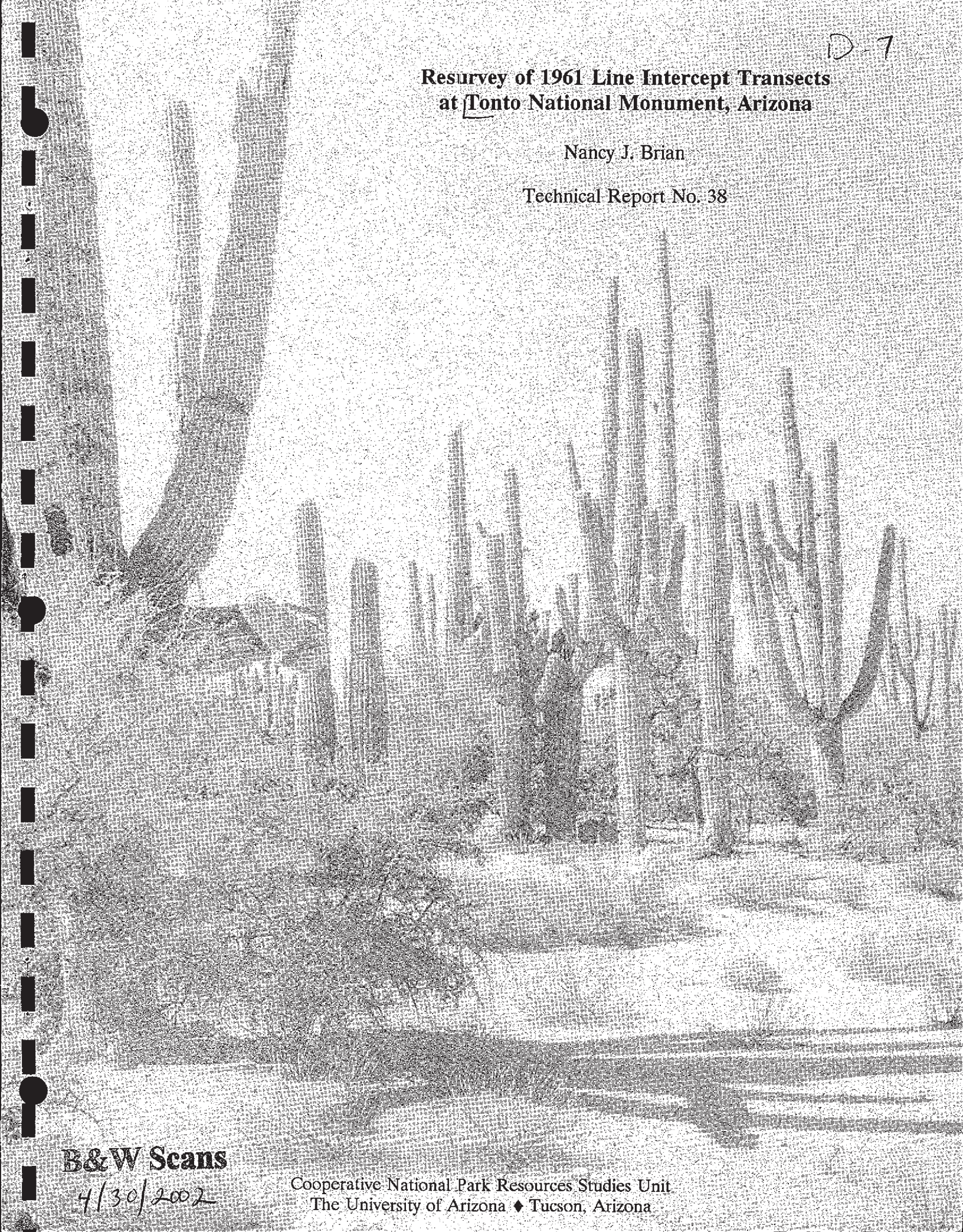


D-7

Resurvey of 1961 Line Intercept Transects
at Tonto National Monument, Arizona

Nancy J. Brian

Technical Report No. 38



B&W Scans

4/30/2002

Cooperative National Park Resources Studies Unit
The University of Arizona ♦ Tucson, Arizona



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Final Report

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July 1991

Cooperative National Park Resources Studies Unit
School of Renewable Natural Resources
The University of Arizona
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ABSTRACT

Five line transects at Tonto National Monument were resurveyed in 1986 and the results compared to a 1961 survey. Differences in field techniques and data presentation, as well as management practices, made comparisons difficult. However, jojoba (*Simmondsia chinensis*) remains the most abundant species in the monument, followed by foothill palo verde (*Cercidium microphyllum*) and brittlebush (*Encelia farinosa*).

INTRODUCTION

The National Park Service Southern Arizona Group Office (SOAR) contracted the author to relocate, read, and interpret (using the same sampling and interpretation methods) five line intercept transects originally studied in 1961 by Charles William Strong at Tonto National Monument (TONT), Gila County, Arizona. This report presents the results of the 1986 resurvey of over 9,500 ft (over 2,900 m). Strong's unpublished final report, dated 1962, is presented in Appendix 1. The flora of TONT is classified as part of the Arizona Upland Subdivision of the Sonoran Desertscrub (Brown 1982), sometimes referred to as the Arizona, or Upland Desert. Floral collections for the monument were made by John Peavy in 1940, William Bromberg in 1958, and an inventory was prepared by Robert Burgess (aided by Charles Strong in 1961) [1965].

METHODS

1961 METHODOLOGY

Strong began his work at Tonto National Monument, Arizona in June 1961 and completed it the first week of December 1961. The line intercept method was used; however, Strong did not outline the procedure. It is assumed that Strong used the line intercept method as outlined by Parker and Savage (1944), a technique that was originally developed by Bauer in the late 1930s. The line intercept method is a technique for quantitatively determining both basal and aerial plant cover area, by actual measurement along a randomly oriented straight line (Brower and Zar 1977; Cain and Castro 1959; Phillips 1959; Lindsey 1955). The total length of the plant cover along the line is accepted as a numerical value representing the cover or ground surface occupied by the plants. Cover is considered to be the best criterion for ascertaining succession, responses following management, or other ecological changes. The method is most suitable for sparse vegetation in which the limits of the individual plants are quite distinct. It has been used with success in the semi-arid vegetation of Arizona, the southwestern Great Plains mixed grassland shrub, the northern Dakotan bunchgrass pastures, California chaparral, Australian sparsely covered natural pastures, and reproductive studies conducted in forest communities. It is suitable for large and small areas in prairie ranges, chaparral, and forest communities.

Strong's original field data notes are not available, so it is difficult to recalculate his measurements to verify how the results were obtained. Strong made his readings in English units and recorded intercepts along the line accurate to 0.01 ft. It is assumed that he followed the Parker and Savage method by counting herbaceous vegetation only within a 1-cm belt of the transect line (National Academy of Sciences 1962). Also, it is assumed that he followed the convention that grasses, rosettes, and dicotyledonous herbs are measured along the line at ground level, while shrubs and tall dicotyledonous herbs are measured along the "shadow", or distance covered by a downward projection of the edge of the foliage above the line.

Strong (1962) stated that as the late spring, summer, and early fall of 1961 were unusually dry, he recorded only three groups of plants: perennial trees, shrubs, and "miscellaneous", i.e., those species that were neither trees nor shrubs and members of the plant families Fouquieriaceae (ocotillo), Cactaceae (cactus), and Agavaceae (agave). He placed five transect lines, which he labeled A through E, on compass lines running north-south or east-west (Strong's map, p. 59; Table 1). Directions for relocating his transect beginnings and ends are indicated in a hand drawn map (apparently redrawn in 1963 by Hank Jones) and briefly described in the report. Bare ground between plants was not measured and/or listed.

Strong presented the results of his field work for each separate transect in three subsets or growth habits (trees, shrubs, "miscellaneous"), rather than for all the vegetation along the entire transect line or lines, the common method for line intercept analysis. He listed the species by genera (except for a few cacti), in some cases combining two species of the same genera. A significant example of this is palo verde (*Cercidium* spp). Two species are present at the monument: foothill palo verde (*C. microphyllum*) and blue palo verde (*C. floridum*). Both were noted to be abundant throughout the monument by Burgess (1965).

Table 1. Basic information on transect lines placed by Strong in 1961. Transects were read in late spring, summer, and early fall.

Transect	Length		Orientation
	Feet	Meters	
A	6,000	1,800	North-South
B	1,100	330	East-West
C	850	255	East-West
D	1,000	300	East-West
E	1,000	300	East-West

Strong included up to seven data sets for each transect subset: number of intercepts, total intercepts (in feet), average intercept (in feet), percent cover, percent frequency, relative cover, and relative frequency. These terms are defined for the reader in a glossary in Appendix 2. It is not known how percent frequency, as defined in Appendix 2, was interpreted by Strong (see "Discussion" section of this report). Only percent frequency is listed for the "miscellaneous" group in Transect A, due to "certain philosophical problems having to do with validity of other statistics and this method of measurement when applied to these life forms" (Strong 1962). (It is not clear what Strong meant by this statement).

Strong also listed 87 vascular plant species that he collected during the study, although he only recorded line intercepts for 31 species (or 36% of the species he collected), including five trees, fourteen shrubs, and twelve "miscellaneous". In addition, Strong censused a small deciduous community at the bottom of Cave Canyon, formerly known as Cholla Canyon (see Appendix 3, Note 1) using a modified stratified random sampling technique. He obtained (but did not report) basal area figures on all trees greater than 0.4 ft in circumference at breast height and enumerated trees less than that circumference.

1986 METHODOLOGY

The author, assisted by a field assistant, relocated and resurveyed the transect lines (Fig. 1) over a series of three weekends from September through December 1986 (Table 2). The author "read" the intercepts by noting the species and calling out the beginning and the end of intercept, after which a new reading was made. The assistant wrote down the intervals on a prepared data sheet (Appendix 4). Samples of unknown plants on transect were collected from the same species near the transect line for later identification.

A 100 m (300 ft) Keson fiberglass tape measure was placed along the ground in a straight line using a hand held compass for sighting (declination was used for magnetic correction). Metric measurement was chosen because metric is the accepted unit of measurement in scientific investigations and metric units can easily be converted to approximate English units. Single plants whose cover overlapped two sets (for example, 99 m on the first leg to 1 m on the second leg) were circled to indicate one individual. In cases where the shrub cover was so dense as to make placing the tape on the ground not practical, the tape was placed upon the horizontal surface of the shrubs and pulled taut. In cases where a "cliff" or the edge of a large boulder on a slope was encountered along the transect line, measurements were stopped at the top or edge and the tape repositioned at the base of the cliff. All measurements were made in metric units, with readings accurate to 1 cm. Intercepts of bare ground were noted, as well as points of interest that intersected the transect line (e.g., rocks, fence posts, trails, and washes). Frequency was noted by presence or absence of a species in every 15 m section along the transect (i.e., 0-15, 15-30, 30-45, etc.). Common and scientific names of plants are listed in Appendix 5.

All plants that intersected the transect line were included in the data collection effort (Strong recorded only 31 species). An exception to this rule was made for the annual, single stemmed, exotic grass red brome (*Bromus rubens*). This species had "cured out", was generally found under the canopy cover of large shrubs and trees on Transects D and E, and was not included in the data collection. Counting every individual along the one centimeter wide transect line would have been time-consuming and yielded useless information.

On Transect B, red brome was significant and it was noted as a dicotyledonous herb by measuring the distance of each "clump" or section. This did bias the number of intercepts for relative density as density is defined by the number of individuals of a species on a unit of area. Notes on the presence of red brome were taken and included on the data sheets.

The five line transects can be resurveyed by using the notes on the 1986 data sheets outlined below. Strong's description of the transect start and end points were not clear and did not enable exact replication of the line. Two examples of vague and indefinite

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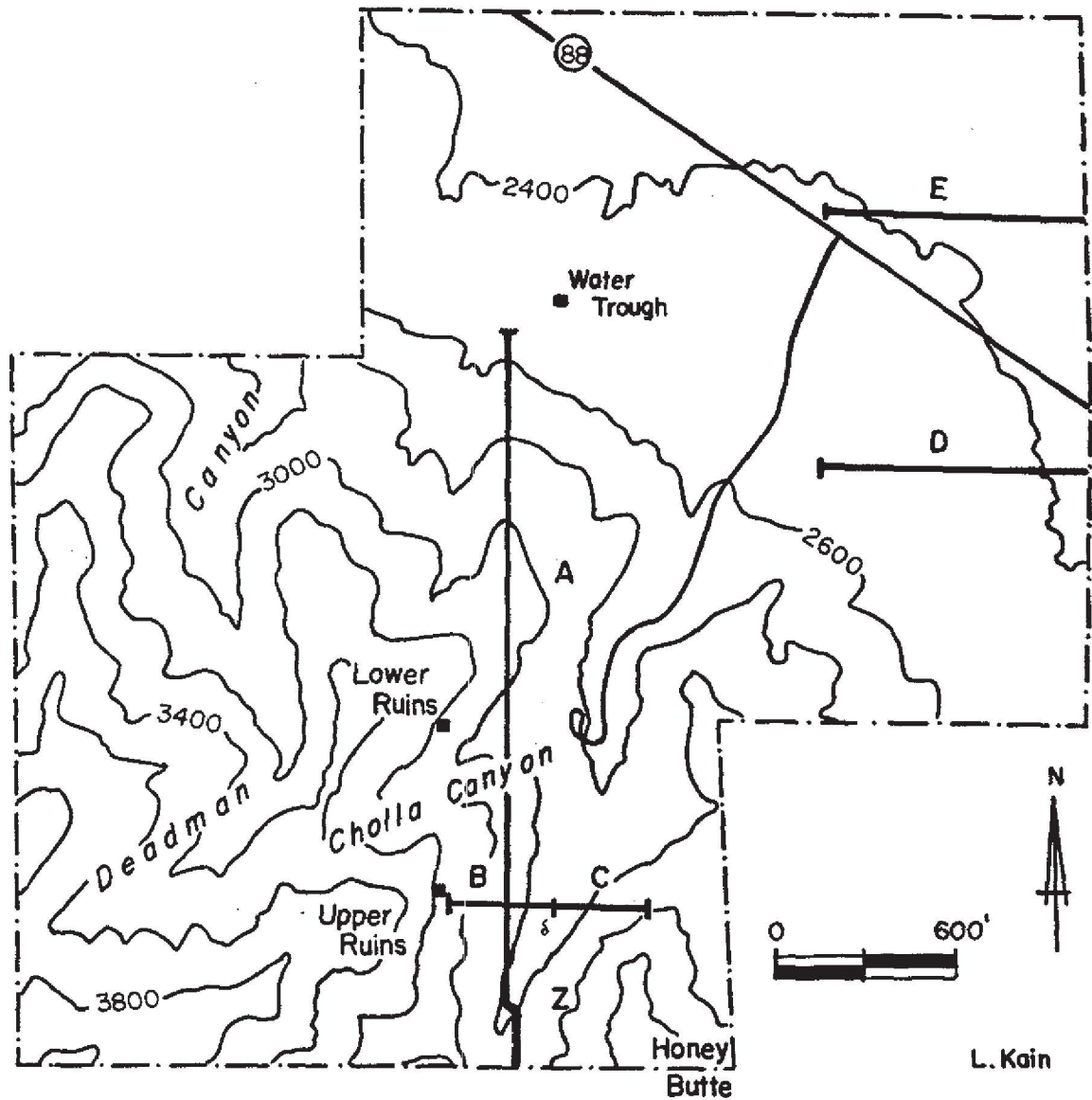


Figure 1. Topographic map of Tonto National Monument showing approximate locations of line intercept transect lines (A, B, C, D, E, and Z). (Adapted from USGS topographic maps (1964a and 1964b). Cholla Canyon is now known as Cave Canyon.

directions are Strong's (1962) statements, "beginning at a point on the East boundary approximately 300 ft above Highway 88" and "beginning at the base of the cliff on Honey Butte".

Table 2. 1986 transect information.

Transect	Length		Date (1986)	Orientation
	Meters	Feet		
A + Z	1400 + 400	4620 + 1320	Nov. 15-16 and Dec. 13	North-South
B	308.5	1018.05	Sept. 27	East facing
C	170.16	561.53	Sept. 28	West facing
D	300	990	Sept. 28	East-West
E	300	990	Nov. 15	East-West

RELOCATION OF TRANSECTS

Transect A

The start of this transect was originally begun from the southern boundary of the monument in Cave Canyon. However, Strong's "jog" at 75 ft did not displace the transect line west of the wash as indicated in Figure 1. Therefore, the transect was restarted at the northern end of the line because that "end" of the transect was more easily located. The fence line mentioned in Strong's description and labelled on the 1963 hand drawn map is no longer in place (it is shown on the 1964 topographic maps). Therefore, the transect line was relocated by estimating the distance and angle between the water trough (see location on Fig. 1) and the "end" or northern part of Transect A. To locate the water trough, walk overland from the intersection of the security gate on the main monument road by the private residence road and follow the semi-buried pipeline that leads to the "trough" made of concrete. A cairn of rocks was constructed to mark the start of Transect A. Fourteen sets of 100-m (660-ft) transects heading due south comprise Transect A. In the 14th leg of Transect A, the transect line intersected the edge of the wash in Cave Canyon at the 86-m (283.8-ft) mark. At the end of the 1,400 m (4,620 ft), the transect intersects the creek channel near the trunk of a netleaf hackberry (*Celtis reticulata*) tree. (To locate this spot, walk forty paces up the trail (to the south) from the rock bridge by the Arizona dewberry (*Rubus arizonensis*) population, look west to see a man-made pile of rocks which had been placed to divert any flash floods into the main stream channel, thus keeping water off the trail. The transect ends in the stream channel between this point and the netleaf hackberry tree.)

Since Transect A ended "prematurely", i.e., at 1,400 m (4,620 ft) of an 1,800-m (5,940-ft) transect, a new transect was run in order to extend Transect A to match the total length of Strong's original transect. This addition would also include more information from the community on the east-facing slope above Cave Canyon and below the Upper Ruins. We named this new transect, Transect Z. Line intercept data were collected for 400 m (1,320 ft) to bring the total for the north-south transect to 1,800 m (6,000 ft). To locate the beginning of Transect Z, walk along the Cave Canyon trail to the southern boundary line of the monument marked by a barbed wire fence. The trail to the Upper Ruins switchbacks up the slope from this point. Walk along the southern boundary fence (heading west) until you reach a corner in the fence (this is visible from the southern boundary line). This point is 84 m (277.2 m) from the southern boundary line and located at the second switchback of the Upper Ruins trail. Transect Z runs due north for 400 m (1,320 ft).

Transect B

This transect was relatively easy to relocate as it begins "5 feet east of the bench mark at the Upper Ruins" and runs "due east to the bottom of Cholla Wash - total distance, 1,100 feet" (Strong 1962). The U.S. Geological Survey bench mark is easy to locate. Five sets of transects (equal to 56, 70, 53, 69, and 60.5 m in length) comprise the line intercept for a total of 308.5 m (1,018.05 ft). However, it is 21.5 m (70.95 ft) short from the 330 m (1,100 ft) surveyed by Strong. The discrepancy may be due to many things: two "cliffs" (or large rock outcrops) on the transect where Strong may have run his measurement tape along the vertical surface, Strong's tape placement was not as taut, or other differences in methodology. Red brome was counted as a dicotyledonous herb by noting discrete patches as an individual.

Transect C

The start of Transect C was difficult to locate due to its vague beginning at the base of the cliff on Honey Butte. However, it ran due east to the bottom of Cholla Wash and according to Strong's map was a straight line "continuation" of Transect B. Thus, a sighting was made to align with plants known to be on Transect B on the opposite slope (large saguaros (*Carnegiea gigantea*), boulders, cliffs, the ruins, etc.). A point at the base of Honey Butte was chosen at the base of a jojoba (*Simmondsia chinensis*). Two sets comprise Transect C (equal to 72 and 98.16 m). A new start was made because of a cliff at 72 m. Notes are made on the field data sheets of several "points of interest" along Transect C that enable relocation of the line: a large rock cairn which was approximately 10-15 m north of the transect line at the first 53-m mark, a cliff at the first 51.1-m mark, a scree field at the first 66.5-68.8-m mark and the second 40.4-73.3 and 77.2-78.5-m mark, stream bed at the second 90-m mark, evidence of a burn at the second 5-m mark. Again, the transect was shorter than the original Strong transect. The 1986 transect was 170.16 m (561.53 ft), or 86.54 m (288.47 ft) short of the 255-m (850-ft) transect. The

discrepancy could be the result of many factors: we may not have started at the correct "base of Honey Butte"; Strong may have laid his tape along the vertical face of several small cliffs; or other differences in methodology may have occurred.

Transect D

The information about the location of this transect was also vague. To approximate the start of the transect, we first located the eastern fenced boundary of the monument along Highway 88. We measured from the center line of the highway to the highway fence and telephone line (102 ft), then measured (198 ft) along the east boundary fence. The start of the transect began near the bottom of a gully at a green fence post. The transect ran due east toward the private residences on the monument. A total of 333 m were read for Transect D in four sets (equal to 94, 75, 92, and 72 m or 310, 247.5, 303.6, and 237.6 ft). However, data for comparison on this transect were included up to the 39-m (128.7-ft) mark on the fourth set to total an equivalent length of 300 m (1,000 ft). The center of a wash was noted at the 82.4-m (271.9-ft) mark on the first set. Red brome was tabulated as area covered rather than individual stems since it occurred throughout the community under the shade of shrub and tree canopies.

Transect E

The start of Transect E was difficult to locate because Strong's description only noted, "Transect E - beginning at the Northeast fence boundary below Highway 88 was run due west - total distance 1,000 ft." (Strong 1962). However, the hand-drawn map gave the indication that the start was close to an unimproved dirt road. Thus, we began the transect at the intersection of the eastern boundary fence and the "boundary" on the south side of the cattleguard along the dirt road and continued due east for 300 m (1,000 ft). Three sets of 100 m (330 ft) each comprised the transect; however, the end of the transect did not stop next to the fenceline along the highway as indicated by Strong's map. Red brome was not tabulated as it occurred throughout the community under the shade of shrub and tree canopies.

In summary, only Transect B was relatively easy to relocate with confidence, given the description and map location from Strong's final report. All other transects were in their approximate locations but it is doubtful whether the beginnings or ends were identical to Strong's original transects. However, the inability to relocate the transects that had been surveyed 26 years previously, is not surprising given the rough terrain, lack of cairns or metal rods driven into the ground to mark transects, and accurate measurements from permanent locations (as in Transect B's bench mark). It is unfortunate that Strong did not design his study with some type of permanent location markings and directions that could be used to mark transect lines and important features along the transect. It is possible that the transects could have been relocated by using the original data sheets, which (if they were noted correctly) would mark the plant intercepts as they were noted in 1961.

RESULTS

1986 LINE TRANSECT SURVEY

The results of the 1986 line intercept calculations are given in Tables 3 through 7 for Transects A through E. Line intercept quantitatively determines areas of both basal and aerial plant cover by actual measurement along a straight line. Jojoba was shown to be the dominant species in TONT, followed by foothill palo verde and brittlebush. Other common species include snakeweed (*Gutierrezia microcephala*), spurge (*Euphorbia* sp.), *Keckiella antirrhinoides* (a bushy penstemon), honey mesquite (*Prosopis glandulosa* var. *torreyana*), globe mallow (*Sphaeralcea* sp.), three-awn (*Aristida parishii*), desert straw (*Stephanomeria pauciflora*) or wire lettuce, and desert senna (*Senna covesii*). All species encountered along the transects are listed and they are not separated by growth habitat as per Strong's report. Line intercept calculations are given for each transect.

A total of 71 different species was encountered: 56 species on Transect A, 28 species on Transect B, 21 species on Transect C, 15 species on Transect D, and 14 species on Transect E. More species were probably encountered on Transect A because it was about six times as long as the other transects.

Importance value is the sum of relative density, relative cover (or dominance), and relative frequency. Importance value gives an overall estimate of the influence or importance of a plant species in the community. Importance value has the advantage of using more than one measure of influence. However, there are disadvantages that should be recognized: similar values are attained for different combinations of the three relative values, the term "importance" may be interpreted differently by different ecologists; and three different yet not independent measures are summed.

The ranking of the top five plant species by importance value for each transect are in descending order:

Transect A: jojoba, brittlebush, snakeweed, globe mallow, foothill palo verde

Transect B: red brome, brittlebush, spurge, jojoba, three-awn

Transect C: jojoba, globe mallow, brittlebush, three-awn, desert straw

Transect D: jojoba, foothill palo verde, *Keckiella antirrhinoides* (no common name), brittlebush, desert senna

Transect E: jojoba, foothill palo verde, honey mesquite, *Keckiella antirrhinoides*, snakeweed

Table 3. Plant species data for Transect A. Transect length is 1,800 m (120 intervals of 15 m each).

Scientific Name	No. of Indiv.	Sum of Intercept		Frequency Interval	Average Intercept	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency	Relative Density	Importance	
		Metric	English								Value	Rank
<i>Lycium fremonti</i>	28	31.80	104.94	22	1.14	1.77	18.33	3.69	4.41	2.58	10.76	
<i>Acacia greggii</i>	11	21.65	71.45	9	1.97	1.20	7.50	2.51	1.84	1.01	5.36	
<i>Gutierrezia microcephala</i>	186	60.60	199.98	40	0.04	3.37	33.33	7.03	8.16	17.02	32.21	3
<i>Simmondsia chinensis</i>	192	235.65	777.65	85	1.22	13.09	70.83	27.32	17.35	17.66	62.33	1
<i>Prosopis glandulosa</i> var. <i>torreyana</i>	11	42.55	140.42	9	3.87	2.36	7.50	4.93	1.84	1.01	7.78	
<i>Phoradendron californicum</i>	1	1.10	3.63	1	1.10	2.36	4.93	1.84	1.01	7.78		
<i>Senna covesii</i>	12	2.59	8.55	3	0.22	0.14	2.50	0.30	0.61	1.10		
<i>Encelia farinosa</i>	199	112.25	370.43	71	0.06	6.24	59.17	13.01	14.49	18.31	45.81	2
<i>Opuntia acanthocarpa</i>	19	14.50	47.85	15	0.76	0.81	12.50	1.68	3.06	1.75	6.49	
<i>Sphaeralcea</i> sp.	80	22.30	73.59	26	0.28	1.24	21.67	2.68	5.30	7.36	15.24	4
<i>Opuntia phaeacantha</i>	8	12.55	41.42	7	1.57	0.70	5.83	1.45	1.43	0.74	3.62	
Unknown #1	7	3.85	2.01	4	0.55	0.21	3.33	0.45	0.82	0.64	1.91	
<i>Ambrosia confertiflora</i>	48	24.42	80.59	20	0.51	1.36	16.67	2.83	4.08	4.42	11.33	
<i>Porophyllum gracile</i>	28	9.51	31.38	21	0.34	5.28	17.50	1.10	4.29	2.58	7.97	

Table 3 (Continued).

Scientific Name	No. of Individ.	Sum of Intercept*		Frequency Interval	Average Intercept	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency	Relative Density	Importance	
		Metric	English								Value	Rank
<i>Platanus wrightii</i>	3	0.55	1.82	3	0.18	0.03	2.50	0.06	0.61	0.28	0.95	
<i>Bouteloua curtipendula</i>	4	8.07	26.63	3	2.02	0.45	2.50	0.94	0.61	0.37	1.92	
<i>Keckiella antirrhinoides</i> ssp. <i>microphylla</i>	6	8.90	29.37	6	1.48	0.49	5.00	1.03	1.22	0.55	2.80	
<i>Aristida parishii</i>	47	16.15	53.30	22	0.34	0.90	18.33	1.87	4.49	4.32	10.68	
<i>Cheilanthes fendleri</i>	8	1.50	4.95	7	0.19	0.08	5.08	0.17	1.45	0.74	2.34	
<i>Ferocactus acanthodes</i>	3	0.50	1.65	3	0.17	0.02	2.50	0.06	0.61	0.27	0.94	
<i>Echeveria collomiae</i>	7	0.41	1.35	5	0.06	0.02	4.17	0.04	1.02	0.64	1.70	
<i>Cercidium microphyllum</i>	24	68.20	225.06	10	2.84	3.79	8.33	7.91	2.04	2.21	12.16	5
<i>Galium stellatum</i>	2	0.80	2.64	2	0.40	0.04	1.67	0.09	0.41	0.18	0.68	
<i>Aloysia wrightii</i>	5	4.45	14.69	3	0.89	0.25	2.50	0.52	0.61	0.46	1.59	
<i>Fouquieria splendens</i>	4	5.10	16.83	3	1.28	0.28	2.50	0.59	0.61	0.37	1.57	
<i>Mammillaria microcarpa</i>	1	0.04	0.13	1	0.04	T***	0.83	T***	0.20	0.09	0.29+	
<i>Bebbia juncea</i>	3	1.70	3.63	3	0.57	0.09	2.50	0.20	0.61	0.27	1.08	
<i>Baccharis sarothroides</i>	2	2.80	4.79	2	1.40	0.16	1.67	0.32	0.41	0.18	0.19	

Table 3 (Continued).

Scientific Name	No. of Indiv.	Sum of Intercept*		Frequency Interval	Average Intercept	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency	Relative Density	Importance	
		Metric	English								Value	Rank
<i>Carnegiea gigantea</i>	4	3.45	4.79	4	0.86	0.19	3.33	0.40	0.82	0.37	1.59	
<i>Yucca baccata</i>	8	5.95	19.64	1	0.74	0.33	0.83	0.69	0.20	0.74	1.63	
<i>Dasyllirion wheeleri</i>	5	7.95	26.24	5	1.59	0.44	4.17	0.92	1.02	0.46	2.40	
<i>Krameria parvifolia</i>	7	3.20	10.89	2	0.46	0.18	1.67	0.37	0.41	0.64	1.42	
<i>Heteropogon contortus</i>	18	4.40	14.52	6	0.24	0.24	5.00	0.51	1.22	1.66	3.39	
<i>Opuntia bigelovii</i>	7	3.66	12.08	5	0.52	0.20	4.17	0.42	1.02	0.64	2.08	
<i>Trixis californica</i>	2	1.80	5.94	2	0.90	0.10	1.67	0.21	0.41	0.18	0.80	
<i>Notholaena cochinchensis</i>	6	0.55	1.82	2	0.92	0.03	1.67	0.06	0.41	0.55	1.02	
Unknown #3	2	0.70	2.31	2	0.35	0.04	1.67	0.08	0.41	0.18	0.67	
<i>Stipa speciosa</i>	3	1.10	3.63	3	0.37	0.06	2.50	0.13	0.61	0.28	1.02	
<i>Euphorbia</i> sp.	1	0.20	0.66	1	0.20	0.01	0.83	0.02	0.20	0.09	0.31	
<i>Haplopappus spinulosus</i>	3	0.65	2.15	3	0.21	0.04	2.50	0.07	0.61	0.28	0.96	
<i>Canotia holacantha</i>	1	4.50	14.85	1	4.50	0.25	0.83	0.52	0.20	0.09	0.81	
<i>Eriogonum fasciculatum</i>	22	11.80	38.94	11	0.54	0.66	9.17	1.37	2.24	2.02	5.63	

Table 3 (Continued).

Scientific Name	No. of Indiv.	Sum of Intercept*		Frequency Interval	Average Intercept	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency	Relative Density	Importance	
		Metric	English								Value	Rank**
<i>Muhlenbergia microsperma</i>	1	0.55	1.82	1	0.55	0.03	0.83	0.06	0.20	0.09	0.35	
<i>Cirsium neomexicanum</i>	5	1.85	6.11	4	0.37	0.10	0.33	0.21	0.82	0.46	1.49	
<i>Bothriochloa barbinodis</i>	17	8.90	29.37	9	0.52	0.49	7.50	1.03	1.84	1.56	4.43	
<i>Selaginella arizonica</i>	6	7.00	23.10	3	1.17	0.39	2.50	0.81	0.61	0.55	1.97	
<i>Artemisia dracunculoides</i>	1	1.30	4.29	1	1.30	0.07	0.83	0.15	0.20	0.09	0.44	
<i>Celtis reticulata</i>	1	3.30	9.90	1	3.00	0.17	0.83	0.35	0.20	0.09	0.64	
<i>Ambrosia dumosa</i>	1	1.10	3.63	2	1.10	0.06	1.67	0.13	0.41	0.09	0.63	
<i>Eragrostis arida</i>	9	65.70	216.81	8	7.30	3.65	6.67	7.62	1.63	0.83	10.08	
<i>Bromus rubens</i>	1	6.90	22.77	1	6.90	0.38	0.83	0.80	0.20	0.09	1.09	
Unknown grass	6	1.15	3.80	3	0.19	0.06	2.50	0.13	0.61	0.55	1.29	
<i>Stephanomeria pauciflora</i>	1	0.30	0.99	1	0.30	0.02	0.83	0.03	0.20	0.09	0.32	
<i>Mirabilis bigelovii</i>	2	0.55	1.82	2	0.28	0.03	1.67	0.06	0.41	0.18	0.65	
TOTAL	1087	862.60	2846.58				408.32	99.95	99.94	99.95	299.84+	

* Distance on line intercept covered by the species.

** Highest importance is rated 1; lowest is rated 5.

*** T = Trace

Table 4. Plant species data for Transect B. Transect length is 308.5 m (20 intervals of 15 m each).

Scientific Name	No. of Indiv.	Sum of Intercept*		Frequency Interval	Average Intercept	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency	Relative Density	Importance	
		Metric	English								Value	Rank**
<i>Bromus rubens</i>	16	221.26	730.16	10	13.80	71.72	47.62	74.90	8.62	5.78	89.301	
<i>Mirabilis bigelovii</i>	17	2.29	7.56	8	0.13	0.74	38.10	0.78	6.90	6.14	13.82	
<i>Pellaea truncata</i>	14	2.36	7.79	6	0.17	0.76	28.57	0.80	5.17	5.05	11.02	
<i>Encelia farinosa</i>	45	15.54	51.28	17	0.35	5.04	80.95	5.26	14.65	16.25	36.16	2
<i>Notholaena cochinchensis</i>	1	0.01	0.03	1	0.01	T***	4.76	T***	0.86	0.36	1.22+	
<i>Aristida parishii</i>	21	3.17	10.46	9	0.15	1.03	42.86	1.07	7.76	7.58	16.41	5
<i>Euphorbia</i> sp.	62	3.91	12.90	14	0.06	1.27	66.67	1.32	12.07	22.38	35.77	3
<i>Sphaeralcea</i> sp.	15	6.24	20.59	7	0.42	2.02	33.33	2.11	6.03	5.41	13.55	
<i>Galium stellatum</i>	1	0.60	1.98	1	0.60	0.19	4.76	0.20	0.86	0.36	1.42	
<i>Porophyllum gracile</i>	2	0.21	0.69	2	0.11	0.07	9.52	0.07	1.72	0.72	2.51	
<i>Festuca octoflora</i>	3	0.39	1.29	3	0.13	0.13	14.29	0.13	2.59	1.08	3.80	
<i>Bebbia juncea</i>	8	4.37	14.42	5	0.55	1.42	23.81	1.48	4.31	2.89	8.68	
<i>Malva</i> sp.	1	0.28	0.92	1	0.28	0.09	4.76	0.09	0.86	0.36	1.31	
<i>Heteropogon contortus</i>	15	2.78	9.17	6	0.19	0.90	28.57	0.94	5.17	5.42	11.53	
<i>Simmondsia chinensis</i>	15	16.47	54.35	7	1.10	5.34	33.33	5.58	6.03	5.42	17.03	4
<i>Allionia incarnata</i>	1	0.02	0.07	1	0.02	T***	4.76	T***	0.86	0.36	1.22+	

Table 4 (Continued).

Scientific Name	No. of Indiv.	Sum of Intercept*		Frequency Interval	Average Intercept	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency	Relative Density	Importance	
		Metric	English								Value	Rank**
<i>Muhlenbergia microsperma</i>	1	0.10	0.33	1	0.10	0.03	4.76	0.03	0.86	0.36	1.25	
<i>Artemisia dracunculoides</i>	10	0.50	1.65	3	0.05	0.16	14.29	0.17	2.59	3.61	6.37	
<i>Bouteloua curtipendula</i>	1	0.20	0.66	1	0.20	0.06	4.76	0.07	0.86	0.36	1.29	
<i>Eragrostis arida</i>	15	2.41	7.95	4	0.16	0.78	19.05	0.82	3.44	5.42	9.68	
<i>Bothriochloa barbinodis</i>	3	0.63	2.08	1	0.21	0.20	4.76	0.21	0.86	1.08	2.15	
<i>Stephanomeria pauciflora</i>	2	0.67	2.21	1	0.34	0.22	4.76	0.23	0.86	0.72	1.81	
<i>Carnegiea gigantea</i>	1	0.95	3.14	1	0.95	0.31	4.76	0.32	0.86	0.36	1.54	
<i>Psoralea lanceolata</i>	1	0.25	0.83	1	0.25	0.08	4.76	0.08	0.86	0.36	1.30	
<i>Lycium fremontii</i>	1	0.92	3.04	1	0.92	0.30	4.76	0.31	0.86	0.36	1.53	
<i>Acacia greggii</i>	3	5.27	17.39	2	1.76	1.71	9.52	1.78	1.72	1.08	4.58	
<i>Aster bigelovii</i>	1	0.40	1.32	1	0.40	0.13	4.76	0.14	0.86	0.36	1.36	
<i>Prosopis glandulosa</i> var. <i>torreyana</i>	1	3.20	10.56	1	3.20	1.04	4.76	1.08	0.86	0.36	2.30	
TOTAL	227	295.40	974.84				552.36	99.97	99.95	99.99	299.91	

* Distance on line intercept covered by the species.

** Highest importance is rated 1; lowest is rated 5.

*** T = Trace

Table 5. Plant species data for Transect C. Transect length is 170.16 m (11 intervals of 15 m each).

Scientific Name	No. of Indiv.	Sum of Intercept*		Frequency Interval	Average Intercept	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency	Relative Density	Importance	
		Metric	English								Value	Rank
<i>Simmondsia chinensis</i>	49	43.26	142.76	9	0.88	25.42	81.82	70.91	20.93	46.23	135.07	1
<i>Nicotiana trigonophylla</i>	1	0.50	1.65	1	0.50	0.29	9.09	0.82	2.33	0.94	4.09	
<i>Sphaeralcea</i> sp.	15	4.61	15.21	6	0.30	2.71	54.54	7.56	13.95	14.15	35.66	2
<i>Encelia farinosa</i>	5	2.42	7.99	3	0.48	1.42	27.27	3.97	6.98	4.72	15.67	3
<i>Machaeranthera</i> sp.	2	1.03	3.40	2	0.52	0.60	18.18	1.69	4.65	1.89	8.23	
<i>Stephanomeria pauciflora</i>	3	0.37	1.22	2	0.12	0.22	18.18	0.61	4.65	2.83	8.09	
<i>Mirabilis bigelovii</i>	1	0.05	0.17	1	0.05	0.03	9.09	0.08	2.33	0.94	3.35	
<i>Stipa speciosa</i>	3	0.92	3.04	2	0.31	0.54	18.18	1.50	4.65	2.83	8.98	5
<i>Opuntia phaeacantha</i>	1	0.08	0.26	1	0.08	0.04	9.09	0.13	2.33	0.94	3.40	
<i>Festuca octoflora</i>	3	0.21	0.69	1	0.07	0.12	9.09	0.34	2.33	2.83	5.50	
<i>Echeveria collomiae</i>	4	0.51	1.68	2	0.04	0.09	18.18	0.25	4.65	3.77	8.67	
<i>Notholaena standleyi</i>	1	0.05	0.17	1	0.05	0.03	9.09	0.08	2.33	0.94	3.35	
<i>Porophyllum gracile</i>	2	0.65	2.15	2	0.33	0.38	18.18	1.07	4.65	1.89	7.61	
<i>Canotia holacantha</i>	1	0.27	0.89	1	0.27	0.16	9.09	0.44	2.33	0.94	3.71	

Table 5 (Continued).

Scientific Name	No. of Indiv.	Sum of Intercept*		Frequency Interval	Average Intercept	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency	Relative Density	Importance	
		Metric	English								Value	Rank**
<i>Arisida parishii</i>	6	0.48	1.58	2	0.08	0.28	18.18	0.79	4.65	5.66	11.10	4
<i>Galium stellatum</i>	2	0.75	2.48	2	0.38	0.44	18.18	1.22	4.65	1.89	7.76	
<i>Calochortus</i> sp.	1	0.15	0.50	1	0.15	0.09	9.09	0.25	2.33	0.94	3.52	
<i>Lycium fremontii</i>	1	1.00	3.30	1	1.00	0.59	9.09	1.63	2.33	0.94	4.90	
<i>Kromeria parviflora</i>	1	0.20	6.60	1	0.20	0.11	9.09	0.33	2.33	0.94	3.60	
<i>Ambrosia dumosa</i>	3	1.20	3.96	1	0.40	0.70	9.09	1.97	2.33	2.83	7.13	
<i>Acacia greggii</i>	1	2.66	8.78	1	2.66	1.56	9.09	4.36	2.33	0.94	7.63	
TOTAL	106	61.01	201.33				390.88	100.00	100.60	99.98	300.58	

* Distance on line intercept covered by the species.

** Highest importance is rated 1; lowest is rated 5.

Table 6. Plant species data for Transect D. Transect length is 300 m (20 intervals of 15 m each).

Scientific Name	No. of Indiv.	Sum of Intercept*		Frequency Interval	Average Intercept	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency	Relative Density	Importance	
		Metric	English								Value	Rank
<i>Acacia greggii</i>	6	7.75	28.58	6	1.29	2.58	30.00	3.61	7.59	4.17	15.37	
<i>Simmondsia chinensis</i>	51	85.55	282.32	15	1.68	28.52	75.00	39.92	18.99	35.41	94.32	1
<i>Cercidium microphyllum</i>	26	84.75	279.68	19	3.26	28.25	95.00	39.54	24.05	18.06	81.65	2
<i>Porophyllum gracile</i>	7	4.75	15.68	6	0.68	1.58	30.00	2.21	7.59	4.86	14.66	
<i>Janusia gracilis</i>	1	0.03	0.10	1	0.03	0.01	5.00	0.01	1.27	0.69	1.97	
<i>Keckiella antirrhinoides</i>	14	14.64	48.31	10	1.04	4.88	50.00	6.83	12.67	9.72	29.22	3
<i>Celtis reticulata</i>	3	2.75	9.08	3	0.92	0.92	15.00	1.28	2.08	3.78	7.14	
<i>Euphorbia</i> sp.	2	0.35	1.16	1	0.17	0.12	5.00	0.16	1.27	1.38	2.81	
<i>Gutierrezia microcephala</i>	2	0.35	1.16	1	0.17	0.12	5.00	0.16	1.27	1.38	2.81	
<i>Krameria parvifolia</i>	1	0.95	3.14	1	0.95	0.32	5.00	0.44	1.27	0.69	2.40	
<i>Encelia farinosa</i>	11	5.31	17.52	6	0.48	1.77	30.00	2.48	7.59	7.64	17.71	4
<i>Prosopis glandulosa</i> var. <i>torreyana</i>	4	3.45	11.39	3	0.86	1.15	15.00	1.61	3.78	2.78	8.17	

Table 6 (Continued).

Scientific Name	No. of Individ.	Sum of Intercept*		Frequency Interval	Average Intercept	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency	Relative Density	Importance**	
		Metric	English								Value	Rank
<i>Senna covesii</i>	12	1.70	5.61	5	0.14	0.57	25.00	0.78	6.33	8.33	15.44	5
<i>Opuntia phaeacantha</i>	1	1.50	4.95	1	1.50	0.50	5.00	0.70	1.27	0.69	2.66	
Unknown shrub #2	1	0.50	1.65	1	0.50	0.17	5.00	0.23	1.27	0.69	2.19	
TOTAL	142	214.33	707.29				395.00	99.96	98.27	100.37	298.62	

* Distance on line intercept covered by the species.

** Highest importance is rated 1; lowest is rated 5.

Table 7. Plant species data for Transect E. Transect length is 300 m (20 intervals of 15 m each).

Scientific Name	No. of Individ.	Sum of Intercept		Frequency Interval	Average Intercept	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency	Relative Density	Importance	
		Metric	English								Value	Rank ^a
<i>Gutierrezia microcephala</i>	9	4.04	13.33	4	0.45	1.34	20.00	2.81	7.27	9.47	19.55	5
<i>Cercidium floridum</i>	2	6.05	19.97	2	3.03	2.02	10.00	4.24	3.64	2.11	9.96	
<i>Cercidium microphyllum</i>	20	35.48	117.08	10	1.77	11.83	50.00	24.61	18.18	21.05	63.84	2
<i>Sphaeralcea</i> sp.	1	0.30	0.99	1	0.30	0.10	5.00	0.20	1.82	1.05	3.07	
<i>Prosopis glandulosa</i> var. <i>torreyana</i>	15	36.30	119.79	7	2.42	12.07	35.00	25.24	12.73	15.79	53.76	3
<i>Simmondsia chinensis</i>	24	43.05	142.07	11	1.79	14.35	55.00	29.93	20.00	25.26	75.19	1
<i>Canotia holacantha</i>	4	3.10	10.23	4	0.78	1.03	20.00	2.16	7.27	4.21	13.64	
<i>Keckiella antirrhinoides</i> sp. <i>microphylla</i>	6	7.70	25.41	5	1.28	2.57	25.00	5.35	9.09	6.32	20.76	4
Unknown shrub #2	1	0.70	2.31	1	0.70	0.23	5.00	0.49	1.82	1.05	3.36	
<i>Ambrosia conferiflora</i>	3	1.25	4.13	3	0.42	0.42	15.00	0.87	5.45	3.16	9.48	
<i>Aristida parishii</i>	4	0.25	0.83	1	0.06	0.08	5.00	0.17	1.82	4.21	6.20	
<i>Krameria parvifolia</i>	3	2.80	9.24	3	0.93	0.93	15.00	1.95	5.45	3.16	10.56	

Table 7 (Continued).

Scientific Name	No. of Individ.	Sum of Intercept [*]		Frequency Interval	Average Intercept	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency	Relative Density	Importance	
		Metric	English								Value	Rank ^{**}
<i>Acacia greggii</i>	2	1.80	5.94	2	0.90	0.60	10.00	1.25	3.64	2.11	7.00	
<i>Opuntia acanthocarpa</i>	1	1.00	3.30	1	1.00	0.33	5.00	0.69	1.82	1.05	3.56	
TOTAL	95	143.82	474.61				275.00	99.93	100.00	100.00	299.93	

* Distance on line intercept covered by the species.

** Highest importance is rated 1; lowest is rated 5.

CAVE CANYON COMMUNITY

In addition to the line transects, Strong also sampled a community of riparian trees in Cave Canyon (formerly Cholla Canyon) below the spring (Fig. 1). Our 1986 transect in the deciduous, mesic community in Cave Canyon began 34.75 m (114.7 ft) downslope from the intersection of Transects B and C, at the upstream edge of the community, and continued for 114 m (376 ft) along the center of the creek bottom, to the downstream end of the community. In contrast, Strong's transect distance was 77.9 m (260 ft). It was assumed that Strong intersected the entire community as it existed in 1961, not just a portion. Hence the 1986 transect also sampled along the entire length of the community. All deciduous trees were counted and measured on the left (looking at the downstream) or west side of the transect. Results for the deciduous community in Cave Canyon are shown in Table 8. Only the number of trees and saplings (less than 0.4 ft or 0.12 m in circumference at breast height) are presented, as listed by Strong. Our original 1986 field notes are on file in the office of the Cooperative Parks Resources Studies Unit at The University of Arizona.

Table 8. Deciduous community comparison of number of trees and saplings in Cave Canyon in 1961 and 1986.

Species (common name)	No. Trees		No. Saplings	
	1961	1986	1961	1986
Netleaf hackberry	56	41	109	240
Arizona sycamore	13	31	75	6
Arizona walnut	19	29	0	91
Elderberry sp.	8	4	16	4+

It is difficult to draw conclusions from the Cave Canyon deciduous community given the 116-ft difference in transect length. However, the community appears to have increased in area along the creek bottom, perhaps in response to the wildfire of 1964. The same species are present: netleaf hackberry, Arizona sycamore (*Platanus wrightii*), elderberry (*Sambucus* sp.), and Arizona walnut (*Juglans major*). It can be noted that the number of trees is somewhat similar for netleaf hackberry and Arizona walnut, halved for elderberry, and doubled for Arizona sycamore.

The number of saplings doubled for netleaf hackberry, decreased dramatically for Arizona sycamore and elderberry, and increased dramatically for Arizona walnut. Without measuring foliage cover of the community, it is difficult to rank the four tree species. Netleaf hackberry reaches tree size, but is often classed as a shrub. Arizona sycamore is still the dominant tree, followed by Arizona walnut and elderberry. This ranking agrees with Strong's 1962 observations.

DISCUSSION

Tonto National Monument supports a rich and diverse assemblage of vascular plant species due to the topography, geology, soils (see Appendix 3, Note 2), and climate of the area. The flora of the monument has undoubtedly changed over the past 50 years in response to land management practices. Grazing in the Tonto Basin by cattle (*Bos taurus*), horses (*Equus caballus*), sheep (*Ovis aries*), goats (*Capra hircus*), and pigs (*Sus scrofa*) began in the 1870s (Croxen 1926). In 1941, 720 a of TONT's 1,120 a were fenced, resulting in a significant recovery of species and growth within the fenced area due to the exclusion of livestock grazing (Burgess 1965). The entire boundary of the monument was fenced during the 1960s.

Burgess (1965) stated that "a chance visitor to Tonto National Monument may never see approximately 50 percent of the flora" due to the ephemeral nature of the large number of species, both annual and perennial herbs, which occur sporadically following abundant winter rainfall. In his inventory of the flora of the monument, he recorded 265 species (or 270 taxa if varieties are included in the total), of which 45% are classified as ephemeral (this includes 66 taxa of perennial herbs and 112 taxa of annuals). Burgess found jojoba to be the single most abundant species in the monument.

From June 27 to July 2, 1964, a natural wildfire burned over 500 a (200 ha) of the monument, 45% of the southwestern portion (Burgess 1965). The extent to which the 1964 wildfire may have altered the cover of species along Transects A, B, and C over the past 23 years is difficult to ascertain without an exact determination of the location of the 500 burned acres.

Strong (1962) encountered nine species that were not encountered in 1986: golden eye (*Viguiera* sp.), menodora (*Menodora* sp.), hop bush (*Dodonaea viscosa*), giant hyssop (*Agastache* sp.), deer vetch (*Lotus* sp.), condalia (*Condalia* sp.), agave (*Agave* sp.), hedgehog cactus (*Echinocereus* sp.), and prickly pear (*Opuntia* sp.). Strong also encountered one species not listed by Burgess (1965) in the vascular flora for the monument: *Platyopuntia* sp. Our study encountered one species not encountered by Strong, but listed by Burgess: wolfberry (*Lycium* sp.). The reasons for the inclusion and omissions may be explained by: differences in the placement of the line; the wildfire of 1964; errors in identification; time of year; differences in the germination of annuals; disturbance; plant succession; disease; and grazing by mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), javelina (*Pecari angulatus*), rabbits (*Sylvilagus floridanus* and *S. auduboni*), hares (*Lepus californicus*), and rodents, e.g., whitethroated woodrat (*Neotoma albigula*) (Johnson n.d.). It is not known exactly what Strong was referring to by the genus *Platyopuntia*, for this species is not listed as a member of Arizona's flora by Lehr (1978) or Lehr and Pinkava (1980, 1982). He was undoubtedly referring to a prickly pear (*Opuntia*-type) cactus. I noted that menodora, hop tree, agave, and hedgehog cactus were present in areas adjacent to the transect lines.

However, giant hyssop, deer vetch (*Lotus* sp.), and condalia (*Condalia* sp.) were not noted, although they were not searched for in a systematic matter.

I encountered difficulties in understanding Strong's methods and results. For example, there were several "rounding" or typographic errors on Transect A ("Trees" section): the number of *Acacia* should be 14 (not 13) as per the results of his report. Likewise, for percent frequency, the value for *Juniperus* should be 0.83 (not 0.84) and *Canotia* should be 2.50 (not 2.51). The values for number of intercepts, and in some cases frequency, for Transects B-E were not checked as the number of species intercepts per inclination/exposure were not listed. Also, Strong did not clearly state that his interval for frequency calculations is 50 ft, except to note that this distance was used for inclination-exposure readings on Transect A. His reasons for not giving all cover information for the "miscellaneous" section for each transect are not altogether clear.

Separation of results for the three growth habits (i.e., trees, shrubs, and miscellaneous) is artificial and subjective. There can be a fine line, for example between suffrutescent herbs, subshrubs, shrubs, and small trees. Separation of growth forms introduces unnecessary "noise" into analysis; three "windows" are created through which one is forced to view the results. I think it is better to view the flora as one community. Otherwise, faulty or obscure impressions may be made. If one is interested in groupings of growth forms, floristic families, or native/exotic species, distinctions can easily be made by looking at the overall Importance Values and ranking the species of interest.

Exclusion of other species (in addition to the 31 species recorded by Strong) also introduces unnecessary noise. Omitting species that are present at the time of the field work makes the analysis "color blind" and is a disservice to future analysis. It is a value judgement to exclude grasses, parasitic angiosperms, and/or succulents. Grasses are important members of the flora of the monument. Red bromus was very notable along Transect B and three-awn was significant on Transects B and C.

In spite of the differences in presentation of the two studies, comparison of the line intercept data can be made. Jojoba was the most abundant species in the monument in both studies, followed by foothill palo verde and brittlebush. Strong's exclusion of grasses as well as various perennial herbs (i.e., desert straw and spurge) makes complete comparisons difficult. However, it is notable that the number of intercepts from 1961 to 1986 for snakeweed (Transect A: 26 to 185) and globe mallow (Transect A: 2 to 80) increased dramatically, indicative of disturbance or a range in unsatisfactory condition, i.e., low species diversity, or the presence of unpalatable forage species (Judd 1962). The number of jojoba decreased on the three upland transects (Transect A: 284 to 192, Transect B: 58 to 15, and Transect C: 76 to 49) and increased in two lower elevation transects (Transect D: 30 to 51, Transect E: 6 to 24). The decrease of jojoba on Transects A, B, and C may be due to the wildfire of 1965, which was centered in Cave Canyon. The increase in the numbers of jojoba on Transects D and E is not altogether

surprising, for the species withstands heavy browsing well and may be grazed to the point of near extermination, especially on depleted ranges (Judd 1962).

The number of "trees" on Transects A through C showed little change in the two years, while those of Transects D and E showed an interesting variation. In Transect D, palo verde numbers declined from 24 to 19, while on Transect E, palo verde almost doubled from 12 to 22. Cat-claw numbers tripled on Transect D from 2 to 6, and were halved on Transect E from 4 to 2. Honey mesquite increased on Transect D from none to 2 and on Transect E from 8 to 15.

Other observations on specific shrubs can be made. First, it is not known which perennial species Strong was recording for deer vetch. The reason for the reduction in the number of range ratany (*Krameria parvifolia*), which Burgess (1965) stated is moderately common on slopes and in canyons throughout the monument, is unknown. It may be due to the 1964 wildfire or to errors in field identification.

SUMMARY

Differences in field techniques and data presentation between Strong's 1961 line intercept study and the 1986 resurvey created difficulties in comparison. Strong used English units, recorded intercepts for only 31 species, did not clarify his methods, gave vague directions for transect relocation, and separated the results for the five transects into three groupings by growth habit. Two events have had an unknown impact on the flora since the 1961 study: a wildfire in Cave Canyon occurred three years after Strong's fieldwork, and the entire boundary of the monument was fenced thereafter. The 1986 study recorded intercepts for all (71) of the species encountered along the line intercept, used metric units, and used standard methods (as per Parker and Savage 1944) for line intercept data collection and analysis. Exact coincidence of the 1961 transect lines with the 1986 study is uncertain.

Strong's summary stated that jojoba is dominant at higher elevations and palo verde is dominant at lower elevations. I found that jojoba is dominant at both high and low elevations and palo verde is important in low elevations and on the northern section of Transect A. The mesic tree community in Cave Canyon may have increased in areal extent; however, the dominant tree continues to be Arizona sycamore, followed by Arizona walnut and elderberry.

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APPENDIX 1

CHARLES WILLIAM STRONG'S REPORT*

PREFACE

This paper falls quite naturally into two sections. The first part consists of a description of the area, its recent history, the purpose of the study, the procedures used in sampling the vegetation, the data obtained, and an interpretation of this data. The second section deals with new methods of analysis conceived by this author with the aid of his friend and mentor, Dr. Robert Burgess.

The new techniques were developed in order to provide a method of deriving density from line intercept data. Insofar as some density approximation is better than none these results are included in the second section. The summary of this section brings together the data from both parts of the paper. It should be stressed that the new methods have not been exhaustively proven. However, all preliminary tests have shown the results to be accurate. The derivation and sample calculations appear in the appendix.

The collecting of botanical specimens was commenced in June and pursued on weekends until September when the author took up residence at the monument and assumed duties as a general park ranger. After this date collection was done as new specimens appeared until the end of the first week of December. Through September, October, and November ecological studies were pursued on an average of four mornings a week. The balance of the time was occupied by interpretive duties.

Acknowledgement should be made to many persons who have aided and supported this study. This includes the entire Tonto staff and particularly the Superintendent, Wiffler R. Oakes. Within the Service I would like to express appreciation also to Dr. Reid of the Regional Office for his encouragement and comments.

Many persons at Arizona State University lent their assistance. Frank Crosswhite, curator of the A.S.U. herbarium, identified a great number of plants; Dr. Burgess, professor of ecology at A.S.U., was unstinting in his help; and, my brother, Jack Strong, spent many hours classifying and assisting in calculations.

* January 1, 1962. Some formatting changes have been made.

Most of all I wish to thank my wife, Judith, for aid in every phase of the project.

Charles Wm. Strong

January 1, 1962
Sydney, Australia

Please Note: Due to a Geographical Board of Names change, Cholla canyon or wash is now known as Cave Canyon. The change was effective November 8, 1962.

INTRODUCTION

Description

Tonto National Monument comprises an area of 1,120 acres, 740 of which are fenced. Topographically the area shows considerable variation in altitude, rising from 2,200 feet to 4,000 feet in a mile and one half. The high regions in the South are dissected by several canyons running to the low northern playa. Cholla Wash, one of these canyons, is of particular interest as the presence of a spring has preserved a small deciduous community some five hundred feet in length and sixty feet in width.

Geologically there is little variation in the soil types except in terms of texture. The parent rock is of two basic groups, Dripping Spring Quartzite and Gila Conglomerate, both of which are exposed on the monument. The texture varies from coarse broken rock on the bajadas to "desert pavement" on the playa to the North.

The climate is relatively mild. Statistics for Phoenix, approximately sixty miles northwest of the monument, shows a yearly normal range of temperature from 34.5° to 105.1° Fahrenheit, and a yearly total precipitation of 7.16 inches. The rain falls in two periods, a general winter rainy season and sporadic summer rains. Consequently there are two well defined flowering terms, one in the spring months and one in the fall.

The vegetation of the area agrees well with that described by Benson and Darrow (*Southwestern Trees and Shrubs*) as Arizona Lower Sonoran Desert.

The monument supports a wealth of animal life including mule deer, peccary, jack rabbits, cotton-tail rabbits, ground squirrels, grey squirrels, skunk, racoons, ring-tailed cats, and occasional wildcats and coyotes to mention only the mammals. There are also lizards, snakes (including rattlesnakes), and birds in numbers (quail outstanding).

Recent History

According to a grazing report issued by the Forest Service in the 1920's the Tonto Basin (and Roosevelt Basin) was, just before the turn of the century, heavily forested on the slopes and covered with lush grass on the bottoms. Tonto Creek was a slowly flowing stream, in many places a series of quiet pools draining one into another. The report describes, in the words of the early cattle ranchers, the tremendous herds of cattle which over-grazed the land. Flooding of the creeks ensued, valuable soil was swept away, the watershed ceased to hold water efficiently, and the area gradually dried out and died out.

PURPOSE

Tonto represents a type of area almost unique in Arizona in that it has not been grazed within the fenced boundaries for over twenty years. It was therefore deemed advisable to obtain data on as much of the vegetation as possible in order to preserve this floral record.

The late spring, summer, and early fall of 1961, the duration of the study, were unusually dry. As a result the survey was concentrated on perennial trees and shrubs.

An herbarium collection of eighty-seven species was made and line intercept transects were established along compass lines in order to secure data which will be of value for comparison with succeeding studies. Also, such data should form the basis of botanical interpretation.

METHOD

In order to obtain current data on vegetational composition, distribution, and environmental relationships, line intercept transects were established in the following locations:

- Transect A - beginning at the boundary monument in Cholla Wash was run due north for 150 feet at which point it veered 30° west for 75 feet before proceeding due north to the fenced boundary on the North (the jog was made in order to raise the transect to include the higher elevations on the West hillside of Cholla Wash, and to avoid passing the transect through the deciduous community) - total distance, 6,000'.
- Transect B - beginning 5 feet east of the bench mark at the Upper Ruins was run due east to the bottom of Cholla Wash - total distance, 1,100'.
- Transect C - beginning at the base of the cliff on Honey Butte was run due west to the end of Transect B - total distance 850'.

Transect D - beginning at a point on the East boundary approximately 300 feet above Highway 88 was run due west - total distance 1,000'.

Transect E - beginning at the Northeast fence boundary below Highway 88 was run due west - total distance 1,000'.

All transects were run on compass lines using a lensatic type compass.

On Transect A inclination-exposure readings, using an Abney level, were obtained every fifty feet throughout the transect. Transect A was placed so as to provide the perspective on species composition and distribution along the altitude gradient running north and south. Transects B and C were placed so as to give a measure of the vegetation occurring on the two major exposures west and east. Transects D and E sampled the fairly homogeneous populations inhabiting the playa, Transect D sampling the well-vegetated area above the highway and Transect E the more depauperate area below.

Cholla Wash contains a small deciduous community which was quadratted using a modification of stratified random sampling. A line was established running north and east through the community for 260 feet beginning 130 feet from the intersection of Transects B and C at the bottom of Cholla Wash. The location of each tree to the west of the line was fixed in terms of two coordinates representing the distance along the line and the distance from the line. Basal area figures were obtained on all trees greater than .4 feet in circumference as circumference at breast height. Trees smaller than this were classified as saplings and enumerated.¹

DATA

In the list below all species collected and placed in the herbarium are grouped alphabetically by family, genus, and species. This list is by no means complete. It may be regarded as being most extensive where trees and shrubs are concerned and least extensive in the coverage of grasses and forbs. The list contains eighty-seven species, seventy-two genera, and forty-four families. There are several conspicuous omissions in the list notably *Populus fremontii*, *Prosopis juliflora*, *Fouquieria splendens*, *Opuntia acanthocarpa*, *Opuntia bigelovii*, *Echinocereus fendleri*, *Mammillaria microcarpa*, and *Platyopuntia*. These plants were either collected and damaged in transport or left for subsequent collection because they were not in flower.

¹ See map of transects at the end of this report.

PLANTS OF TONTO NATIONAL MONUMENT

Fam. Amaranthaceae

Amaranthus fimbriatus (Torr.) Benth.

Fam. Amaryllidaceae

Agave chrysantha Peebles

Fam. Anacardiaceae

Rhus ovata Wats.

Fam. Aristolochiaceae

Aristolochia watsoni Woot. & Standl.

Fam. Buxaceae

Simmondsia chinensis (Link) Schn.

Fam. Cactaceae

Carnegiea gigantea (Engelm.) Britt. & Rose

Ferocactus lecontei (Engelm) Britt. & Rose

Opuntia leptocaulis D.C.

Fam. Campanulaceae

Nemacladus glanduliferus Jepson

Fam. Capparidaceae

Polanisia trachysperma T. & G.

Fam. Caprifoliaceae

Sambucus mexicana Presl.

Fam. Celastraceae

Canotia holacantha Torr.

Fam. Chenopodiaceae

Atriplex wrightii Wats.

Salsola kali L.

Fam. Compositae

Aplopappus gracilis (Nutt.) Gray

Aplopappus laricifolius Gray

Artemisia dracunculoides Pursh.

Artemisia ludoviciana Nutt.

Aster bigelovii Gray

Baccharis sarothroides Gray

Fam. Compositae (continued)

- Baileya multiradiata* Harv. & Gray
- Bebbia juncea* (Benth.) Greene
- Franseria confertiflora* (D.C.) Rydb.
- Gutierrezia microcephala* (D.C.) Gray
- Hymenoclea salsola* T. & G.
- Perezia nana* Gray?
- Porophyllum gracile* Benth.
- Psilostrophe cooperi* (Gray) Greene
- Senecio* sp.
- Stephanomeria pauciflora* (Torr.) A. Nels.
- Stephanomeria tenuifolia* (Torr.) H. M. Hall
- Viguiera deltoidea* Gray
- one specimen, unable to determine genus or species.

Fam. Convolvulaceae

- Ipomoea coccinea* L.?

Fam. Crassulaceae

- Cucurbita palmata* Wats.

Fam. Euphorbiaceae

- Croton texensis* (Klotzch) Muell.
- Euphorbia albomarginata* T. & G.
- Euphorbia heterophyllum* L.?
- Euphorbia hirta* L.

Fam. Fagaceae

- Quercus turbinella* Greene

Fam. Geraniaceae

- Erodium cicutarium* (L.) L'Her.

Fam. Gramineae

- Agrostis alba* L.?
- Bouteloua curtipendula* (Michx.) Torr.

Fam. Juglandaceae

- Juglans major* (Torr.) Heller

Fam. Labiatae

- Agastache micrantha* (Gray) Woot. & Standl.
- Hyptis emoryi* Torr.
- Marrubium vulgare* L.

Fam. Leguminosae

- Acacia greggii* A. Gray
- Acacia millefolia* Wats.
- Cassia covesii* Gray
- Cercidium floridum* Benth.
- Lotus rigidus* Benth.

Fam. Liliaceae

- Dasyllirion wheeleri* Wats.

Fam. Loasaceae

- Mentzelia pumila* (Nutt.) T. & G.

Fam. Loranthaceae

- Phoradendron californicum* Nutt.
- Phoradendron juniperum* Engelm.

Fam. Malpighiaceae

- Janusia gracilis* Gray

Fam. Malvaceae

- Hibiscus coulteri* Harv.
- Sphaeralcea ambigua* Gray
- Sphaeralcea coccinea* (Pursh.) Rydb.
- Sphaeralcea* sp.

Fam. Nyctaginaceae

- Allionia incarnata* L.
- Boerhaavia coccinea* Mill.

Fam. Oleaceae

- Menodora scoparia* Engelm.

Fam. Pinaceae

- Juniperus monosperma* (Engelm.) Sarg.

Fam. Platanaceae

- Platanus wrightii* S. Watts.

Fam. Polemoniaceae

- Phlox tenuifolia* E. Nels.

Fam. Polygonaceae

Eriogonum fasciculatum Benth.

Eriogonum wrightii Torr.

Eriogonum sp.---three unidentified specimens

Fam. Polypodiaceae

Notholaena sinuata Kaulf.

Fam. Rhamnaceae

Condalia lycioides (A. Gray) Weberb.

Fam. Rosaceae

Rubus arizonensis Focke

Fam. Rubiaceae

Galium stellatum Kellogg

Fam. Sapindaceae

Dodonaea viscosa Jacq.

Fam. Scrophulariaceae

Penstemon antirrhinoides Benth.

Penstemon eatoni Gray

Fam. Solanaceae

Datura metaloides D.C.

Nicotiana attenuata Torr.

Nicotiana glauca Graham

Nicotiana trigonophylla Duval

Physalis crassifolia Benth.

Fam. Ulmaceae

Celtis laevigata Willd. var. *reticulata* (Torr.) L. Benson

Celtis pallida Torr.

Fam. Zygophyllaceae

Larrea tridentata (D.C.) Coville

Plus two specimens which could not be keyed to family.

The data from the transects follows. For the Cactaceae, *Fouquieria*, yucca, agave, and sotol on transect A where they were most numerous, only the percent frequency has been calculated. This is because of certain philosophical problems having to do with the validity of other statistics and this method of measurement when applied to these life forms.

Table 1. Transect A - Trees.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Cercidium</i>	21	172.70	8.22	2.88	15.09	51.15	40.12
<i>Acacia</i>	13	62.00	4.78	1.04	10.00	18.47	26.58
<i>Prosopis</i>	11	75.70	6.97	1.26	9.17	22.38	24.38
<i>Canotia</i>	4	21.00	5.25	.35	2.51	6.22	6.67
<i>Juniperus</i>	1	<u>6.00</u>	6.00	<u>.10</u>	<u>.84</u>	<u>1.78</u>	<u>2.23</u>
		337.40		5.63	37.61	100.00	99.98

Table 2. Transect A - Shrubs.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Simmondsia</i>	284	923.50	3.28	15.39	81.67	63.15	30.81
<i>Krameria</i>	128	192.30	1.50	3.21	49.16	13.17	18.54
<i>Encelia</i>	49	45.90	.94	.77	21.67	3.16	8.17
<i>Viguiera</i>	39	55.20	1.41	.92	24.17	3.77	9.12
<i>Gutierrezia</i>	26	23.50	.90	.39	13.34	1.60	5.03
<i>Menodora</i>	38	29.20	.78	.49	18.42	2.01	6.95
<i>Janusia</i>	17	19.10	1.12	.32	11.67	1.31	4.40
<i>Aplopappus</i>	20	33.75	1.69	.56	5.83	2.29	2.20
<i>Galium</i>	16	34.80	2.17	.58	12.50	2.38	4.71
<i>Dodonaea</i>	2	2.00	1.00	.03	1.67	.12	.63
<i>Agastache</i>	9	26.00	2.89	.43	6.67	1.76	2.52
<i>Sphaeralcea</i>	2	2.00	1.00	.03	1.67	.12	.63
<i>Lotus</i>	26	72.60	2.79	1.21	14.16	4.97	5.34
<i>Condalia</i>	4	2.50	.63	.04	2.50	.16	.94
			24.37	265.10	99.97	99.99	

Table 3. Transect A - Miscellaneous.

Species	Percent Frequency
<i>Carnegiea</i>	10.00
<i>Ferocactus</i>	.84
<i>Echinocereus</i>	2.50
<i>Mammillaria</i>	.84
<i>Opuntia</i>	
<i>acanthocarpa</i>	22.50
<i>bigelovii</i>	5.84
<i>leptocaulis</i>	.84
<i>Platyopuntia</i>	11.67
<i>Agave</i>	1.67
<i>Yucca</i>	11.67
<i>Dasylirion</i>	6.67
<i>Fouquieria</i>	16.67

Table 4. Transect B - Trees.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Prosopis</i>	2	21.00	10.50	1.91	4.55	-	-

Table 5. Transect B - Shrubs.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Simmondsia</i>	58	174.50	3.01	15.82	86.36	63.51	34.54
<i>Krameria</i>	38	46.40	1.22	4.18	63.64	16.78	25.45
<i>Encelia</i>	27	32.50	1.20	2.95	40.91	11.97	16.36
<i>Viguiera</i>	2	2.50	1.25	.23	9.09	.92	3.64
<i>Janusia</i>	5	4.50	.90	.41	18.18	1.64	7.27
<i>Galium</i>	2	1.00	.50	.09	9.09	.36	3.64
<i>Agastache</i>	5	12.00	2.40	1.09	18.18	4.37	7.27
<i>Lotus</i>	1	1.50	1.50	.14	4.55	.56	1.82
				24.91	250.00	100.11	99.99

Table 6. Transect B - Miscellaneous.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Dasyllirion</i>	1	4.50	4.50	.41	4.55	-	-

Table 7. Transect C - Trees.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Acacia</i>	2	1.00	5.00	1.18	11.76	33.90	33.34
<i>Canotia</i>	6	19.50	3.25	<u>2.30</u>	<u>23.51</u>	<u>66.09</u>	<u>66.66</u>
				3.48	35.27	99.99	100.00

Table 8. Transect C - Shrubs.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Simmondsia</i>	76	197.00	2.59	23.18	95.02	76.48	43.96
<i>Krameria</i>	24	37.70	1.57	4.35	58.82	14.35	27.22
<i>Encelia</i>	8	7.50	.94	.88	5.88	2.90	2.72
<i>Viguiera</i>	4	4.00	1.00	.47	23.51	1.55	10.88
<i>Gutierrezia</i>	10	4.50	.45	.53	11.76	1.75	5.46
<i>Galium</i>	5	3.00	.60	.35	23.51	1.15	10.88
<i>Dodonaea</i>	1	.20	.20	.02	5.88	.07	2.72
<i>Eriogonum</i>	4	3.00	.75	.35	11.76	1.15	5.46
			30.13	236.14	99.40	99.46	

Table 9. Transect C - Miscellaneous.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Ferocactus</i>	1	1.00	1.00	.12	5.88	20.33	50.00
<i>Dasyllirion</i>	1	4.00	4.00	.47	5.88	79.66	50.00
				.59	11.76	99.99	100.00

Table 10. Transect D - Trees.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Cercidium</i>	24	152.40	6.35	15.24	80.00	88.65	88.89
<i>Acacia</i>	2	19.50	9.75	<u>1.95</u>	<u>10.00</u>	<u>11.34</u>	<u>11.11</u>
				17.19	90.00	99.99	100.00

Table 11. Transect D - Shrubs.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Simmondsia</i>	30	98.50	3.28	9.85	55.00	65.23	45.83
<i>Krameria</i>	2	5.00	2.50	.50	10.00	3.31	8.33
<i>Gutierrezia</i>	2	1.00	.50	.10	10.00	.66	8.33
<i>Janusia</i>	4	11.00	2.75	1.10	10.00	7.28	8.33
<i>Lotus</i>	4	24.00	6.00	2.40	20.00	15.89	16.67
<i>Condalia</i>	3	11.50	3.82	<u>1.15</u>	<u>15.00</u>	<u>7.61</u>	<u>12.50</u>
				15.10	120.00	99.98	99.99

Table 12. Transect D - Miscellaneous.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Opuntia</i>							
<i>acanthocarpa</i>	2	3.20	1.60	.32	10.00	61.53	66.67
<i>Platyopuntia</i>	1	2.00	2.00	<u>.20</u>	<u>5.00</u>	<u>38.46</u>	<u>33.33</u>
				.52	15.00	99.99	100.00

Table 13. Transect E - Trees.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Cercidium</i>	12	68.00	5.67	6.80	45.00	48.85	50.00
<i>Acacia</i>	4	12.00	3.00	1.20	15.00	8.62	16.66
<i>Prosopis</i>	8	59.20	7.40	<u>5.92</u>	<u>30.00</u>	<u>42.53</u>	<u>33.33</u>
				13.92	90.00	100.00	99.99

Table 14. Transect E - Shrubs.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Simmondsia</i>	6	27.00	4.50	2.70	25.00	60.67	41.67
<i>Krameria</i>	6	8.80	1.47	.88	25.00	19.77	41.67
<i>Lotus</i>	1	6.00	6.00	.60	5.00	13.48	8.33
<i>Condalia</i>	1	2.70	2.70	<u>.27</u>	<u>5.00</u>	<u>6.07</u>	<u>8.33</u>
				4.45	60.00	99.99	100.00

Table 15. Transect E - Miscellaneous.

Species	No. of Intercepts	Total Intercepts (in feet)	Average Intercept (in feet)	Percent Cover	Percent Frequency	Relative Cover	Relative Frequency
<i>Opuntia acanthocarpa</i>	3	5.00	1.67	.17	15.00	-	-

Table 16. The following table shows the relation between the number of intercepts and the inclination-exposure values over transect A. It should be remembered that large species are intercepted with greater frequency than smaller ones of equal density.

Transects	1-6	7-13	14-16	17-47	48-54	55	56-79	80-83	84-90	91-119	120
Exposure	wash	N71°W	wash	S84°E	N 4°E	wash	S56°E	N36°E	N67°E	N19°E	playa
Inclination	0%	66%	0%	64%	63%	0%	41%	30%	25%	35%	0%
<u>Species</u>											
<i>Cercidium</i>	1	-	-	5	-	-	14	-	-	1	-
<i>Acacia</i>	4	3	2	-	-	1	1	-	-	3	-
<i>Prosopis</i>	2	-	2	-	-	2	1	-	1	3	-
<i>Canotia</i>	2	-	-	-	1	-	-	-	1	-	-
<i>Juniperus</i>	-	-	-	-	-	-	-	-	-	1	-
<i>Simmondsia</i>	11	32	11	80	31	4	52	1	5	56	1
<i>Krameria</i>	2	9	-	57	13	-	35	1	-	11	-
<i>Encelia</i>	12	1	-	16	-	-	17	-	3	-	-
<i>Viguiera</i>	-	1	-	12	5	-	3	1	6	11	-
<i>Gutierrezia</i>	1	-	-	-	-	-	-	6	4	13	-
<i>Menodora</i>	3	2	1	-	-	-	3	3	2	22	-
<i>Janusia</i>	-	-	-	5	-	-	4	2	2	4	-
<i>Aplopappus</i>	2	9	9	-	-	-	-	-	-	-	-
<i>Galium</i>	-	-	-	4	6	-	2	-	1	3	-
<i>Dodonaea</i>	-	2	-	-	-	-	-	-	-	-	-
<i>Agastache</i>	2	1	-	1	-	-	-	-	-	5	-
<i>Sphaeralcea</i>	1	-	-	-	-	-	-	-	-	1	-
<i>Lotus</i>	-	-	-	-	1	-	1	-	1	23	-
<i>Condalia</i>	-	-	-	-	-	-	2	-	-	1	1

Number of Deciduous Trees Occuring in Approximately 12,00 sq. ft. of Cholla Wash
species = no. trees/no. saplings

Celtis = 56/104
Juglans = 19/0

Platanus = 13/75
Sambucus = 8/16

INTERPRETATION

In this section interpretation of transect A will be detailed and with explanations of the reasoning involved. The remaining transects will then be interpreted individually and the information brought together into a synthesis of the vegetation throughout the monument. It must be borne in mind that the line intercept method samples large individuals with greater frequency than smaller ones of equal density.

Transect A

None of the trees are of truly dominant status. *Cercidium* occurs with greater frequency and covers more area than do any of the others; this can be seen by reference to both sets of frequency and cover statistics. Furthermore, it seems to occur most prevalently on southeast facing slopes. *Acacia* occurs with greater frequency than *Prosopis* but *Prosopis* is the larger plant as is shown by the average intercept values. Both species occur in the washes. *Canotia* and *Juniperus* occur only occasionally.

Simmondsia is the dominant species; that is, it controls the environment to a greater extent than the other species. This may be seen by the relative cover value of 63.15 and the relative frequency of 30.81, indicating greater cover and homogeneous distribution than the other shrubs. The percent frequency value of 81.67 compared with that for *Cercidium*, 15.09, shows the greater homogeneity of distribution. The percent cover value indicates that 15.39 percent of the surface of the ground is covered by *Simmondsia*.

Krameria is next in cover, abundance, and homogeneity. *Encelia* is abundant but distributed sporadically in groups. This can be seen from the fact that the average intercept is smaller yet the number of intercepts is greater than those of *Viguiera*. It is, therefore, far more abundant than the latter species. The low relative frequency value shows that the distribution of *Encelia* must be non-homogeneous.

It may be seen that *Gutierrezia* and *Menodora* are likewise sporadically distributed in groups.

Transect B

Simmondsia is dominant with a relative cover of 63.51, and a relative frequency of 34.54. *Krameria* and *Encelia* are next in order.

Transect C

Simmondsia and *Krameria* are dominant. *Gutierrezia* occurs sporadically but is of little importance because the relative cover and frequency values are so low. *Encelia* occurs with a non-homogeneous distribution. It may be seen that the frequency values are the same as for *Dodonaea*; thus, all eight *Encelia* individuals must occur in one fifty foot interval of the transect.

Transect D

Cercidium is dominant; its percent frequency and cover values exceed those of all the other plants. *Simmondsia* is numerically more abundant however. *Lotus* and *Condalia* are next below *Simmondsia* in importance and *Janusia* and *Krameria* follow. It should be noted that *Janusia*, in a vine-like growth habit, spreads through plants of larger size. Thus *Janusia* should most properly fall below *Krameria* in importance.

Transect E

Cercidium is dominant, followed by *Prosopis*, *Simmondsia*, and *Acacia*. *Krameria* is fourth in importance.

It is most instructive to compare the results from the various transects for here the basic relationships become clearest.

The exposure over all of transect B is easterly and transect C is westerly. The two *Prosopis* of transect B and the two *Acacia* of transect C occurred in the washes. The only other trees, the six *Canotia*, all occurred on transect C the western exposure. No *Canotia* were intercepted on the playa.

Simmondsia is much more numerous on the westerly exposure and *Krameria* less numerous. But, the greatest difference in abundance is indicated by the statistics for *Encelia*. On the east facing slope *Encelia* has a percent cover of 2.95, and a percent frequency of 40.91; while on the west facing slope the values are .88, and 5.88. The numbers of intercepts are 27, and 8 respectively. *Gutierrezia* does not occur on the east facing slope.

On the playa, *Prosopis* was sampled only on the transect run to the north of Highway 88, transect E. This area, the so called "lower forty", is depauperate by comparison with the area south of the highway. The transects in the two areas were of equal length, one thousand feet, yet transect D intercepted eight species and seventy-one individuals whereas transect E, north of the road, intersected only seven species and thirty-eight individuals (two of the species, *Lotus* and *Condalia*, were intercepted only once.)

In general, *Simmondsia* is dominant over the higher elevations to the south and occurs with greater frequency than any other shrub throughout the monument except in the extreme northern reaches where *Krameria* is numerically more abundant. In the low northern areas *Cercidium* becomes dominant. In some northern areas *Prosopis* occurs with notable frequency.

Krameria is the next dominant shrub, exceeding *Simmondsia* in abundance in the "lower forty". In the low area south of Highway 88, however, *Krameria* is not as important as *Lotus* or *Condalia*.

Encelia is abundant in the higher southern areas but is distributed irregularly in groups seeming to favor southeastern exposures. *Canotia* occurs only in the higher elevations, in washes and generally in northern or western exposures.

The difference in the growth habit of *Janusia* in the higher and lower elevations is worthy of mention. In the southern areas *Janusia* grows as a shrub or half-shrub but on the playa it spreads vine-like through other plants, twining around their branches.

The deciduous community in Cholla Wash is so small that it was decided not to express the statistics in terms of the square acre but to merely list the number of each species occurring in the sampled area, approximately twelve thousand square feet. *Celtis* occur mainly on the fringes of the community. *Platanus* is dominant within the community, followed by *Juglans* and *Sambucus*.

SECTION II

INTRODUCTION

The line intercept method was decided upon for use at Tonto for several reasons. It can be employed rapidly and by two persons. There has been, however, one serious limitation to this method. It has not been previously possible to obtain a density statistic by its use.

The author and his colleague, Dr. Robert Burgess, have developed several methods which have proven to be theoretically valid yet have not been tested in the field on a stand of known density. The results are introduced in this section.

As with any methods there is necessary a certain number of individuals in order to be statistically valid. This number has not been positively determined for these methods but it seems to lie at about thirty individuals.

It was not deemed advisable to take values from all the transects together as equal weight would not be given to the various communities on the monument.

The density calculations were made by the mean chord method, which, gives only a density approximation because it does not take into account the distribution of sizes. Its use might be considered acceptable however as the sample of most species on transect A is not great enough to indicate a diameter distribution.

The diameter distributions were determined by the second method appearing in the appendix.

DATA

The following table brings together the density, relative density, relative cover, and relative frequency data from transect A. The sum of the relative value statistics is represented by the importance value. For each species the theoretical maximum importance value is three hundred.

INTERPRETATION

The addition of relative density to the relative frequency and relative cover values provides a single valued statistic for determining importance.

The greater importance of *Simmondsia* is clearly shown. *Menodora* appears of importance here because of its relatively large density and frequency values. *Gutierrezia*, and *Agastache* are shown to be more important after addition of the density figure. *Viguiera* and *Lotus* owe their importance to relatively high frequency and cover values.

Table 17.

Species	Approximate Density per acre	Relative Density	Relative Cover	Relative Frequency	Importance Value
<u>Trees</u>					
<i>Cercidium</i>	15	33.33	51.15	40.12	124.60
<i>Acacia</i>	16	35.55	18.47	26.58	80.60
<i>Prosopis</i>	9	20.00	22.38	24.38	66.76
<i>Canotia</i>	4	8.78	6.22	6.67	21.67
<i>Juniperus</i>	<u>1</u>	<u>2.22</u>	<u>1.78</u>	<u>2.23</u>	<u>6.23</u>
	45	99.88	100.00	99.98	299.86
<u>Shrubs</u>					
<i>Simmondsia</i>	490	22.30	63.15	30.81	116.26
<i>Krameria</i>	488	22.24	13.17	18.54	53.95
<i>Encelia</i>	301	13.69	3.16	8.17	25.02
<i>Viguiera</i>	2	.09	3.77	9.12	12.98
<i>Gutierrezia</i>	165	7.33	1.60	5.03	13.96
<i>Menodora</i>	273	12.86	2.01	6.95	21.82
<i>Janusia</i>	88	4.00	1.31	4.40	9.71
<i>Aplopappus</i>	67	3.05	2.29	2.20	7.54
<i>Galium</i>	42	1.91	2.38	4.71	9.00
<i>Dodonaea</i>	10	.45	.12	.63	1.20
<i>Agastache</i>	176	7.83	1.76	2.52	12.11
<i>Sphaeralcea</i>	10	.45	.12	.63	1.20
<i>Lotus</i>	53	2.41	4.97	5.34	12.72
<i>Condalia</i>	<u>34</u>	<u>1.55</u>	<u>.16</u>	<u>.94</u>	<u>2.65</u>
	2199	100.16	99.97	99.99	300.12

SUMMARY

This paper contains the results of an ecological and taxonomic floral study carried out in the summer and fall of 1961, at Tonto National Monument. About one half of the monument has been fenced for twenty years. Now Arizona Lower Sonoran desert, the area was forested in the mid- and late eighteen hundreds. The study was made in order to preserve the floral record within the fenced boundaries.

Five line intercept transects were established on compass lines. One running north-south, the others running east-west. The total transect length was 9,950 feet. The deciduous community in Cholla Wash was sampled by a modification of stratified random sampling.

As methods were used to obtain density which have yet to be exhaustively proven, the data occurs in two sections; the line intercept proven methods data in the first section of the paper, the data from the new methods occurs in the second section. Analysis of both sections indicates *Simmondsia chinensis*, the goat-nut, is dominant over the higher elevations, *Cercidium*, or Palo Verde, over the lower. Exposure was found to be a factor. The data on Cholla Wash was expressed as the number of individuals per species in the twelve thousand square feet sample. *Platanus* is dominant.

Details of both new methods appear in the appendix.

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APPENDIX

Method by the Mean Chord

Proof that 1.27 times the mean chord is an approximation of the diameter.

$$\frac{A}{2} = \frac{\pi}{2} r^2$$

$$\frac{A}{2} = c_1 \left(\frac{r}{n+1} \right) + c_2 \left(\frac{r}{n+1} \right) + \dots + c_n \left(\frac{r}{n+1} \right)$$

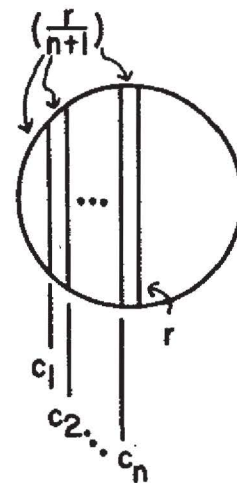
$$\frac{\pi}{2} r^2 = \left(\frac{r}{n+1} \right) (c_1 + c_2 + \dots + c_n)$$

$$\frac{\pi}{2n} r^2 = \left(\frac{r}{n+1} \right) \frac{(c_1 + c_2 + \dots + c_n)}{n}$$

$$\frac{\pi r^2}{2n \left(\frac{r}{n+1} \right)} = \bar{c} \quad \left(\frac{n}{n+1} \right) = 1$$

$$\frac{\pi r^2}{2r \left(\frac{n}{n+1} \right)} = \bar{c} \quad n \rightarrow \infty$$

$$c = \bar{c} = \frac{\pi}{2} r \text{ or } D = \frac{4}{\pi} \bar{c} = 1.273 \bar{c}$$



A METHOD OF DETERMINING DENSITY FROM LINE INTERCEPT DATA

Introduction

It is a fact well noted in the literature of the line intercept that large plants are intercepted more frequently than smaller ones. If it is accepted that 1) all chords of a given plant size have an equal probability of interception (henceforth plants will be referred to as circles), that 2) the probability of interception within a zone of a given width is proportional to that width, and that 3) the largest chord is an approximation of the largest diameter occurring with any frequency, then it is possible to construct a histogram giving the distribution of diameters within the species. From this histogram the average area per individual of the species can be determined, and the density per unit area can be calculated as the quotient of the percent cover times the unit area over the average area per individual.

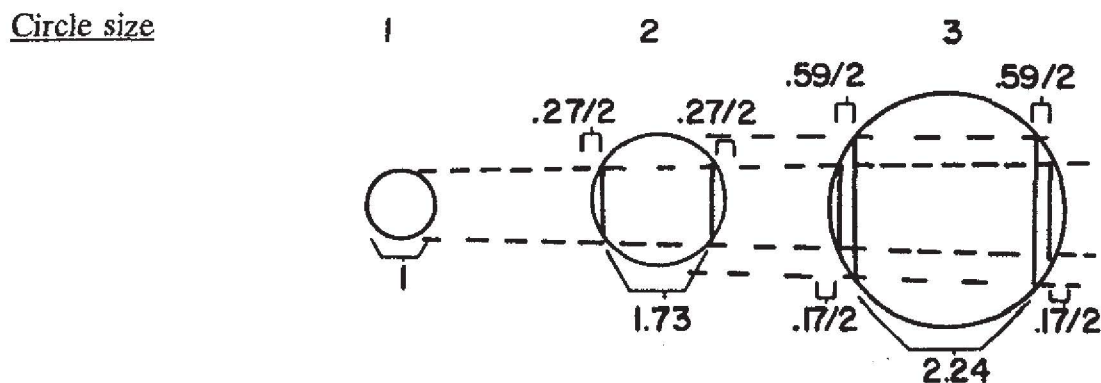
Derivation

The range of the intercepts within a species can be divided into a number of size classes and the number of intercepts falling within each size class tabulated as follows:

<u>Size classes</u>	<u>Tally</u>	<u>Total</u>
A 0+ - 1	 111	8
B 1+ - 2	 1	16
C 2+ - 3	 	15
		39

For each circle size there is a given probability that the chord created by intersection of a random line will fall within any given size class. This probability is proportional to the width of the zone bounded by chords equal to the limits of the size class.

Thus:



<u>Size class</u>				<u>Widths</u>			
A	0+	-	1	1	.27	.17	W_A
B	1+	-	2		1.73	.59	W_B
C	2+	-	3			2.24	W_C

The formula for calculating these widths may be found on the last page.

The number of intercepts occurring in a size class is then proportional to the sum of the products of the width of the contributing zone from each circle size times the frequency of occurrence of the circle size.

For the preceding tabulation of intercepts: (where the frequencies of the circle sizes 1, 2, and 3, are respectively a, b, and c) the equation for solving for frequency a would be:

$$\frac{a + .27b + .17c}{a + 2b + 3c} = \frac{8}{39} = .21$$

That is, the sum of all widths contributing to size class A over the sum of all the widths is equal to the number of intercepts in size class A over the total number of intercepts. This is equivalent to the statement that the sum of the widths contributing to A is proportional to the number of intercepts in size class A.

The equations for b and c follow:

$$\frac{1.73b + .59c}{a + 2b + 3c} = \frac{16}{39} = .41$$

$$\frac{2.42c}{a + 2b + 3c} = \frac{15}{39} = .38$$

As the divisor in the left member is the same for all three equations it may be eliminated from them. This is because the solutions will be in terms of a value relative to this divisor and therefore in proportion regardless of its value.

Let the divisor of the left member equal x.

Then:

$$a + .27b + .17c = .21x$$

$$1.73b + .59c = .41x$$

$$2.24c = .38x$$

$$c = \frac{.38x}{2.24} = .17x$$

Substituting .17x for c in the second equation and solving for b;

$$b = .28x$$

Substituting for b and c in the first equation; $a = .13x$

Regardless of the value of x it may be eliminated and the proportions will remain 13:18:17, thus justifying the statements of the last paragraph. 13:18:17, can have no simple value but 1:1:1, and indeed these are the results of a simple test in which twenty-five random transects were plotted on a population of three circles measuring one, two, and three inches in diameter.

$$1) y^2 + x^2 = r^2$$

1) equation for a circle

$$2) y^2 + x^2 = \frac{D^2}{4}$$

2) substitution of $\frac{D}{2}$ for r

$$3) y^2 = \frac{D^2}{4} - x^2$$

3) isolation of y^2

$$4) y = \sqrt{\frac{D^2}{4} - x^2}$$

4) solution for y

$$5) 2y = 2\sqrt{\frac{D^2}{4} - x^2}$$

5) multiplication by 2, to obtain a complete chord

$$6) D - 1 = 2\sqrt{\frac{D^2}{4} - x^2}$$

6) imposition of $D - 1$, the condition that the chord equal the diameter minus 1 unit

$$7) (D - 1)^2 = 4\left(\frac{D^2}{4} - x^2\right)$$

7) 8) 9) 10) isolation of the x term and solution for 2x

$$8) D^2 - 2D + 1 = \frac{4}{4D^2} - 4x^2$$

$$9) 4x^2 = 2D - 1$$

$$10) 2x = \sqrt{2D - 1}$$

$$11) W_1 = \sqrt{2D - 1}$$

11) as this formula gives the width of the sector in which the condition is met, that the chords $D = 1$, it is termed W_1

If $D = 3$

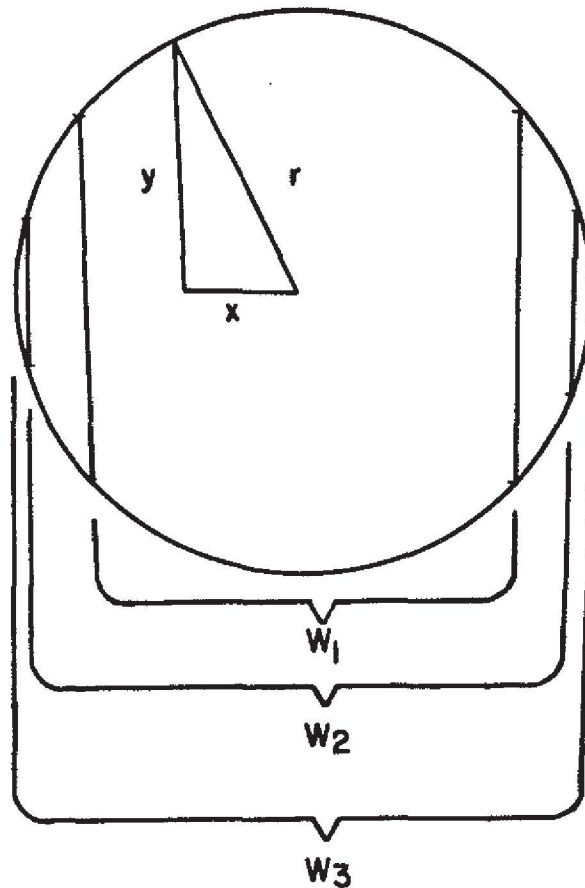
$$W_A = W_3 - W_2$$

$$W_B = W_2 - W_1$$

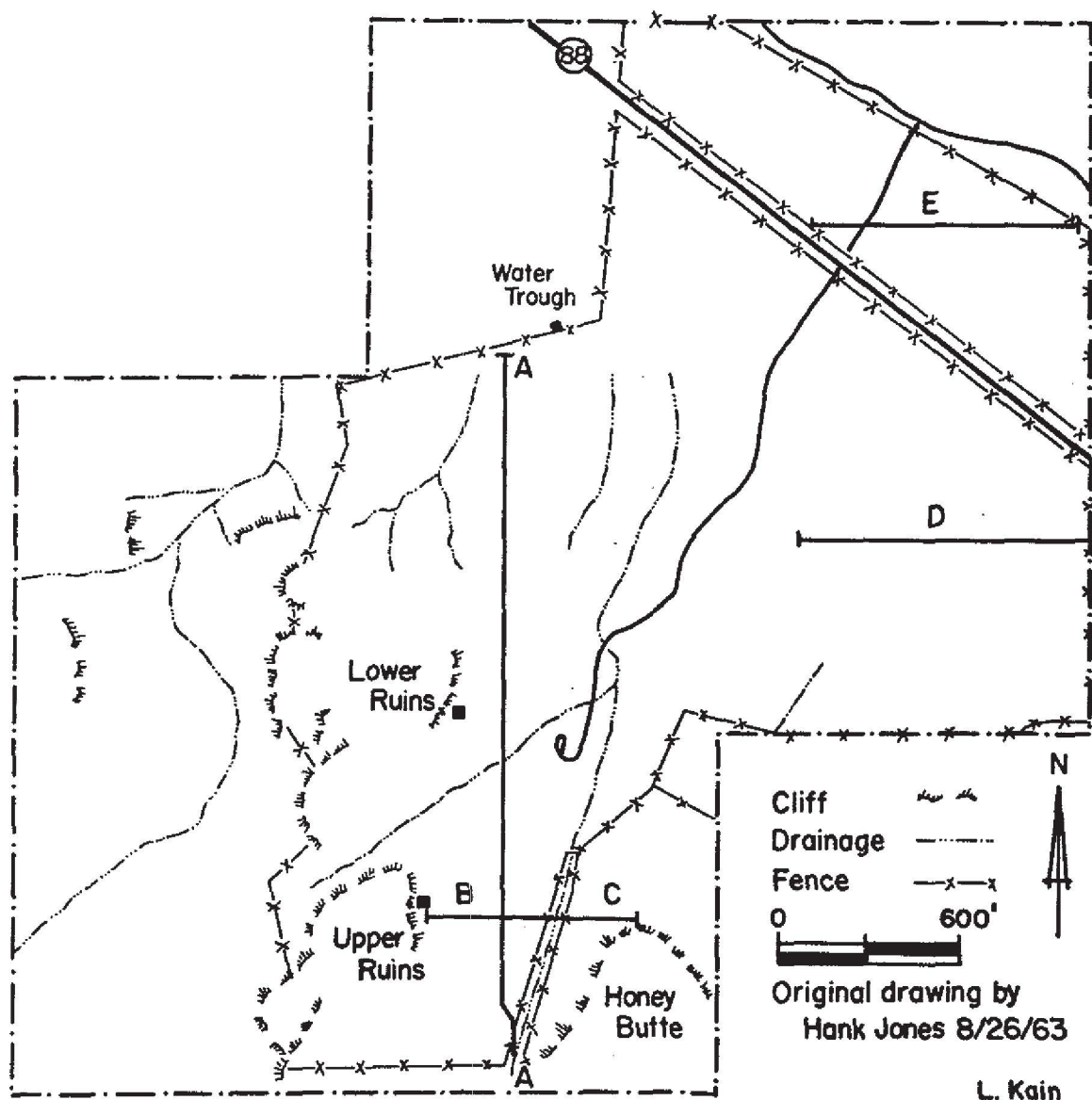
$$W_C = W_1$$

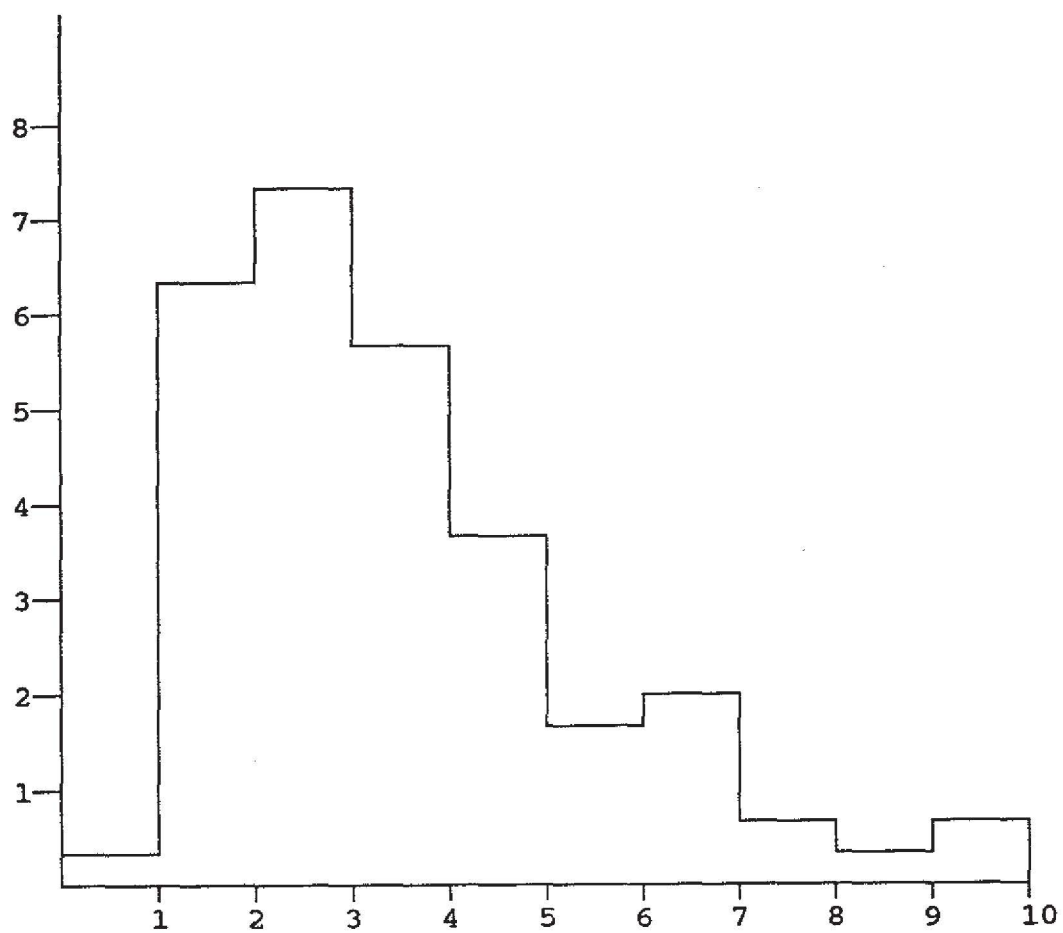
Where A, B, and C are intercept size classes

A	0+	-	1
B	1+	-	2
C	2+	-	3



TRANSECT LINES FOR STRONG'S REPORT TONTO NATIONAL MONUMENT





DIAM. DISTRIBUTION OF SIMMONDSIA

AVE. DIAM., 3.76 FT.

TRUE DENSITY/ACRE = 663

APPENDIX 2

GLOSSARY OF LINE INTERCEPT TERMINOLOGY

Average intercept: total length of intercept of a species divided by the number of intercepts of that species. Note, Strong's (1962) data were divided in subsets or growth habit (trees, shrubs, "miscellaneous") for each transect.

Cover: proportion of the ground occupied by a perpendicular projection to the ground from the outline of the aerial parts of the members of a plant species; the degree of cover is considered as a measure of dominance in a community.

Density: the number of individuals of a species (counted, not estimated) on a unit of area.

Dominance: extent of area covered, space occupied, or degree of control of a community by one or more species, also referred to as cover.

Frequency: a term defined by Danish ecologist C. Raunkiaer for the degree of uniformity that a species shows in its distribution over an area, also the number of times a given event occurs.

Importance value: sum of relative density, relative cover (or dominance), and relative frequency.

Number of intercepts: number of times each individual of a species appears along the transect line.

Percent cover: total intercept of a species divided by the length of the transect, times 100; also called linear density index.

Percent frequency: The proportion of the total number of samples taken which contains the species in question, times 100; for example, if a species occurs in 7 out of 10 plots, its frequency is 7/10 or 0.7.

Relative cover: sum of intercept of a species divided by the sum of intercepts for all species on the transect line, times 100; also called relative dominance. Note: Strong's (1962) data indicates that he defined this term as the sum of intercept of a species divided by the sum of intercepts for species within the subset of growth habit (trees, shrubs, "miscellaneous").

Relative density: the number of individuals of a species divided by the total number of individuals, times 100.

Relative frequency: number of line intercept intervals containing a species divided by the total number of intervals on the transect. Note: Strong's (1962) data indicates that he defined this term as the percent frequency of a species divided by the sum of percent frequency within the subset of growth habit (trees, shrubs, "miscellaneous").

Total intercepts: the sum of length or linear distance an individual species occupies along the transect line.

APPENDIX 3

MISCELLANEOUS NOTES

Note 1. Granger (1983) notes that Cave Canyon (T3N, R12E) is also known as Cholla Canyon, a name approved by the U.S. Geological Survey in 1917. However, the U.S.G.S. Gazetteer (1987) states that the Board of Geographic Names approved Cave Canyon in 1962 as the official name and Cholla Canyon as a variant. Strong (1962) notes that the Cave Canyon name change was effective November 8, 1962. Note that on the topographic maps (USGS 1964a and 1964b) show Cholla Canyon as a small dry wash between the Upper and Lower Ruins at TONT which flows into the Cave Canyon drainage, the larger or main watershed to the west of Honey Butte.

Note 2. Tonto National Monument includes outcrops of Dripping Spring Quartzite, a redeposited limestone and Gila Conglomerate, as well as alluvium and talus of recent derivation. The gray desert soils, range from shallow regosols on the ridges to deeper alluvial soils to the north (Burgess 1965). The monument is within the Continental-Latene-Pinaleno-Association (Hendricks 1985). The proportions of this association are: 30% Continental, 25% Latene, 25% Pinaleno, and 20% other minor soils. The association is characterized by deep, gravelly, medium to fine-textured, nearly level to steep soils on dissected alluvial fan surfaces. The soils have slow permeability and high shrink-swell properties of the Continental Association.

APPENDIX 4

SAMPLE DATA SHEET

TRANSECTS

Total Length: 100 mSampling Area: Heading North from
South Boundary transect # 244Date: 12-13-86Sampler: N. BriamRecorder: m. Muray

SPECIES	TOTAL	INTERCEPTS (cm)
Aristida n=10	2.15	1.0-1.4, 1.75-2.15, 3.8-3.95, 11.2-11.3, 18.0-18.1, 18.3-18.6, 18.5-18.6, 21.2-21.3, 23.3-23.4, 54.5-54.9, .4 .15 .1 .1 .3 .1 .1 .4
Enfa n=17	7.15	5.1-5.6, 68.8-69.1, 70.1-70.6, 71.6-72.3, 72.45-72.7, 73.2-74.0, 80.6-80.7, 81.3-81.4, 81.95-82.0, 82.1-82.6, 82.8-83.1, 84.3-84.7, 84.4-85.0, 85.2-85.4, 85.65-86.2, 87.5-88.4, 95.8-96.2,
sich n=13	12.75	5.5-6.7, 7.6-8.3, 24.9-26.5, 34.5-34.65, 37.6-38.3, 38.3-39.0, 50.7-52.8, 56.4-57.0, 59.1-59.5, 66.3-66.8, 66.6-68.3, 78.8-79.1, 79.2-80.3,
Sphaeralcea n=10	2.85	7.05-7.3, 19.4-19.55, 24.4-24.6, 28.1-28.4, 32.4-32.6, 32.7-33.1, 36.6-36.8, 36.85-37.7, 38.6-38.7, 65.9-66.1, 0.25/.15/.2/.3/.0.2/.0.4/.2/.0.2/.65/.1
Low Grass/Scrub n=2	0.7	11.2-11.6, 30.8-31.1, .4 .3
Diospyllum n=1	0.4	16.8-17.2,
Lady Fern n=1	0.15	42.5-42.65,
Stipa? n=1	0.5	42.9-43.4,
Selaginella n=1	0.1	44.1-44.2,
Shrubby Penstemon n=1	2.2	61.9-64.1,
Mirabilis n=1	0.4	74.3-74.7,
Gallium n=1	0.20	82.85-83.05
Goat Grass n=5	2.50	91.3-92.2, 92.3-92.9, 93.1-93.6, 97.9-98.3, 99.1-99.2, 0.9 .6 .5 .4
Enfr n=1	0.3	95.0-95.3,

APPENDIX 5

VASCULAR PLANT SPECIES

Alphabetical list of the species encountered (September to December 1986) along the line intercept transects in Tonto National Monument by common and scientific name (Lehr 1978, Lehr and Pinkava 1980, 1982). Synonyms are listed parenthetically where necessary.

<u>COMMON NAME</u>	<u>SCIENTIFIC NAME</u>
Aster	<i>Aster bigelovi</i>
Banana yucca	<i>Yucca baccata</i>
Barrel cactus	<i>Ferocactus acanthodes</i>
Beardgrass	<i>Bothriochloa barbinodis</i> (= <i>Andropogon barbinodis</i>)
Blue palo verde	<i>Cercidium floridum</i>
Brittlebush	<i>Encelia farinosa</i>
Brownfoot	<i>Acourtia wrightii</i> (= <i>Perezia wrightii</i>)
Buckhorn cholla	<i>Opuntia acanthocarpa</i>
Canotia	<i>Canotia holacantha</i>
Catclaw acacia	<i>Acacia greggii</i>
Cliff break	<i>Pellaea truncata</i>
Cloak fern	<i>Notholaena cochinchensis</i>
Cloak fern	<i>Notholaena standleyi</i>
Condalia	<i>Condalia lycioides</i>
Creosote bush	<i>Larrea divaricata</i> ssp. <i>tridentata</i> (= <i>Larrea tridentata</i>)
Desert bedstraw	<i>Galium stellatum</i>
Desert broom	<i>Baccharis sarothroides</i>
Desert mistletoe	<i>Phoradendron californicum</i>
Desert needlegrass	<i>Stipa speciosa</i>
Desert senna	<i>Senna covesii</i> (= <i>Cassia covesii</i>)
Desert spoon	<i>Dasyllirion wheeleri</i>
Desert straw	<i>Stephanomeria pauciflora</i>
Desert tobacco	<i>Nicotiana trigonophylla</i>
Dragon sage	<i>Artemesia dracunculoides</i>
Elderberry	<i>Sambucus</i> spp.
Engelmann prickly pear	<i>Opuntia phaeacantha</i> (= <i>Opuntia engelmannii</i>)

COMMON NAME

Fendler's lip fern
Fishhook cactus
Foothill palo verde
Fremont thornbush
Globe mallow
Honey mesquite

Janusia
Jojoba
Keckiella

Krameria
Lemon weed
Littleseed muhly
Lovegrass
Machaeranthera
Mallow
Mariposa
Netleaf hackberry
Ocotillo
Odora
Oreganillo
Red brome
Rock echeveria

Saguaro

Side oats grama
Six-weeks fescue

Slimleaf bursage

Snakeweed
Spike moss
Spiny goldenweed

Spurge
Sweet bush
Arizona sycamore
Tangle head

SCIENTIFIC NAME

Cheilanthes fendleri
Mammillaria microcarpa
Cercidium microphyllum
Lycium fremontii
Sphaeralcea sp.
Prosopis glandulosa var. torreyana
(=Prosopis juliflora
var. torreyana)

Janusia gracilis
Simmondsia chinensis
Keckiella antirrhinoides
ssp. microphylla
(=Penstemon microphyllus)

Krameria parvifolia
Psoralea lanceolata
Muhlenbergia microsperma
Eragrostis arida
Machaeranthera sp.
Malva sp.
Calochortus sp.
Celtis reticulata
Fouquieria splendens
Porophyllum gracile
Aloysia wrightii
Bromus rubens
Dudleya saxosa ssp. collomiae
(=Echeveria collomiae)

Carnegiea gigantea
(=Cereus giganteus)
Bouteloua curtipendula
Vulpia octoflora
(=Festuca octoflora)

Ambrosia confertiflora
(=Franseria confertiflora)
Gutierrezia microcephala
Selaginella arizonica
Haplopappus spinulosus
(=Aplopappus, =Machaeranthera)

Euphorbia sp.
Bebbia juncea
Platanus wrightii
Heteropogon contortus

COMMON NAME

Teddy bear cactus
Thistle
Three-awn
Trailing four-o'clock
Trixis
UNKG
UNK1
UNK3
UNS2
White bursage

Wild buckwheat
Wishbone bush

SCIENTIFIC NAME

Opuntia bigelovii
Cirsium neomexicanum
Aristida parishii
Allionia incarnata
Trixis californica
Unknown grass
Unknown #1
Unknown #3
Unknown shrub #2
Ambrosia dumosa
 (= *Franseria dumosa*)
Eriogonum fasciculatum
Mirabilis bigelovii

The cover photograph was taken October 4, 1935, in Saguaro National Monument by the first National Park Service photographer, George Alexander Grant (1891-1964).



As the nation's principal conservation agency, the U.S. Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting fish, wildlife and plants, preserving the environmental and cultural values of national parks and historic places, and providing for enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.