ADDENDUM TO THE PIMA PINEAPPLE CACTUS SURVEY OF THE PROPOSED ROSEMONT PROJECT WATERLINE ALIGNMENT

PREPARED FOR: Rosemont Copper Company

PREPARED BY: WestLand Resources, Inc.

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PROJECT NO. 1049.10 350 350

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ATTACHMENTS

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SUMMARY

In October 2008, WestLand Resources surveyed for Pima pineapple cactus (PPC) along a 15.77-mile (25.23 km), 120-foot (37-m) wide corridor for a proposed waterline between Sahuarita and Helvetia, Pima County, Arizona. The area surveyed was about 229 acres. Thirty-five live PPC were found along the corridor. Bedrock occurred on the last 1.42 miles (2.27 km) of the east end of the corridor. Because bedrock is only rarely occupied by PPC, the bedrock portion was excluded from an analysis of the distribution of PPC on the waterline. Only the west 14.35 miles (22.36 km) was considered in an analysis of the distribution of PPC. When the PPC plants were mapped as they occurred on the transect, they appeared to be aggregated in three clusters. The mean distance-to-nearest neighbor for these 35 plants was 99 meters. If these plants had been evenly spaced along the 14.35 mile alignment, the distance between each plant would be about 600 meters. Using 200 Monte Carlo simulations to determine the probability distribution associated with randomly placing 35 PPC along the proposed alignment, the mean nearest neighbor distance was 324 meters (± 47 meters, ± 1 s.d.). The probability of producing a mean nearest neighbor value of 99 meters or less at random is about one chance in 1.2 million. The probability of obtaining the opposite extreme of clustering – evenly spaced PPC plants that are 600 m apart – is about one chance in 2.8 trillion.

If a clustered or aggregated distribution of PPC was a likely outcome due to a random process, the factor responsible for the clusters is the random process itself. However, if the clusters observed along the proposed pipeline are so clustered that the phenomenon is extremely unlikely to have occurred due to chance, the factor(s) responsible for clustering should eventually become apparent in the course of natural history observations and these same factors should be available to experimental analysis.

We consider the significantly aggregated patches of this plant along the belt transect in relation to surficial geology, seed dispersal, and several broad local patterns evident in the distribution of PPC.

There are three significantly aggregated patches of PPC along the proposed waterline. If we add the mean distance-to-nearest-neighbor (ca 100 m) to both ends of each of the three segments of the proposed waterline occupied by PPC, we obtain 0.72 miles for Aggregate A, 0.29 miles for Aggregate B, and 2.60 miles for Aggregate C – or a total of 3.61 miles occupied by PPC along the 15.77-mile proposed waterline. The occupied length represents 22.89% of the total proposed waterline. Portions of the 120-ft width along the proposed waterline have already been adversely impacted by dirt roads that lie within the 120-ft and parallel to the waterline route; a more detailed assessment of the footprint of these roads would doubtlessly reduce the amount of acreage impacted within the 3.61 miles occupied by PPC. In addition, segments of Aggregate C on the Sycamore Canyon Plio-Pleistocene alluvial fan cross deep ravines that dissect this fan. These ravines have slopes greater than 15% and the north-facing slopes are densely vegetated with shrubs; areas densely vegetated or with steep slopes are not occupied by PPC. The individual ravine segments could be subtracted from the 3.61 miles we determined is occupied by PPC.

1. INTRODUCTION

In October 2008, WestLand Resources, Inc. (WestLand) surveyed for Pima pineapple cactus (PPC; *Coryphantha scheeri* var. *robustispina*) within a 15.77-mile-long, 120-foot-wide corridor for a proposed waterline (the survey area; Figure 1), on behalf of Rosemont Copper Company. The area surveyed extends from about one mile east of the Santa Cruz River near Sahuarita Road to near the town site of Helvetia at the western base of the Santa Rita Mountains[1] (Figure 1). This document provides:

- the distribution of PPC found along the proposed pipeline.
- an analysis that compares the mean and variance of distance-to-nearest-neighbor measured for the 35 actual PPC plants to the distribution of means and variances for 200 sets of 35 points randomly located along a length equal to the length of the proposed pipeline (without the section on bedrock) and to the distance-to-nearest-neighbor if the 35 plants were evenly or regularly spaced along the length of the proposed pipeline. The plants are aggregated in three patches; this analysis allows us to compare their distribution to that of random and even distributions.
- geomorphic characteristics of the several surficial alluvial units on which the 35 plants occurred compared to the intervals with other surficial alluvial units along the survey route where no PPC were encountered.
- a brief overview of the natural history of PPC, particularly its mode of seed dispersal and the observed high rates of seedling establishment on older, red, clay-rich soils along the upper edges of the Altar and Santa Cruz Valleys. “Directional” seed dispersal by *Lepus* and high rates of seedling establishment on clay-rich soils are sufficient factors to account for the emergence of aggregations of adult PPC.

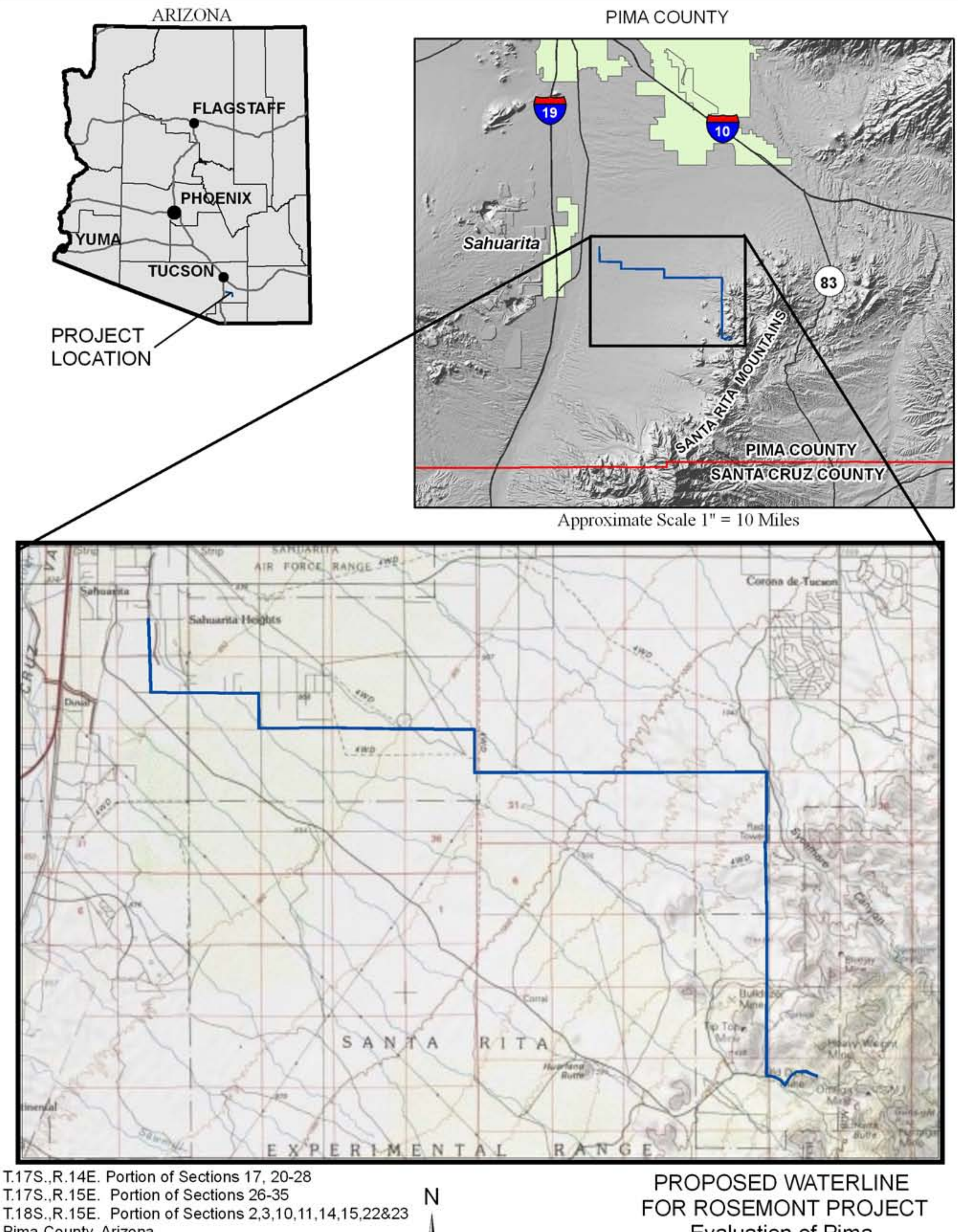
2. PPC OCCURRENCE ALONG THE PROPOSED WATERLINE

During the survey in October 2008, 35 live PPC were found within the approximately 229-acre survey area. The plants were not randomly distributed along the 15.77-mile belt transect; instead the 35 PPC occurred within three distinct patches (Figures 2 and 3).

The first patch was comprised of 16 plants (#s 1-16, Aggregate A) along the west end of the proposed waterline. The second patch was comprised of 5 plants (#s 17-21, Aggregate B). The third patch was 14 plants (#s 22-34, Aggregate C) on the northeast corner of the proposed waterline route. This last cluster was concentrated on the east-west portion of the survey area before it turned south. PPC encounters decreased south of the east corner. No plants were found in the intervening lengths between the three patches, or between the third patch and the east end of the survey area.

[1] Crossing T17S, R14E, Sections 17, 20, 21, and borders of Sections 22/27, 23/26, and 24/25; T17S, R15E, borders of Sections 30/31, 29/32, 28/33, 27/34 and 34/35; and T18S, R15E, borders of Sections 2/3, 10/11, and 14/15, and Section 23, Gila and Salt River Meridian

M:\projects\1049.10\PPC\PPC Evaluation\MXD\Fig1 Vicinity.mxd



T.17S.,R.14E. Portion of Sections 17, 20-28
T.17S.,R.15E. Portion of Sections 26-35
T.18S.,R.15E. Portion of Sections 2,3,10,11,14,15,22&23
Pima County, Arizona,
Sahuarita, Corona De Tucson, Helvetia
USGS 7.5' Quadrangles

WestLand Resources, Inc.
Engineering and Environmental Consultants

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Survey Area

PROPOSED WATERLINE
FOR ROSEMONT PROJECT
Evaluation of Pima
Pineapple Cactus Distribution

Vicinity Map
Figure 1

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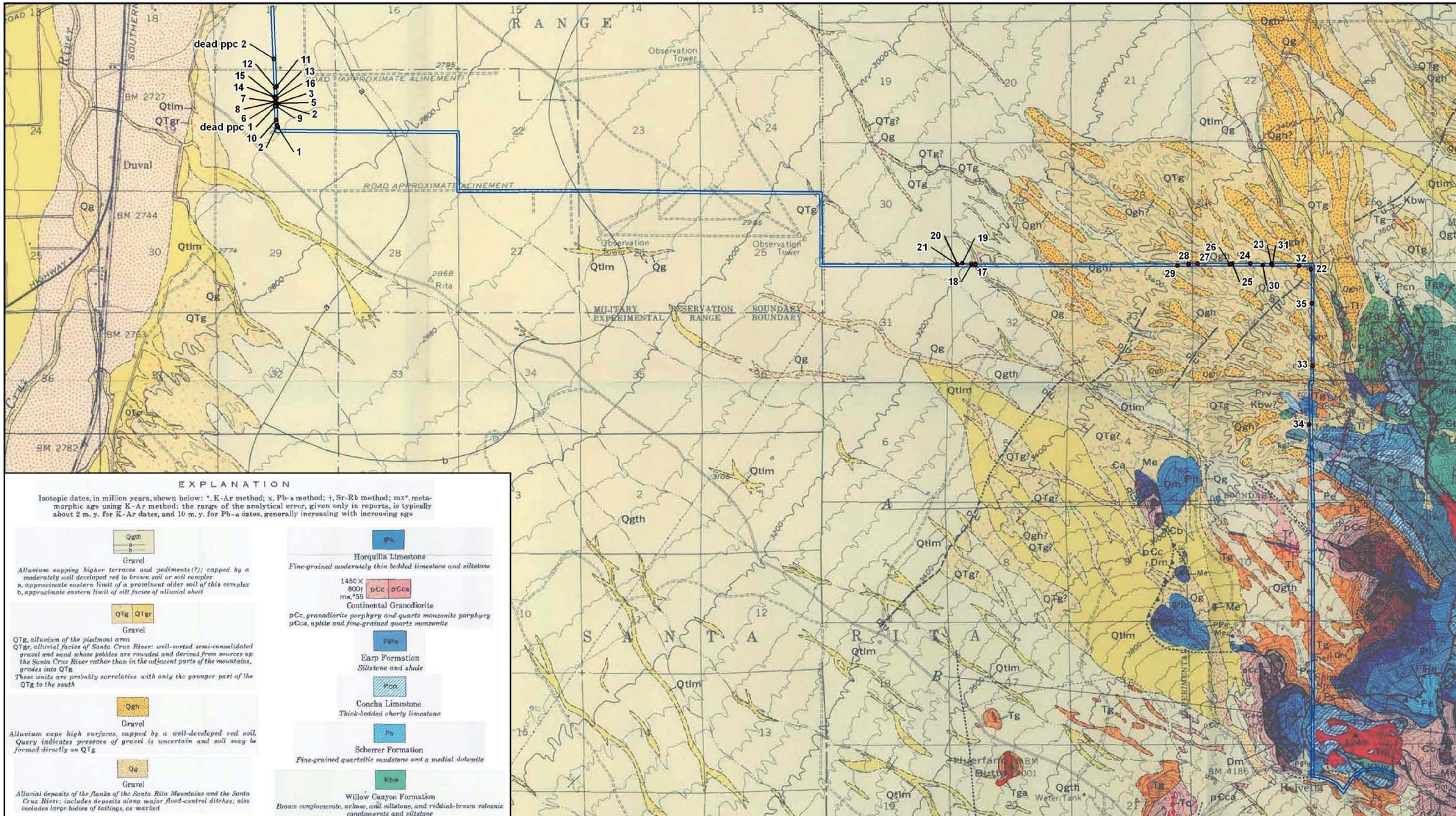

Image Source: Sahuarita Quadrangle Geologic Map
Harald Drewes, 1971

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- PPC Location
- Survey Area

PROPOSED WATERLINE FOR ROSEMONT PROJECT
Evaluation of Pima Pineapple Cactus Distribution

Surficial and Bedrock Geology Map
Figure 2

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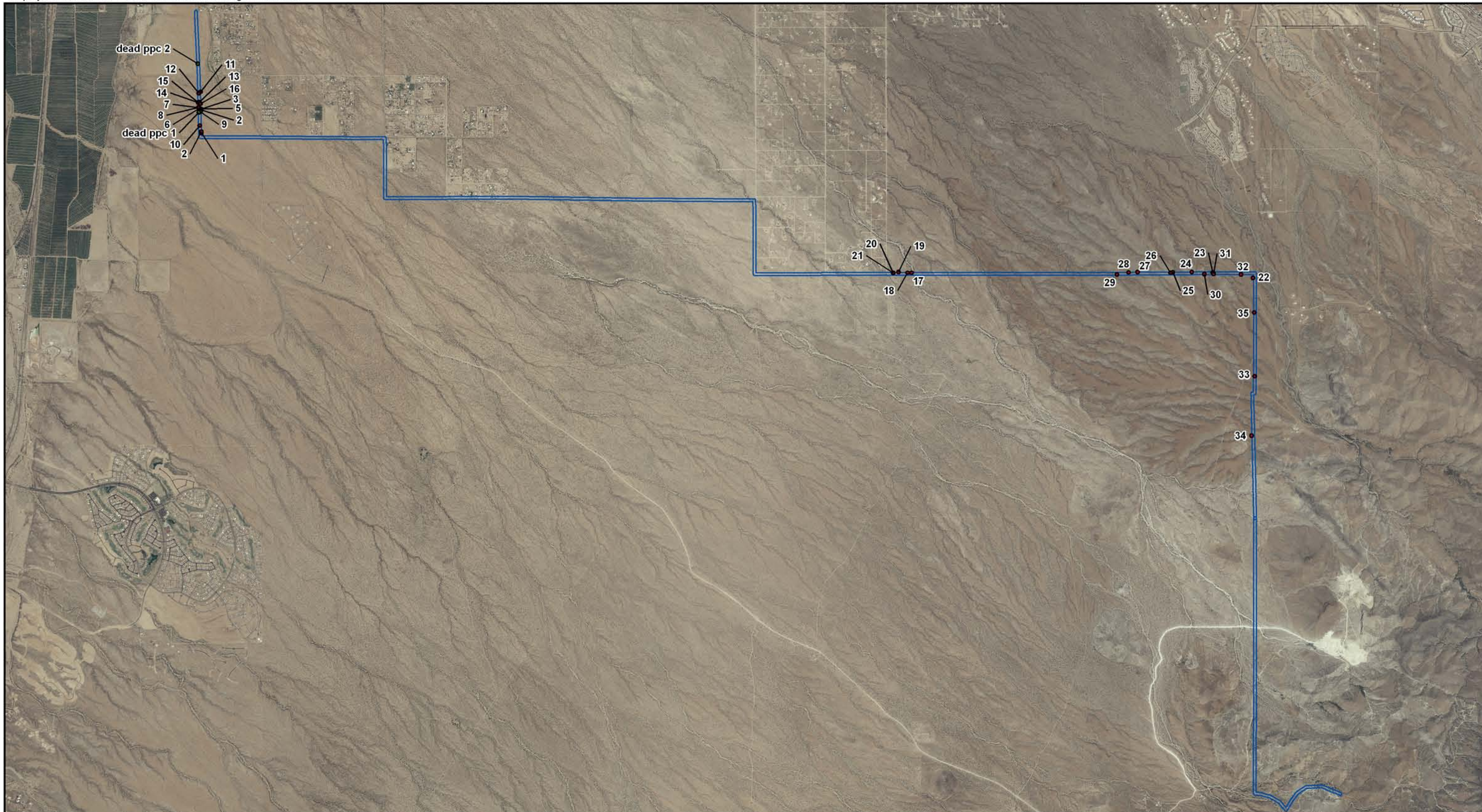

Image Source: NAIP, 2007

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Feet

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Survey Area

• PPC Location

PROPOSED WATERLINE FOR ROSEMONT PROJECT
Evaluation of Pima Pneapple Cactus Distribution

Aerial Overview
Figure 3

The gaps around the three patches of PPC that are evident in Figures 2 and 3 are areas where PPC plants were undetected during the survey. The absence of plants detected in these gaps is an outcome due either (1) to no plants occurring in these gaps or (2) to plants present, but not detected during the survey. If plants were present in the gap and missed by the surveyors, it is likely that there were only one or a few. The central portion of the belt transect where no PPC were detected was a very open landscape. PPC plants on this open portion would have been easily detected. The field biologists conducting the PPC survey were vigilant throughout the survey. Given the vigilance of the field biologists and the open landscape where no PPC were found, a PPC plant had a better chance of detection in the open, relatively flat landscapes than the ridge-and-swale landscapes where the aggregations (particularly Aggregates A and C) were actually found.

3. STATISTICAL ANALYSIS OF THE DISTRIBUTION OF PPC ALONG THE PROPOSED WATERLINE

A statistical analysis of the distribution of the PPC found along the route of the proposed waterline was performed to estimate the probability that the observed clustering phenomena could occur by chance. The mean distance-to-nearest-neighbor (DNN) calculated from the nearest neighbor distance for each PPC was used as a measure of clustering. Distance-to-nearest-neighbor is a measure frequently used in analyses of dispersion (see Clark and Evans 1954, Diggle 1983, Sinclair 1985, Campbell 1996, Coomes et al. 1999, Ripley 2004, and others) and has been applied to spatial data sets in many scientific fields. Distance-to-nearest-neighbor has been used in the analysis of whether a population or age-classes of that population are aggregated, randomly distributed or evenly dispersed. Distance-to-nearest-neighbor measures have been used in spatial analyses of plants, including savanna palms (Barot et al. 1999), trees in a Caribbean semi-evergreen forest (Forman and Hahn 1980), trees in an aspen-white pine forests (Squiers and Klosterman 1981), trees in old-growth cedar-hemlock forests (Turner and Franz 1985), trees in a southern Louisiana hardwood forest (Whipple 1980), and trees in Florida sand pine forests (Laessle 1965). Distance to nearest neighbor analyses have also been applied to animal distributions, with examples as disparate as tropical ant colonies (Levings and Franks 1982) and acorn woodpecker territories (Burgess et al. 1982, Mumme et al. 1983). As with the relationship between two types of sampled points which may suggest spatial association, repulsion, or independence, the distribution of one type of points can be analyzed to determine if the spatial distribution of the points is regular, random, or aggregated (Barot et al. 1999). It should be emphasized that there is a continuum of possible distributions of point data – from an extremely aggregated set of points through more loosely aggregated distributions to the even or regular (hyper-dispersed) condition at the other end of the continuum. Also, if the analysis of point data indicates regular, random, or aggregated distributions, no ecological process can be implied *a priori*.

To simplify computation, all measurements were made as if each PPC was along the centerline of the waterline alignment. This simplification ignored the buffer zone that is included in the analyses of large populations. For large areas and large populations, if no buffer is used some nearest neighbor distances will be too large because the actual nearest neighbor occurs nearby but outside the study area. Not including a survey in the buffer area is expected to result in an increased mean DNN distance and variance. The edge-effect bias can be very serious (Sinclair 1985, Campbell 1996). In this belt-transect example, ignoring the edge effect increases by an unknown amount the mean DNN but does not diminish the general outcome in considering whether the PPC plants along the transect are aggregated, randomly dispersed, or evenly spaced. Using the DNN method, the average nearest neighbor for the 35 observed PPC was approximately 99 meters. Two hundred Monte Carlo simulations were run to determine the probability distribution associated with randomly placing 35 PPC along the proposed alignment. For the simulation, it was assumed that PPC could occur on the northwest 14.35 miles of the 15.77 miles of proposed alignment, but not on the southeast 1.42 miles because this east portion is largely on bedrock (Paleozoic sedimentary rocks). In south-central Arizona, this cactus is only very rarely found on bedrock; it is a species that occurs on alluvium.

The location of each simulated PPC was determined using Microsoft Excel's random number generator function, RAND(). The RAND() function produces pseudo-random numbers from 0 to 1 based on a uniform distribution. Once the 7,000 random numbers were generated, they were converted to constants to prevent them from being recalculated by the software. Each random number was multiplied by the length of proposed alignment used in the analysis: 23,103 meters, or approximately 14.35 miles.

For each of the 200 simulations, the distance to its nearest neighbor was calculated for each of the 35 points (simulated PPC) and a mean DNN was calculated from the 35 distances. The frequency of mean distance to nearest neighbor for the 200 simulations is provided in Figure 4. The mean of the 200 simulations-based DNN means was approximately 324 meters and the standard deviation of the 200 simulation means was 47 meters. Figure 2 shows the frequency distribution of the 200 simulations using 9 50-meter wide bins. The minimum simulation mean nearest neighbor was 187 meters; the maximum was 446 meters.

The binned data used to produce Figure 2 were also used for a Chi-squared goodness-of-fit test to see if the simulation results were normally distributed (Hines and Montgomery 1980). The Chi-squared test showed that the chance that the simulation results were not from a normal distribution with a mean of 324 meters and a standard deviation of 47 meters was less than 1%. Figure 3 shows the binned data plotted at the center point of the bin overlaying a normal distribution. The scales are not exactly the same (see left and right axis), so the figure should be used to compare distribution shape but not absolute value.

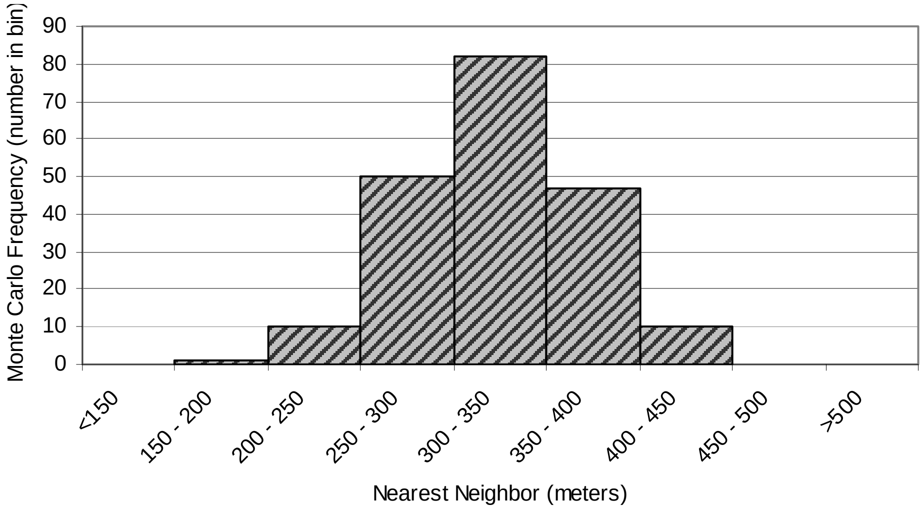


Figure 4. Frequency Distribution of Nearest Neighbor Distance based on 200 Monte Carlo Simulations of 35 Points along a 14.35 mile Alignment

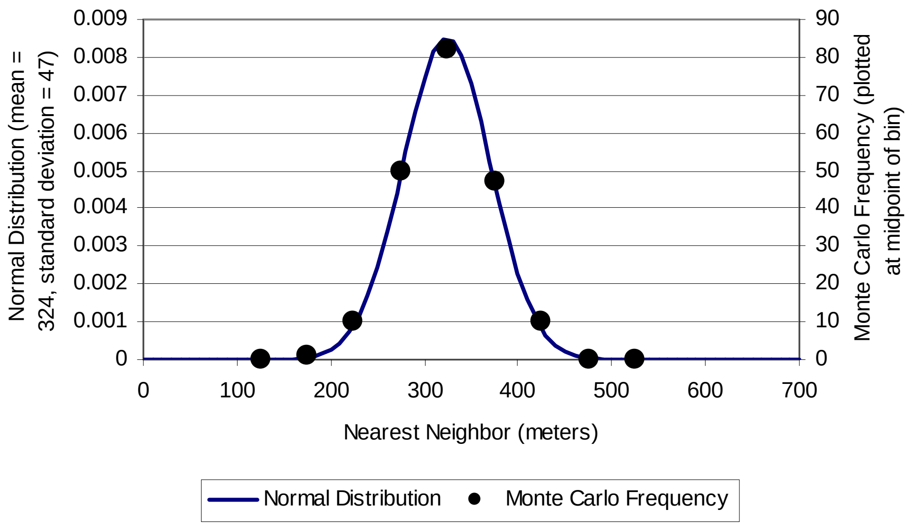


Figure 5. Normal Distribution with mean = 324 and standard deviation = 47 overlain with Simulation Frequency Distribution Plotted at Bin Midpoints

The purpose of the Monte Carlo simulation was to produce a probability distribution of the average distance to the nearest neighbor if 35 PPC were randomly distributed along 14.35 miles of the proposed alignment. The purpose of this section of the report was to calculate the probability that the distribution of PPC found during the survey came from a random distribution of PPC along 14.35 miles of the alignment. Using the methodology described above, the mean distance to nearest neighbor for the observed PPC was about 99 meters. The probability of producing a nearest neighbor value of 99 meters or less is 8.3×10^{-5}%. In other words, there is about one chance in 1.2 million of a nearest neighbor average of 99 or less occurring at random in this case.

The opposite extreme of clustering would result from evenly spacing the PPC along the alignment. The distance between each PPC would be about 660 meters. The probability of producing this pattern at random is about 3.5×10^{-11}%, or about one chance in 2.8 trillion.

3.1 Relationship of the Three PPC Aggregates to the Surficial Geology of the Alluvium

The geology of the entire length of the survey area was mapped by Drewes (1971) at a 1:48,000 scale. The survey belt-transect and locations of the PPC are depicted on Drewes' (1971) map (Figure 2). Pearthree and Youberg (2000) mapped at a 1:24,000 scale the surficial geology of the west portion of the belt transect within the Sahuarita 7.5' quadrangle. Jackson (1990) mapped at a 1:24,000 scale the eastern portion of the belt transect within the Corona de Tucson 7.5' quadrangle. Figure 3 depicts the survey area and PPC locations on a color aerial photograph (NAIP 2007).

Aggregate A (defined above) occurs on Drewes (1971) Pleistocene-age Qgth gravel unit (Figure 2). Drewes' Qgth unit of alluvium occurs as higher terraces and pediments. The Qgth unit is capped by a moderately well developed red to brown soil or soil complex. Drewes delineated an area "a" that had a prominent older soil of the Qgth complex and includes all of Aggregate A (Figure 2). The area encompassed by Drewes' second limit of Qgth, "b", to the east of Aggregate A has no PPC. Drewes described this second soil unit "b" as silt facies of the alluvial sheet (= younger than the "a" unit of Qgth). Pearthree and Youberg (2000) mapped the alluvium on which all of PPC Aggregate A occurs as "Qly." For Pearthree and Youberg, the Qly is a complex of surficial units deposited between late Pleistocene and the Holocene. Middle Pleistocene soils (Qm) underlie much of the Qly and generally have a higher clay content than late Pleistocene or early Holocene soils. As an indication of the proximity of Qm to the surface of the Qly alluvium, middle Pleistocene soils are at the surface only 200 m to the south and again about 500 m east and northeast of Aggregate A (Figure 2). The north half of Section 20 (T17S, R 14E) is occupied by Aggregate A and has about 5 mapped channels on the Pearthree and Youberg 1:24,000 map, enough to suggest that Qm is actually exposed or just barely buried by a shallow veneer of younger alluvium where Aggregate A occurs. WestLand has surveyed for PPC on several private parcels within a few miles to the south, north, and east of Aggregate A. We have found PPC on the ridges of the highly dissected QTs surficial unit that form high bluffs immediately adjacent to and on the east side of to the floodplain of the Santa Cruz River. We have also found PPC on the exposed intact middle Pleistocene soils (Qm) mapped by Pearthree and Youberg in recurring intervals for several miles to the south of Aggregate A. Intact Qm soils have a large clay content. The clay is a dark brick-red and is responsible for the reddish soils evident in color aerial photographs (example, Figure 3).

The large area between Aggregate A and Aggregate B (Figure 2) in which no PPC were located is mapped by Pearthree and Youberg as late Pleistocene and Holocene (Qly) veneers of alluvium. Where there are active channels avulsing over the last several thousand years on this portion of the landscape, Pearthree and Youberg have mapped these areas as Qy, undifferentiated Holocene alluvium. Much but not all of the eastern portion of the unoccupied transect between Aggregates A and B is mapped by Jackson as M2 (latest Pleistocene). Jackson indicated that bar and swale topography was subdued in coarse-grained alluvium and absent in the younger, fine-grained alluvium. The soils of M2 have only incipient reddening and clay accumulation. If fact, Holocene-age alluvial surfaces between Aggregates A and B appear tan colored in Figure 3.

Aggregate B is located on Jackson's M1, a middle to late Pleistocene alluvial deposit. The soils of M1 have a well developed clay accumulation and are red. Interfluves of the M1 are moderately rounded. There is a segment of M1 that is unoccupied by PPC between Aggregates B and C that lies just west of "Sycamore Fan."[2] The maps of Drewes, Pearthree and Youberg, and Jackson do not subdivide M1 alluvium into different types on a finer-grain scale. The eastern PPC cluster, Aggregate C, occurs on Sycamore Fan, the late-Pliocene, early Pleistocene deposition (Jackson's O unit) that is a prominent distinct alluvial fan in Figure 3. Most of the PPC on Sycamore Fan occur on the high, planar ridges where the clay surface has remained intact (un-eroded). In several respects, the mapping of the Sycamore Fan by Drewes at a 1:48,000 scale conveys more detail and information (at least schematically) than that by Jackson at a 1:24,000 scale. The channels that dissect Sycamore Fan have slowly developed over the last ca 1 million years and have removed surface clay from the eroding adjacent slopes, revealing a light-colored subsurface deposit of gravel and grus. The grusy material is derived from boulders originally included within the alluvium that have rotted in place. The gray, eroded surfaces of the Sycamore Fan can be seen in the aerial photograph (Figure 3) in contrast to the adjacent red surfaces which are preserved, intact, clay-rich alluvium on the planar ridges. The PPC plants on Sycamore Fan occur on both the clay-rich preserved surfaces as well as the eroded, gray, gravelly high portions of the slopes. Photographs of four PPC in Aggregate C are provided that illustrate the presence of a gravel lag on a clay-rich soil in the occupied sites of these plants (Attachment A). No PPC plants were found on the north-facing slopes of the channels that dissect Sycamore Fan. These north-facing slopes were thickly vegetated by *Acacia greggii, Acacia constricta, Hyptis emoryi,* and other shrubs. No PPC plants were found in the swales of the channels that dissect Sycamore Fan.

South and off of Sycamore Fan, no additional PPC were found during the survey. The area to the south has areas of bedrock (both igneous and sedimentary) and shallow veneers of soil over bedrock. Paleozoic limestone bedrock makes up a substantial fraction of the parent material of alluvium along this transect. The limestone-derived alluvium can be seen on the belt transect west of the Blue Jay Mine and south of Sycamore Fan as a light colored soil (Figure 3). In general, we have found few (very low densities) or no PPC on soils directly derived from limestone in block-surveys for PPC in other areas of the Santa Cruz and Altar Valleys within the range of this species.

[2] We name the large early Pleistocene massive alluvial fan that has been deposited outside the mouth of Sycamore Canyon as "Sycamore Fan."

In summary, Aggregates B and C are on mid- to early-Pleistocene soils. Aggregate A is in an area mapped as late Pleistocene soil (or early Holocene) as a veneer on mid- to early-Pleistocene soils. Given the number of channels that dissect the area occupied by Aggregate A, it is likely that these plants are growing directly on mid-Pleistocene soils or at least with their taproots reaching these older soils with a higher clay content. The transect results suggest that PPC are absent or occur in undetectable numbers on the shallow, younger, clay-poor veneer of soils across the approximately 6-mile-reach of the transect between Aggregates A and B.

4. TWO FACTORS SUFFICIENT FOR THE EMERGENCE OF PPC AGGREGATIONS

4.1 DIRECTIONAL DISPERSAL OF PPC SEEDS BY JACKRABBITS TO OPEN RIDGELINES (FACTOR 1)

PPC natural history, rarity, and spatial distribution are consistent with the view that this species of cactus is a commensal of jackrabbits. The fruits of PPC when mature are whitish-green, soft, elongate, and up to 7 cm long. When ripe, PPC fruits extend beyond the apical spines of the plant (Attachment A) and can easily be pulled from the plant by humans wielding forceps or *Lepus* with their large incisors. Ripe PPC fruit often have an odor of ripe honeydew melon. Jackrabbits (*Lepus* spp.) eat the fruits of PPC. Using motion-sensitive cameras, we have documented that lagomorphs (cottontails, *Sylvilagus* and jackrabbits, *Lepus*) are the animals primarily responsible for removing the fruit. We have recovered large numbers of PPC seeds from *Lepus* dung and have germinated these seeds. We have not recovered PPC seeds from *Sylvilagus* dung, even after collecting thousands of fecal pellets in sites with high densities of adult PPC and high densities of *Sylvilagus* fecal pellets. We have made enough observations in areas of old, dissected alluvial fans to suggest that most *Lepus* fecal pellets on dissected alluvial fans are deposited on ridge lines with open views, not on slopes or swales. *Lepus* defecate the seeds in jackrabbit latrines. Areas chosen by jackrabbits as latrines tend to be on ridges and open areas where jackrabbits have good visibility of the surrounding landscape and can evade coyotes and other terrestrial predators. The same areas chosen by jackrabbits for resting, vigilance, and defecation have characteristics (bare ground, ridge tops with argillic horizons intact, low densities of herbaceous plants) that provide conditions that are likely to result in higher seedling survival for PPC compared to conditions at a random set of locations. Compared to more common cacti (ex. *Ferocactus* spp., *Carnegiea gigantea*) producing millions of seeds, PPC produces very modest amounts of seed per year and per life-time of the individual PPC plant. With (1) about 90 seeds/fruit, (2) about 5 fruits/year per healthy mature stem, and (3) an adult life-span of about 10 to 20 years, a successful PPC plant may reasonably be expected to produce about 5,000 to 10,000 seeds in its life-time. The commensal relationship of PPC with jackrabbits increases the chance for each seed (out of the relatively low number produced) to be dispersed to jackrabbit latrine sites, sites with characteristics favorable for PPC establishment and survival. The commensal relationship of PPC with jackrabbits is likely to be essential for the long-term persistence in a given area of this plant with its low, normal seed output.

4.2 FACTOR 2. GOOD RATES OF ESTABLISHMENT OF PPC SEEDLINGS ON CLAY-RICH SOILS

WestLand biologists have planted PPC seeds at ca 2 mm depth in clay-rich early and middle Pleistocene soils in several sites in the Altar and Santa Cruz Valleys. The seeded sites were protected by hardware cloth cages nailed to the ground. Seedling germination has been better than 80%. At one site, nearly ten years after planting the seeds, more than 40% of the seedlings that germinated are alive today (Attachment A). Other sites that have been seeded but not for as long suggest similar survivorship rates. These establishment and survival rates for seedling PPC are higher than initially expected. Clay-rich soils may be very important in sustaining PPC presence in an area because of the good establishment rates of PPC seeds. In contrast, we have observed much lower rates of germination and survival of PPC seeds and seedlings where seeds were planted on Holocene soils.

As described above in the section on geology, the clay-rich soils are found on early and mid-Pleistocene alluvial surfaces that are still intact. The densest PPC aggregations that we know occur on dark red, clay-rich soils in the Corona de Tucson area. One site, Mirasol, has over 80 PPC adults in less than 2 acres of this clay-rich alluvium. In this case, the distribution of PPC plants stops just before the contact between the mid-Pleistocene alluvial surface and the surrounding younger alluvium. The clay-rich soils of the aggregations of PPC along the proposed waterline is a shared feature of the densest known aggregations of PPC around Corona de Tucson, only several miles north and northeast of the Sycamore Fan.

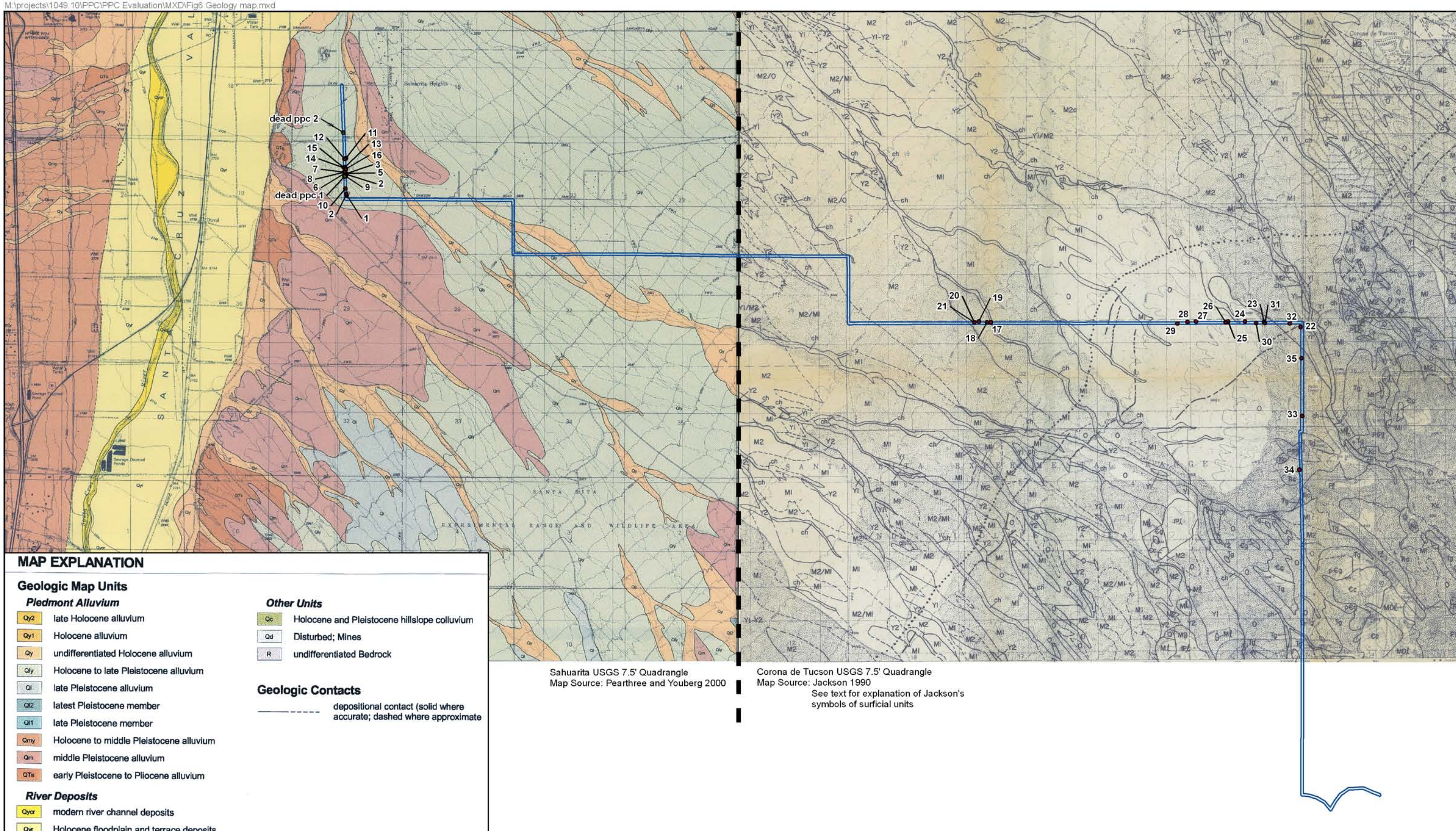
Open ridge lines appear to be preferred resting and defecation sites for *Lepus.* A few of the key characteristics of the ridge line sites chosen by *Lepus* – flat, open, bare patches of ground with few shrubs – make these same sites suitable for PPC establishment. Ridge lines suited both to resting *Lepus* and for PPC seedling establishment are likely to develop aggregations (patches or clusters) of PPC. *Lepus* dispersing PPC seeds directionally into sites preferred by *Lepus* and with good rates of PPC seedling establishment are likely to create a positive feedback loop, with aggregations of adult PPC plants emerging over time. Such sites are expected to persist for decades, but can cease as aggregations if grass cover and shrub density increase or jackrabbits vacate the area.

“Directional” seed dispersal by *Lepus* to clay-rich ridge line soils (where there is a ridge and swale topography) and high rates of seedling establishment on clay-rich soils are sufficient factors to account for the emergence of aggregations of adult PPC. At latrine sites favorable for seedling establishment, PPC patches are expected to develop over decades.

Several field experiments could be devised and carried out within a short period of time (two years) that would test components of the general hypothesis that PPC is a commensal of jackrabbits and occurs in association with jackrabbit latrines.

5. AMOUNT OF THE BELT-TRANSECT OCCUPIED BY PPC

As discussed above, there are three significantly aggregated patches of PPC along the proposed waterline. If we add the mean distance-to-nearest-neighbor (ca 100 m) to both ends of each of the three segments of the proposed waterline occupied by PPC, we obtain 0.72 miles for Aggregate A, 0.29 miles for Aggregate B, and 2.60 miles for Aggregate C – or a total of 3.61 miles occupied by PPC along the 15.77-mile proposed waterline. The occupied length represents 22.89% of the total proposed waterline. Portions of the 120-ft width along the proposed waterline have already been adversely impacted by dirt roads that lie within the 120-ft and parallel to the waterline route; a more detailed assessment of the footprint of these roads would doubtlessly reduce the amount of acreage impacted within the 3.61 miles occupied by PPC. In addition, segments of Aggregate C on the Sycamore Canyon Plio-Pleistocene alluvial fan cross deep ravines that dissect this fan. These ravines have slopes greater than 15% and the north-facing slopes are densely vegetated with shrubs; areas densely vegetated or with steep slopes are not occupied by PPC. The ravine segments could be subtracted from the 3.61 miles we determined is occupied by PPC.



PROPOSED WATERLINE FOR ROSEMONT PROJECT
Evaluation of Pima Pineapple Cactus Distribution

Surficial Geology Map
Figure 6

6. LITERATURE CITED

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ATTACHMENT A

PHOTO PAGES

Photo 1.

Photo 3.

Photo 2.

Photo 4.

Photographs of four PPC (#s 23, 28, 33, and 34) located in Aggregate C on the proposed waterline. Substrate of all four plants is a gravel lag over a clay-rich, reddish soil of early- to mid-Pleistocene age. These four plants occur on the older Pleistocene fan that was deposited near the mouth of Sycamore Canyon.

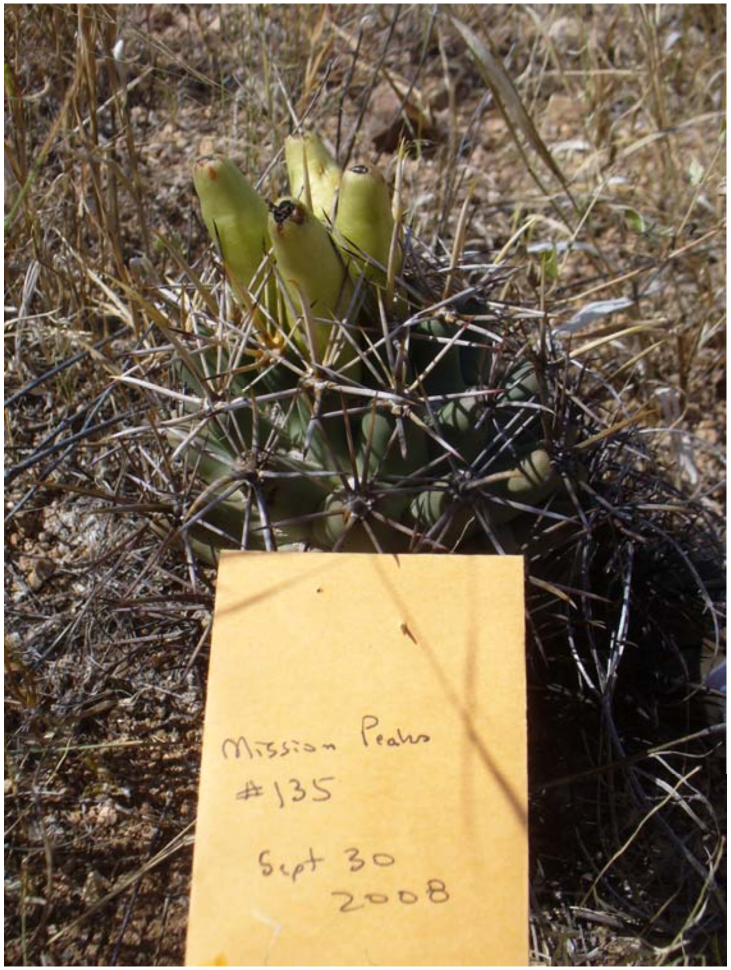

Photo 5. Four mature fruits on PPC #135 on Mission Peaks property west of Sahuarita, Arizona. Photograph taken

Photo 6. Eight PPC seedlings photographed October 13, 2008 growing on clay-rich soils in the Altar Valley. Of 10 seeds planted under small hardwood cloth cages, in the late summer of 2001, 8 seedlings survive today, of which the largest is 12.6 mm, the smallest 4.2 mm. Survivorship in this case was 80% during 7 years; the two seeds or seedlings died during the first season.