

DRAFT The Effect of Picture Rocks Road on Saguaros

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EXECUTIVE SUMMARY

Picture Rocks Road is a 2.9 mile section of road that bisects Saguaro National Park's Tucson Mountain District. Traffic has increased with development in Avra Valley, which is evidence of the road's main use as a commuter and commercial traffic route. Motor vehicle accidents on Picture Rocks Road account for the majority of accidents on roads in the Tucson Mountain District. Accidents on Picture Rocks Road caused an estimated \$40,000 or more in plant damage 2001-2002. Another threat to native plants along Picture Rocks Road is from poachers. Although all resources in the Park are protected, people have been caught illegally collecting plants and dead saguaro ribs. + boots

Because Picture Rocks Road receives such heavy use, we were interested to know what effects the road had on saguaros, for which the Park was established. We had three hypotheses: 1) there would be more dead saguaros away from the road than along road-sides because of collecting, 2) there would be more recruitment of saguaros near the road because of increased moisture from run-off, and 3) there would be more large saguaros away from the road because over time traffic accidents remove those near the road.

The stretch of Picture Rocks Road within the park was divided into 12 transects, six on each side of the road. Each "road" transect had a corresponding "interior transect." Surveyors walked a 10-m wide swath on one side of a tape measure. They located all saguaros and recorded distance from the tape, height, whether it was alive or dead and if dead, whether it was standing or had fallen.

There were more saguaros on combined interior transects than on combined road transects. The number of saguaros in the 1-2 m height class was greater in interior transects than in road transects ($p = 0.004$). The number of saguaros in the 2-4 m height class was also greater in interior transects than in road transects ($p = 0.0007$). The number of saguaros in height classes ≤ 1 m, 4-6 m, 6-8 m, and > 8 m for road transects was similar to interior transects (all $p > 0.2$).

When live saguaros were divided into six height classes, there was a significant difference between certain class proportions in road transects compared to interior transects ($p < 0.0001$). The greatest difference was for saguaros 2-4 m high, which comprised 11% of interior saguaros but only 4% of road saguaros. Saguaro 1-2 m high comprised 9% of interior saguaros and 6% of road saguaros.

There were significantly less saguaros 1-4 m high along the road compared to the interior. A rough age estimate for saguaros 1-4 m tall is 40-70 years old, so whatever has affected road-side cacti has occurred within the last 70 years. Saguaro > 1 m are difficult to poach, so loss could be from poaching during the last 30 years. Saguaro 4 m tall today would have been about 1 m tall 30 years ago and those 1 m tall today would have been about 0.04 m. Heavy poaching beginning in the mid-1970's would explain the loss of road-side plants 1-4 m tall today.

Gradual improvement in road condition may also explain the difference in number of saguaros 1-4 m tall between the two types of transects. These cacti would have been about 0.04-1 m tall in the mid-1970's, when Picture Rocks Road was gravel and then chip-sealed. By 1980, it was "improved and graded," and by 1990 it was paved. [As a road improves, people drive faster and are more likely to drive off the road, but they would probably try to avoid large cacti, certainly those > 1 m tall.]
can't avoid; accidents correspond more to curves? some spots had multiple accidents

The number of saguaros < 1 m high was greater, although not statistically, in interior transects than in road transects. It seems reasonable that recruitment along the road would be greater due to increased moisture from run-off, but if this is true, it appears to be offset by collecting or mortality of small saguaros along the road. Comparing recruitment along the road to interior transects of other cacti that are not as prone to theft may provide insight as to the amount of poaching of small saguaros that occurs. It would also be valuable to repeat this study every 10 years or so to determine if differences between road and interior transects become significant for saguaros that are < 1 m tall today.

INTRODUCTION

Picture Rocks Road is a 2.9 mile section of road that bisects Saguaro National Park's Tucson Mountain District. The road connects the northwestern side of Tucson (Ina Road) with the growing rural community of Avra Valley. Traffic counts for 2002 showed an average of about 7000 cars per day using Picture Rocks Road; this is more than four times the daily traffic volume compared to other Tucson Mountain District interior roads, and more than double the daily average on Sandario Road, on the district's west boundary. Unlike other interior roads that show spring seasonal peaks coinciding with park visitation, traffic on Picture Rocks Road is level year-round. Traffic has increased with development in Avra Valley, which is evidence of the road's main use as a commuter and commercial traffic route. Traffic on the road is heavy during morning and afternoon rush hours, and the set speed limit of 40 MPH is generally exceeded by an average of 10 MPH. The road was never designed for this high volume or speed of traffic.

Accidents involving spilled materials within the park on Picture Rocks Road to date have been of small scale (an electric transformer, wet cement, paint, motor oil, and gasoline). The potential for a more hazardous material spill is ever present; a large or especially toxic spill would be catastrophic, causing damage of park resources and requiring extensive clean up.

Motor vehicle accidents and DUI incidents on Picture Rocks Road account for the majority of accidents and incidents on roads in the Tucson Mountain District. Accidents destroy a significant amount of vegetation and wildlife habitat along the road edges and into the desert. The Park estimates that accidents on Picture Rocks Road caused over \$40,000 in plant damage costs over 2001 and 2002. *-of documented accidents - many are hit + run*

Exotic grasses have become an increasing problem by spreading along the roadsides. Buffel grass (*Pennisetum ciliare*), fountain grass (*Pennisetum setaceum*), bromes (*Bromus* spp.), Bermuda grass (*Cynodon dactylon*), Mediterranean grasses (*Schismus* spp.) and other exotic grasses increase the fire hazard and often out compete native plants.

A final threat to native plants along Picture Rocks Road is from poachers. Although all resources in the Park are protected, people have been caught illegally collecting plants and dead saguaro ribs.

boots

Because Picture Rocks Road receives such heavy use, we were interested to know what effects the road had on saguaros, for which the Park was established.

OBJECTIVES

Our objective was to determine the effects of Picture Rocks Road on saguaros growing along side of the road. We had three hypotheses:

1. There would be more dead saguaros away from the road than along the sides of the road because of collecting.
2. There would be more recruitment of saguaros near the road because of increased moisture from run-off.
3. There would be more large saguaros away from the road because traffic accidents remove them over time.

METHODS

The stretch of Picture Rocks Road within the park was divided into 12 transects, six on each side of the road (Figure 1). The transects varied in length from 350-1050 m long. These transects were 10 m wide, began 1 m in from where desert vegetation began along the side of the road, and ran parallel to the road. Each "road" transect had a corresponding "interior transect." Interior transects were 100 m in from the road, and were also 10 m wide and ran parallel to the road.

Surveyors recorded UTM's for the beginning and end points of each transect using a GPS unit. They put down a tape measure and walked the 10 m wide swatch on the side of the tape away from the road. They located all saguaros and recorded the distance from the tape (using a tape measure), the height (using a clinometer), whether it was alive or dead and if dead, whether it was standing or had fallen.

Data were entered into an Access database and analyzed using JMP-IN software (JMP®, SAS Institute). Live saguaros were placed in six height classes: 1) ≤ 1 m, 2) 1-2 m, 3) 2-4 m, 4) 4-6 m, 5) 6-8 m, and 6) > 8 m for some analyzes and in five height classes (classes 1 and 2 combined) for others.

RESULTS

There were more saguaros (including dead ones) on combined interior transects (1054) compared to combined road transects (700). For live saguaros only, there were 949 on interior transects and 638 on road transects (Figure 2).

The number of dead saguaros was greater in interior transects compared to road transects (paired t test, $t = 2.83$, 2-sided $p = 0.0162$). The mean difference in number was estimated to be 3.6 (± 1.3 SE, 95% CI = 0.8-6.4) per transect. The proportion of dead saguaros to the total number of saguaros was similar for combined road (9%) and combined interior transects (10%) (Table 1).

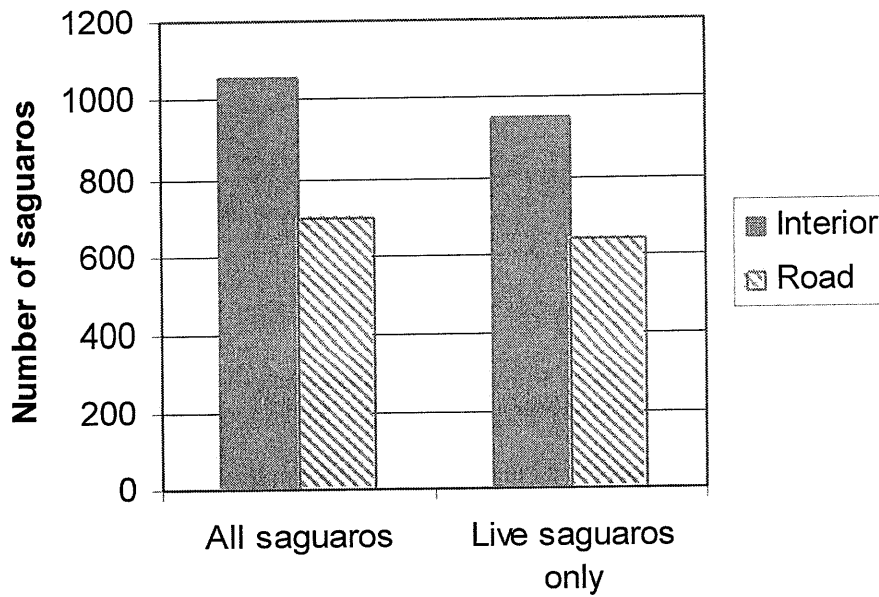


Figure 2. Number of saguaros on combined interior transects compared to combined road transects, Picture Rocks Road, Saguaro National Park, 2005.

Table 1. Number and proportion of live and dead saguaros in road and interior transects along Picture Rocks Rd., Saguaro National Park, 2005.

Height Class	Interior		Road	
	Number	%	Number	%
Dead	105	10	62	9
≤1 m	596	57	447	64
1-2 m	85	8	36	5
2-4 m	107	10	28	4
4-6 m	92	9	57	8
6-8 m	45	4	42	6
> 8 m	27	3	28	4
Total number	1054		700	

The number of saguaros in the 1-2 m height class was greater (mean difference = 3.8 ± 1.1 SE, 95% CI = 1.5-6.2) in interior transects than in road transects (paired t test, $t = 3.62$, 2-sided $p = 0.004$). The number of saguaros in the 2-4 m height class was also greater (6.6 ± 1.4 SE, 95% CI = 3.5-9.7) in interior transects than in road transects (paired t test, $t = 4.6$, 2-sided $p = 0.0007$). The number of saguaros in height classes ≤ 1 m, 4-6 m, 6-8 m, and > 8 m for road transects was similar to interior transects (paired t test, all 2-sided $p > 0.2$).

Of 1587 live saguaros on all transects combined, 66% (range 29.2-86.5%) were ≤ 1 m high. Only 2 transects had $< 50\%$ of saguaros that were ≤ 1 meter high (2I-29.2%, 9R-47.1%).

Only 9% (142) of live saguaros were > 6 m tall, and only 3% (55) were > 8 m tall. Almost half (11) of all transects had no saguaros > 8 m tall. Four interior transects and nine road transects contained saguaros > 8 m tall. Saguaro > 8 m tall comprised $> 10\%$ of live saguaros on only three transects: 9R-24%, 2I- 28%, 3I- 16%.

Mean height for live saguaros on road transects ($1.83 \text{ m} \pm 0.1$) was similar ($t = -0.397$, 2 sided $p = 0.6919$) to mean height for saguaros on interior transects ($1.78 \text{ m} \pm 0.1$). Estimated difference in height was $0.05 \text{ m} \pm 0.1$ (95% CI = $-0.3 - 0.2 \text{ m}$). When individual transects were compared, mean height was similar in all transects except for three. Transects 11R, 2I, and 9R had mean heights (3.4, 3.7, 4.1 m respectively) significantly higher than the other 21 transects (Tukey-Kramer all pairs comparison $\alpha = 0.05$).

When live saguaros were divided into six height classes, there was a significant difference between certain class proportions in road transects compared to interior transects (Pearson $\chi^2 = 34.2$, $p < 0.0001$). The greatest difference was for saguaros 2-4 m high. This class comprised 11% of interior saguaros but only 4% of road saguaros. Saguaro 1-2 m high comprised 9% of interior transect saguaros and 6% of road transect saguaros. Although saguaros ≤ 1 m high were a greater proportion of road saguaros (70%) compared to interior saguaros (63%), there were more plants this size in the interior (596) compared to the road (447).

When classes 1 and 2 were combined to make classes in 2-m increments, another difference between road and interior transects became apparent. For interior transects, numbers (Table 2), and proportions (Figure 3), of saguaros decreased progressively with increasing size classes. In road transects, the number and proportion of saguaros also decreased with each class, except that the number and proportion of saguaros in the 2-4 m class were less than in the 4-6 m class.

Table 2. Number and proportion of live saguaros divided into 5 height classes for interior and road transects on Picture Rocks Rd, Saguaro National Park, 2005.

Height Class	Interior		Road	
	Number	%	Number	%
$\leq 2 \text{ m}$	678	71	483	76
2-4 m	107	11	28	4
4-6 m	92	10	57	9
6-8 m	45	5	42	7
$> 8 \text{ m}$	27	3	28	4

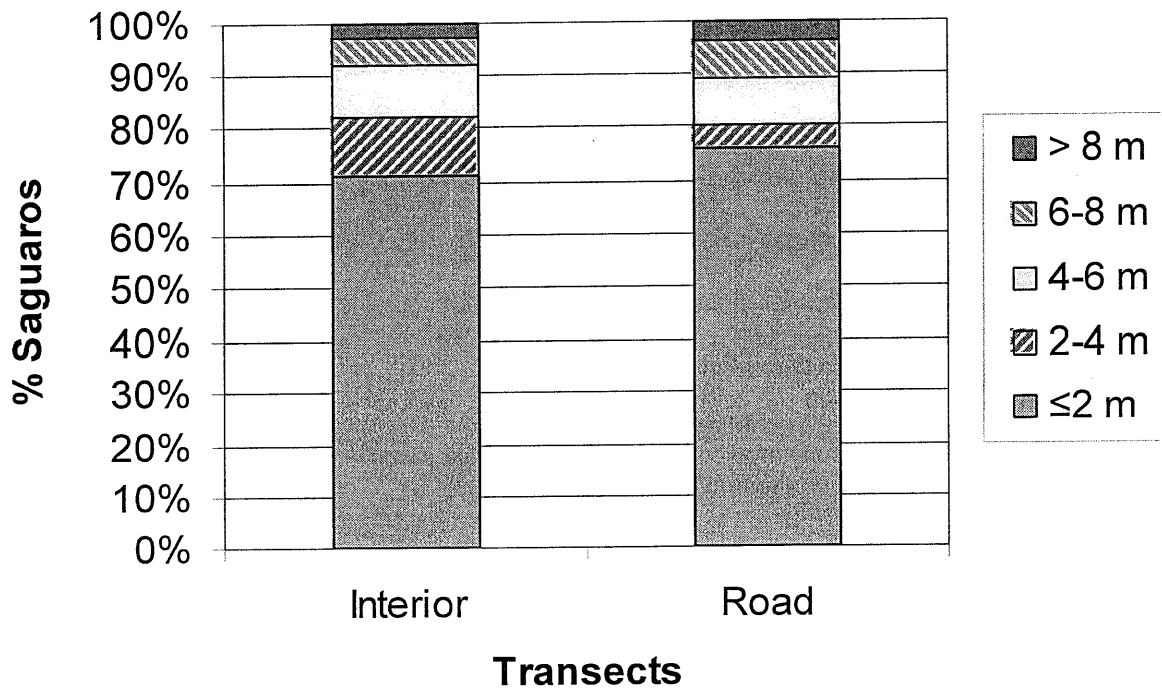


Figure 3. Proportions of live saguaros in five height classes in interior transects compared to road transects, Picture Rocks Road, Saguaro National Park, 2005.

DISCUSSION

For saguaros > 4 m tall, there was no difference between the number in road transects compared to interior transects. Saguaro > 4 m tall are about 70 years old or older; data from this study indicate there was no significant poaching or difference in mortality (compared to interior transects) for saguaros along the road before about 1935. In addition to a similar number of older saguaros on interior and road transects, the population structure of older saguaros in both types of transects was similar. Something then, has affected saguaros along the road within the last 70 years, and may still be affecting saguaros today. We have two hypotheses. The first is that the loss of saguaros along the road was, and is, due to poaching and by damage from vehicles running off the road. The second is that there was lower recruitment along the road for some period of time, which may be continuing. These hypotheses are not mutually exclusive.

Interior transects contained 50% more saguaros than road-side transects. One difference appears to be in the number of dead saguaros. The lower number of dead saguaros along the road-sides supports the hypothesis that collection of dead saguaros is occurring. It is puzzling, however, why the proportion of dead saguaros to total number of saguaros was similar in road and interior transects.

In addition to the difference in the number of dead saguaros, there was a significantly lower number of saguaros 1-4 m high along the road compared to the interior. The loss of saguaros 2-4 m high is

readily apparent from Figure 3. When grouped by height in 2-m increments, there were progressively fewer saguaros as height increased for saguaros in interior transects. Because saguaros grow taller with age, interior saguaros illustrate the normal age pyramid. In contrast, there was a sharp decrease in road-side saguaros 2-4 m tall; otherwise, the height/age pyramid was normal. Based on paired *t*-test results, saguaros 1-2 m tall were also significantly fewer in road transects than interior ones. A rough age estimate for saguaros 1-4 m tall would be 40-70 years old. Saguaros 4 m tall today would have been about 1 m tall 30 years ago. If we assume that saguaros > 1 m are difficult to poach, loss could be from poaching within the last 30 years. Saguaros 2 m tall today would have been about 0.3 m tall 30 years ago, and saguaros 1 m tall today would have been about 0.04 m tall 30 years ago, about the smallest size someone would notice. If heavy poaching began in the mid-1970's, it is likely that collectors have taken more plants 0.3-1 m in height than those < 0.3 m because the small ones are harder to find and take longer to grow. This may explain why there is a difference between road and interior transects in the number of saguaros 2-4 m high, and why there is not as great a difference between transects for saguaros 1-2 m high.

If loss of saguaros was, and continues to be, caused by vehicle damage, it is also likely that significant loss began 25-30 years ago. Drivers are more likely to swerve to avoid large cacti, certainly those > 1 m tall, because these saguaros are easier to see and would do more damage to a vehicle than small ones. Prior to 1974, Picture Rocks Road was gravel and then chip-sealed. By 1980, it was "improved and graded," and by 1990 it was paved. As a road improves, people drive faster, and thus are more likely to drive off the road into vegetation. Gradual improvement in road condition may therefore at least partly explain the difference in number of saguaros 1-4 m tall between the two types of transects, as these cacti would have been about 0.04-1 m tall in the mid-1970's.

Although the difference between saguaros < 1 m tall in interior transects vs. road transects was not statistically significant, the total number of saguaros in that height class was greater in interior transects (596) than in road transects (447). It seems reasonable to assume that recruitment along the road would be greater due to increased moisture from run-off, but if this is true, it appears to be offset by poaching of, or vehicle damage to, small saguaros along the road sides. Soil compaction from vehicle, horse, and foot traffic may also lower recruitment of road-side saguaros. Comparing the recruitment along road and interior transects of other cacti that are not as prone to theft may provide insight as to the amount of poaching of small saguaros that occurs. It would also be valuable to repeat this study every 10 years or so to determine if differences between road and interior transects become significant for saguaros that are < 1 m tall today.

It is interesting to note that the tallest saguaros, those > 8 m tall, were distributed more evenly among the road transects than among the interior transects. Only four, or one-third, of interior transects contained saguaros in this height class, compared to nine, or three-quarters, of road transects. Although just conjecture, this may indicate that for those saguaros that survive to a height too tall to poach, or are not damaged by vehicles, the extra water from runoff increases growth. The four interior transects were all at the east end of the study area, and may have benefited from a more favorable microclimate than the majority of interior sites.

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more difficult to poach cacti today. Paved roads, few pull-offs, lots of traffic