unit.

Within each sampling unit, the southeast quarter (0.25 ha) was arbitrarily selected for a detailed survey. WestLand biologists surveyed the southeast quarter of 76 of the 191 selected sampling units between June 16 and September 8, 2008. Within these 0.25-ha survey plots, all living rosettes were counted and assigned to size classes. An estimate of the size class distribution of agaves is needed to evaluate the health of the population and long-term potential as a foraging resource for bats. Size classes were defined in 10 cm increments of rosette diameter, up to 150 cm. Very few individual rosettes were greater than 150 cm, and these were lumped in a single class. An implied assumption of this measurement is that size is a quantifiable parameter that is representative of age class distribution.

In addition to counting living rosettes, flowering stems on each 0.25 ha survey plot were counted. Each flowering stem was assigned to a group based on whether it flowered successfully or whether the stem was lost to herbivory prior to producing flowers. A variety of herbivores are known to consume the early stages of flowering stems of agaves, and their impacts may affect the relative importance of seeds vs. vegetative reproductive efforts. Herbivory of the flowering stem means a complete loss of sexual reproduction from that individual. Palmer’s agave can also reproduce through vegetative cloning, which would provide future opportunities for flowering and sexual reproduction. Primary herbivores in the Rosemont vicinity are believed to be cattle, deer (Odocoileus hemionus and O. virginianus), woodrats (Neotoma spp.), and collared peccary (Pecari tajacu). Any affected flowering stems were examined and the responsible herbivore was identified, if possible. The ratio between successful and unsuccessful flowering stems was determined.

To determine the total density of current successful flowering stems, all flowering stems on the entire ha unit were counted. These stems are highly visible and can be counted easily on this size plot. The larger survey unit also could provide a more accurate estimate of the total density of flowering stems across the Property.

In addition to data collected on agaves, information was recorded for each survey plot on slope, aspect, geological substrate, and the presence of drainages within the survey plot. Because of the possibility that the geological substrate might be a controlling factor in agave density or distribution, we divided the impact area into four areas based on substrate in an attempt to stratify our sampling. Unit 1 is the northeast part of the impact area and is underlain primarily by the Late Cretaceous Mount Fagan Rhyolite (Appendix A, Photo 7). This mapping unit also includes megabreccia and related sediments. Unit 2 is the north-central part of the impact area and includes the Early Cretaceous Apache Canyon Formation and Willow Canyon Formation (Appendix A, Photo 8), both in the Bisbee Group. Unit 3 is the southeast part of the impact area and is underlain by the Pliocene and Miocene Gila Conglomerate (Appendix A, Photo 9). Unit 4 is a region of complex geology on the west edge of the impact area, including a variety of Paleozoic and Mesozoic...
sediments, and more recent alluvium and landslide material (Appendix A, Photo 10). The relative areas of these units are provided in Table 1.

<table>
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<tr>
<th>Potential Stratification Unit</th>
<th>Area (ha)</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mt. Fagan Rhyolite</td>
<td>441</td>
<td>23.0</td>
</tr>
<tr>
<td>2. Willow Canyon/Apache Canyon</td>
<td>531</td>
<td>27.7</td>
</tr>
<tr>
<td>3. Gila Conglomerate</td>
<td>685</td>
<td>35.8</td>
</tr>
<tr>
<td>4. Other</td>
<td>258</td>
<td>13.5</td>
</tr>
</tbody>
</table>

2.2. REGIONAL AREA

In order to determine whether the Property is representative of the agave distribution on a regional basis, additional sampling of agaves was conducted in the northern portion of the Santa Rita Mountains. Because of the large area to be covered, the detailed plot sampling conducted in the proposed Rosemont impact area was not possible on this regional scale.

Different areas of interest were surveyed to provide an evaluation of the effects of scale on the regional analysis. The smallest scale of interest are those parts of the Property that are not expected to be impacted by the Rosemont Project. There are significant areas in the northern and eastern parts of the Property that are outside the proposed area of impact and are expected to have significant numbers of agaves. The next larger scale is the area within a five-mile radius (8 km) of the approximate center of the proposed Rosemont impact area. This distance includes the southwest part of the Empire Mountains, Mt. Fagan, Helvetia, and Box Canyon. The largest practical scale is the area within a 12-mile radius (19 km) of the approximate center of the proposed Rosemont impact area. This area encompasses almost 1,300 mi² and includes Vail, Sahuarita, Green Valley, Patagonia, Sonoita, all of the Santa Rita Mountains, Empire Cienega, and part of the Whetstone Mountains. Regional survey coverage was primarily focused on the north and east side of the Santa Rita Mountains and the Empire Cienega.

WestLand biologists surveyed the selected regional sampling points between July 21 and September 26, 2008. Agaves were counted from the numerous public access roads that are available in suitable habitat throughout the Santa Rita Mountains. At each sampling point, a biologist scanned an area for agaves, counting all visible rosettes and current year flowering stems. The following measures were taken to ensure that the sampling points were randomly located:

- At the Property scale, sampling points were at least 1.0 km apart; at the 8 km scale, sampling points were at least 2.0 km apart; and at the 32 km scale, sampling points were either 2.0 or 3.0 km apart.

- On each road segment, the distance of the initial sample point from the start of the road segment was either 0.5 or 1.0 km, determined by a coin toss.
• At each sample point, quadrants were set up using the road as one axis and a perpendicular line as the other axis. The quadrant sampled was determined by two coin tosses, to determine which side of the road and either ahead of or behind the point.

The area surveyed was carefully outlined using the map and/or aerial photo installed in a lap pad computer for determination of area. To minimize the risk of data loss from computer problems, the data were backed up on a flash drive at every point. In addition, UTM coordinates, agave numbers, quadrant sampled, and area counted were manually recorded on a data sheet for each sample point.

With the data collected during the regional agave survey, rough estimates of the agave density and the density of current year flowering stems were calculated. Because of the difficulty of seeing and counting small or medium-sized rosettes, this density estimate is considered to be a minimum count, and the actual number of agaves on the regional scale is likely much greater. Flowering stems from previous years were not counted, and there was no attempt to quantify impacts of herbivory.

3. RESULTS

3.1. PROPOSED IMPACT AREA

3.1.1. NUMBER OF AGAVES

A total of 76 random grid units were sampled during our field surveys between June 16 and September 8, 2008 (Figure 2). Agave densities on these units ranged from a minimum of 0 plants/ha to a maximum of 1,088 plants/ha, clearly reflecting the clumped nature of their distribution. The maximum observed density can be treated as a statistical outlier, as the next highest observed density was only 464 plants/ha. The mean density for all units is 140.2 plants/ha, with a standard deviation of 166.7 and a standard error of ±19.12. Excluding the maximum outlier, the mean density is 131.2 plants/ha, with a standard deviation of 126.9 and a standard error of ±14.65. These high standard deviations are to be expected with a highly clumped distribution.

The spatial distribution of agave densities can be illustrated on a map of the survey grid area showing sample units in different colors to indicate agave densities (Figure 3). The lack of any pattern on this figure is another confirmation of the clumped nature of the distribution. Another procedure to analyze the effects of clumping is to create a histogram of agave densities. Density classes can be created for groups of 50 agaves/ha, such that class 1 has 0 to 50 agaves/ha, class 2 has 51 to 100 agaves/ha, etc. Each data point is assigned to a group based on its density of agaves. The results of this grouping are shown in Figure 4, excluding the outlier (1,088 plants/ha) that would be off the chart to the right. The large numbers of densities falling into the first group indicate the numerous plots that had no or very few agaves. Relatively few plots had high densities of agaves again reflecting the clumped distribution.
To evaluate the potential usefulness of stratification by geologic unit, the data were sorted and means and standard deviations were calculated for each stratum, as listed in Table 2.

Table 2. Density Data Sorted by Geological Units Defined in Table 1

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<th>Stratification Unit</th>
</tr>
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<td></td>
<td>1</td>
</tr>
<tr>
<td>Number of Grid Units</td>
<td>13</td>
</tr>
<tr>
<td>% of total</td>
<td>17.1</td>
</tr>
<tr>
<td>Max. Dens. (Plants/ha)</td>
<td>228</td>
</tr>
<tr>
<td>Min. Dens. (Plants/ha)</td>
<td>0</td>
</tr>
<tr>
<td>Mean</td>
<td>74.2</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>83.3</td>
</tr>
</tbody>
</table>

Using the $t$-test for pair-wise comparisons of these results, the only significant difference was between strata 1 and 4 ($t = 2.593$, $p < 0.05$). No other pair-wise comparisons gave a significant difference, even when the outlier was excluded. Based on the lack of significant differences among these strata, we must conclude that this stratification approach will not provide an improved estimate of the overall mean agave density.
Another approach that was considered for stratification of the sampling program was slope aspect. It was initially believed that north-facing slopes might have fewer agaves because of the effects of reduced solar insulation and additional shading by a greater density of tree species. The density of agaves in each survey plot were plotted against the slope aspect, with 0 and 360 both indicating due north. Figure 5 shows this scatter diagram for 75 survey plots, excluding the outlier. These data suggest that there might be some effect of slope, with north-facing slopes generally lower and the higher densities on southern exposures. However, when all 76 plots are diagrammed (Figure 6), the effect disappears because the outlier was on a north-facing slope. From these results we conclude that slope aspect is not a useful means of sample stratification.

![Figure 5. Diagram of Slope Aspect Influence on Agave Density, Based on 75 Survey Plots](image_url)

Because of the high variability in agave densities, a useful approach to evaluate the overall mean density is to calculate a running mean and standard deviation as each new data point is added to the set. These calculated values for all survey plots are shown in Figure 7. The sharp spikes in the curves for mean and standard deviation are at the point where the maximum density was recorded. Figure 8 shows the same set of data, except for the deletion of the outlier. Both of these figures illustrate the same pattern in which the high initial variability is gradually dampened with the addition of more data, and eventually each new point makes very little difference in the mean density.
Figure 6. Diagram of Slope Aspect Influence on Agave Density, Based on 76 Sample Plots

Figure 7. Running Mean and Standard Deviation for Agave Densities on 76 plots within Area of Proposed Impact
3.1.2. NUMBER OF SUCCESSFUL FLOWERING STEMS

The critical aspect of agaves, with regard to lesser long-nosed bats, is the density of successful flowering stems which provide the foraging resource. The ratio of successful flowering stems to rosettes on a plot can be calculated from the data collected. This ratio varied from a minimum of 0 on many plots where there were no flowering stems to a maximum of 0.500 on a plot with 3 flowering stems and a total of 6 rosettes. Based on the sums of all successful flowering stems and all rosettes on the 76 plots, the calculated ratio is 0.0245, indicating that about 2.5 percent of the rosettes produced successful flowering stems. If the losses due to herbivory (see below) are taken into consideration, approximately 5 percent of all rosettes attempted to flower during this year. If we assume that the agave population is sustainable at this rate and that this is a normal year with no unique conditions or circumstances, it is coarsely estimated that the average age of a flowering rosette would be about 20 years.

Running means and standard deviations were also calculated for the flowering stems, as shown in Figure 9. As was seen in agave rosette densities, the initial variability is gradually dampened with the addition of more data. The mean density of successful flowering stems is 2.908 stems/ha, with a standard deviation of 3.757 and a standard error of ±0.431.
Data were also collected on the diameter and height of all flowering rosettes, whether successful or not. The average diameter and height of flowering rosettes were 129.9 cm and 86.8 cm, respectively. These averages support our assumption that these agaves do not normally flower until they are relatively large.

### 3.1.3. Size Class Distribution

All living agave rosettes on a survey plot were measured and assigned to a size class, with classes from 1 to 10 cm, 11 to 20 cm, etc., up to 150 cm. All rosettes greater than 150 cm were lumped into a single class. This class distribution pattern is shown in Figure 10. Based on the data in this chart, only 8.25 percent of all rosettes are greater than 120 cm in diameter, the size range that is most likely to produce flowering stems. If diameter can be used as a measure of relative age, this chart indicates a healthy population, with good recruitment of young plants, and relatively few old plants ready to reproduce.
3.1.4. IMPACTS OF HERBIVORY

Evidence of herbivory is very obvious in Palmer’s agaves and the evidence can suggest the responsible herbivore. Where a potential flowering stem is abruptly truncated a few feet above the ground (Appendix A, Photo 11), with no impact to rosette leaves, cattle or deer are the likely herbivores. If the truncation is lower and leaves have been impacted, javelina could be responsible. If the flowering stem has been consumed from the bottom and rat tunnels are present, woodrats are responsible. On the Property, the vast majority of damage is caused by cattle and deer, with woodrats and javelina only impacting a few plants. Unfortunately, it is not possible to distinguish between the impacts of cattle and deer, based on the evidence remaining. Because flowering stems, both successful and unsuccessful, remain on the landscape for several years, the impacts of herbivory can be estimated based on data from several years of flowering attempts.

For the current year, there were 153 flowering attempts on the 0.25-ha survey plots, of which only 64 (41.8 percent) were successful. The previous year’s total attempts numbered 145, of which 57 (39.3 percent) were successful. Because of the difficulty of determining a specific year of flowering, all older standing stems were combined. A total of 348 flowering stems at least two years or older were counted. Of these stems, 229 were successful, for a success rate of 65.8 percent. If all years of evidence are combined, there were 648 flowering attempts on the survey plots and 350 successful stems, for an overall success rate of 54.0 percent.
3.2. REGIONAL AREA

3.2.1. NUMBERS OF AGAVES

For our regional analysis of Palmer’s agave, we surveyed 116 plots (Figure 11). The total area surveyed for agaves was 1218.5 ac (493.1 ha). As noted above, we separated these plots into 3 regions, based on distance from the approximate center of the proposed Rosemont impact area. In Region 1 (outside the potential impact area but within the Property), there were 26 survey plots. In Region 2 (outside the Property but less than 5 mi [8 km] from the approximate center of proposed impact area) there were 24 plots. Region 3 (more than 5 mi [8 km] but less than 12 mi [19 km] from the approximate center of proposed impact) had the remaining 66 plots. These plots were restricted to areas at elevations greater than 3,500 ft. Results of the regional agave survey are listed in Table 3.

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of Plots</th>
<th>Total Area of Plots (ha)</th>
<th>Average Rosette Density (rosettes/ha)</th>
<th>Rosette Density Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26</td>
<td>87.28</td>
<td>23.182</td>
<td>39.306</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>83.72</td>
<td>20.080</td>
<td>69.032</td>
</tr>
<tr>
<td>3</td>
<td>66</td>
<td>322.12</td>
<td>5.392</td>
<td>12.129</td>
</tr>
<tr>
<td>Summary</td>
<td>116</td>
<td>493.1</td>
<td>12.42</td>
<td>37.79</td>
</tr>
</tbody>
</table>

As expected, the estimated density of agave rosettes is far lower on the regional plots than on the intensively surveyed plots in the potential impact area. With the high density of grasses and herbaceous species it is likely that most agaves less than 60 cm in diameter and many agaves less than 80 cm were hidden and not counted. These results suggest that the regions within or close to the Property have somewhat higher numbers of agaves than the more distant areas. Using the t-test for pair-wise comparisons of the means in the different regions indicates a significant difference (p < 0.01) between Region 1 and Region 3, but neither of the other comparisons is significant. This difference may be real, or it could be an artifact of the difficulty in obtaining realistic counts of the agave rosettes present on these plots.

As with the plots within the proposed impact area, it is possible to calculate running means and standard deviations for agave rosette densities in the regional plots. These calculations do not distinguish among data from different regions. Graphs of these values are shown in Figure 12. These graphs show a pattern similar to the corresponding graphs for the detailed surveys of the potential impact area.
Legend
- Rosemont Holdings
- Impact Area
- 5-Mile (8-km) Radius Study Area
- 12-Mile (19-km) Radius Study Area
- Survey Plots

ROSEMONT PROJECT
Agave Survey
Regional Distribution of Random Survey Plots
Figure 11
3.2.2. NUMBERS OF SUCCESSFUL FLOWERING STEMS

On each of the 116 regional plots, the numbers of current successful flowering stems were counted. No attempt was made to count or distinguish previous years’ flowering stems or to identify stems that were subject to herbivory. Because of the high visibility of individual flowering stems, it is expected that these data are more accurate than the counts of agave rosettes. The average of successful flowering stems on all regional plots was 2.808 flowering stems/ha, with a standard deviation of 8.591 and a standard error of ±0.798. Results of the flowering stem densities are tabulated by region in Table 4.

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of Plots</th>
<th>Total Area of Plots (ha)</th>
<th>Average Flowering Stem Density (stems/ha)</th>
<th>Flowering Stem Density - Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26</td>
<td>87.28</td>
<td>5.626</td>
<td>12.183</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td>83.72</td>
<td>3.576</td>
<td>11.594</td>
</tr>
<tr>
<td>3</td>
<td>66</td>
<td>322.12</td>
<td>1.418</td>
<td>4.536</td>
</tr>
<tr>
<td>Summary</td>
<td>116</td>
<td>493.1</td>
<td>2.808</td>
<td>8.591</td>
</tr>
</tbody>
</table>

The pattern of flowering stem densities is similar to that for rosette densities, with Region 1 having the greatest density, Region 3 having the lowest density, and Region 2 having an intermediate value. Based on t-tests for pair-wise comparisons, none of the comparisons of successful flowering stems is statistically significant. The density of successful flowering stems is much greater in Region 1 than in Region 3, and it is very close to statistical significance (p ≈ 0.055). The similarity of the results for the flowering stem density
and the rosette density, with Region 1 higher in both densities than Region 3, suggests that there may, in fact, be a real difference in agave densities between these two regions. The average elevations of the survey differ by about 400 ft, with Region 3 being lower than Region 1. In addition, many plots in Region 3 are very close to the reported lower elevation limit for this species, and lower densities would be expected near the edges of a species’ elevational distribution limits.

Running means and standard deviations were calculated for the successful flowering stems on the regional plots. As with the procedure used for the rosette density, these calculations do not distinguish among the different regions. A graph of these values are shown in Figure 13. The pattern is again similar to preceding graphs, with initial variability gradually dampening as more data are collected.

Figure 13. Running Mean and Standard Deviation for Successful Flowering Stems on 116 Regional Plots

4. DISCUSSION

4.1. ANALYSIS OF AGAVE DISTRIBUTION

Our data on agave distributions on both the impact area and regional survey indicate a high degree of clumping, with some areas having high numbers of agaves, and other apparently similar sites having few or no agaves. This phenomenon can be seen by a casual observer driving State Route 83 between Interstate Highway 10 and Sonoita, with few dense areas of agaves separated by expansive areas with very few agaves. These observations are consistent with literature reports, as cited above, describing the clumped distribution of agaves.
When a clumped distribution is observed, it is logical to expect that some environmental factor, or combination of factors, might be controlling the distribution. For example, many plant species are noticeably more abundant on limestone substrates than on other rock types, and other species need the shade that is more available on north-facing slopes. Unfortunately, our studies found that neither substrate nor slope aspect can be used to predict the distribution of Palmer’s agave with any degree of reliability.

As a consequence of this clumped and apparently random distribution, it is very difficult to predict how many agaves might be impacted by the proposed Rosemont Project. The best predictor of density would be the overall average of all survey plots or the end point in the running average of agave densities. The anticipated total impact on the agave population would then be the average density multiplied by the total area of expected disturbance.

4.2. COMPARISON OF AGAVE ROSETTE DENSITIES

While we are reasonably confident in the data for agave rosette density within the proposed area of impact, we are also certain that the observed agave densities on the regional plots are underestimated because of the survey methods used and difficulty in seeing small rosettes in areas with dense grass and small shrubs. Therefore, we can make no meaningful comparisons between agave rosette densities in the impact area and in the general region.

4.3. COMPARISON OF AGAVE FLOWERING STEM DENSITIES

Because the data collection procedures used in the survey plots in the proposed impact area and regional survey plots were essentially the same for the successful flowering stems, a meaningful comparison of these results is possible. The mean density of flowering stems within the proposed impact area is 2.908±0.431 stems/ha, and the mean density on the regional plots is 2.783±0.781 stems/ha. There is no statistical difference between these means, indicating that the Rosemont proposed impact area is typical of the region and represents no special or unique concentration of foraging resource for lesser long-nosed bats. These densities are in the same range as the 1.8 flowering stems/ha reported by Scott (2004) in the Peloncillo and Chiricahua Mountains, and 1.8 to 3.6 stems/ha reported by Ober et al. (2005) in southeastern Arizona west of the Huachuca Mountains, east of the Patagonia Mountains, and south of the Mustang Mountains.

Similarly, there is no significant difference in the pair-wise comparisons between the impact area and Regions 1 or 2, but there is a significant difference between the impact area and Region 3 (p < 0.05). This contrast supports the possibility raised above that Region 3 has a lower overall agave and flowering stem density than the proposed impact area and Regions 1 and 2.

The overall comparability in flowering stem density suggests that the average rosette density in the regional area is likely to be similar to that on the Property. There is no reason to believe that regional plots would have any different proportion of rosettes blooming in any given year than the impact area plots.
5. SUMMARY AND CONCLUSIONS

5.1. EVALUATION OF ROSEMONT PROPERTY FOR POTENTIAL FORAGING BY LESSER LONG-NOSED BATS

Palmer’s agaves on the Property provide an important foraging resource for lesser long-nosed bats during their late summer, post-maternity dispersal. Our surveys of these bats have shown that this resource is heavily used by both the lesser long-nosed bat and the Mexican long-tongued bat (Choeronycteris mexicana) (WestLand 2009). When bats are in the region, it is likely that they are able to find every agave that is flowering, anywhere on the landscape.

5.2. REGIONAL CONTEXT OF ROSEMONT PROPERTY

Based on our observations of successful flowering agave stems on the Property and within a wider regional area, we believe there is no significant difference between the Property and the surrounding region with regard to its value as a foraging resource for the lesser long-nosed bat. The Property does not support an exceptionally high density of agaves nor does it show any other characteristics with regard to agaves that would make the Property unusual or unique.

5.3. IMPLICATIONS FOR PROPOSED ROSEMONT PROJECT DEVELOPMENT

Development of the Rosemont Project will have adverse direct and indirect impacts on the agaves within the area of impact. All agaves within the impact area will be affected. The larger plants, those that are most likely to produce flowering stems within the next few years, are likely to be lost because they are too large to transplant. Smaller plants may be transplanted, but survivorship is unknown. A study at the University of Arizona is currently underway to examine the transplanting of agaves.

6. REFERENCES


Hayward, B. and E. L. Cockrum. 1971. The natural history of the western long-nosed bat, Leptonycteris sanborni. Western New Mexico University, Research Sciences 1:75-123.


PHOTO 1
Palmer’s agave rosette.

PHOTO 2
Palmer’s agave, flowering panicle.

PHOTO 3
Lesser long-nosed bat foraging at Palmer’s agave. Still photo taken from infrared video recording with supplemental infrared lights.
PHOTO 4
Palmer's agave in semidesert grassland.

PHOTO 5
Palmer's agave in Madrean evergreen woodland.

PHOTO 6
Parry's agave rosette.
PHOTO 7
Substrate Unit 1 – Mt. Fagan Rhyolite.

PHOTO 8
Substrate Unit 2 – Willow Canyon Formation.

PHOTO 9
Substrate Unit 3 – Gila Conglomerate.
PHOTO 10

Substrate Unit 4 – Complex Paleozoic Units.

PHOTO 11

Flowering stem lost to herbivory.