Use of Remote Sensing for Vegetation Inventories in a Desert Shrub Community

by Ernest B. Fish and Edwin L. Smith

With the advent of requirements for environmental impact statements and an acute awareness of the fragile nature of desert ecosystems, land use planners are faced with the task of rapidly, accurately and economically taking inventories of extensive areas of natural ecosystems.

In particular, the sampling of native vegetation is never an easy undertaking and is particularly complex in shrub communities. Techniques have been fairly well developed for use in grassland communities using various sizes and shapes of plots which can be laid down over the vegetation. In forested lands, plotless techniques have been developed but many of these methods depend upon individual plants having a single well defined trunk or main stem. The major difficulties in utilizing plotless techniques in a shrub community are related to life form of the shrub species. Spacing of individuals creates physical problems in laying out plots of sufficient size to obtain a desired level of precision. The variations in size and density of individuals may necessitate several plot sizes for adequate sampling precision.

The purpose of this study was to explore the feasibility of using remote sensing techniques to facilitate vegetative sampling in desert shrub communities.

A mesquite-paloverde community located on the Santa Rita Experimental range at approximately 3200 feet elevation was chosen as the test site. The study area was initially stratified into two subcommunities: the braided channel type which included major drainages and adjacent flood plains, and an upland type between channels, not subject to frequent flooding. Delineations were made utilizing complete stereo coverage of the area at a scale of 1:6000 (approximately 10 inches per mile) with black and white panchromatic and with Ektachrome color infrared film. See Figure 1, Page 5. The delineation was performed equally well with either film type.

*Research Associate and Associate Professor, respectively, Watershed Management Department.

In an attempt to quantify attributes of the two subcommunities in terms of species crown cover percentages, surface area of drainage channels, and the relative proportion of the area occupied by each subcommunity, subsampling was undertaken using large scale 1:600 (approximately 1 inch per 50 feet) Ektachrome color infra-red photographs. A key question in using imagery to sample vegetation is: "Can species be accurately identified and by what means?" (See Figures 2 & 3, Page 5.) We found that multiseasonal color infrared imagery at a scale of 1:600 permitted identification of the major shrub and cacti species. The size at which a young plant becomes recognizable seems to depend on each individual species. The individuals of many species can be seen at this scale but are not of a sufficient size for accurate identification. This is particularly true in the case of burroweed *Aplopappus tenuisectus;* zinnia, *Zinnia pumila* and young staghorn cacti, *Opuntia versicolor.*

Imagery samples consisted of stereo triplets with the center frame having a 100 square grid superimposed on the frame. On 1:600 scale imagery a typical "frame" plot is approximately 120 feet ground distance on a side or a one-third acre ground area. Cover estimates were determined by recording the species present, if any, at the

Table 1. Upland site percent cover estimates.

	Ground Sample		*Imagery Sample*				
Species or feature	*Number of Samples*	*Mean*	*Number of Samples*	*Mean*	*Difference of Means*	*Standard error of the difference*	*t*
Mesquite	42	4.20	15	8.20	4.00	2.12	1.89
Paloverde	42	1.10	15	0.80	0.30	1.00	0.30
Catclaw	42	0.94	15	0.70	0.24	0.82	0.29
Hackberry	42	0.41	15	1.10	0.69	0.52	1.33
Chain Cholla	42	1.15	15	1.90	0.75	0.67	1.12
Staghorn Cholla	42	0.96	15	0.50	0.46	0.48	0.96
Prickly Pear	42	0.35	15	0.30	0.05	0.38	0.13
Barrel Cactus	42	0.00	15	0.10	0.10	0.04	2.50*
Greythorn	42	0.08	15	0.00	0.08	0.14	0.57
Sandy Wash	42	0.00	15	0.00	0.00	0.00	0.00

* indicates significance at $P \leq .05$, d.f. 55

intersection of grid lines for 100 points on each frame. Ground truth cover estimates were made using line intercept data on 30-meter transects. Sample estimates of mean differences between imagery and ground truth cover values by species were tested using a "t" test for unequal sample size (Steel and Torrie, 1960).

Tables 1 and 2 show the results of cover determination for species and the surface area of sandy stream channels. In only one instance are the imagery and ground estimates significantly different. Because of the number of tests performed and the significance level ($P \leq .05$) this result is not unusual. These data tend to confirm that density estimate differences from earlier studies (Fish and Smith, 1971) were either due to failure to detect small young individuals which would not contribute materially to cover or due to failure to distinguish separate individuals in a clump.

Table 3 shows a comparison of the two subcommunities on the basis of the ground truth samples. The primary differences appear to be increased crown cover of mesquite, paloverde, catclaw, staghorn cholla, and hackberry in the braided channel type as well as the greater proportion of drainage channel surface. Table 4 shows a comparison of the two subcommunities on the basis of crown cover estimates from the imagery. The primary differences between the imagery results and the ground truth results were that significant cover differences were not detected by the imagery sampling for staghorn cholla or for hackberry.

These results tend to indicate that the initial subdivision of the study area into two subcommunities using 1:6000 scale imagery were in fact valid and that a quantitative measure of the differences is possible using the larger scale 1:600 imagery. The imagery techniques, using approximately one-third as many sample units, adequately detected crown cover differences nearly as well as more intensive ground sampling.

Table 2. Braided channel site percent cover estimates.

	Ground Sample		Imagery Sample				
Species or feature	*Number of Samples*	*Mean*	*Number of Samples*	*Mean*	*Difference of Means*	*Standard error of the difference*	
Mesquite	31	14.52	12	16.92	2.40	4.44	0.54
Paloverde	31	3.51	12	2.33	1.18	1.56	0.76
Catclaw	31	8.70	12	6.67	2.03	9.41	0.22
Hackberry	31	1.91	12	2.42	0.51	1.25	0.41
Chain Cholla	31	0.17	12	0.83	0.66	0.39	1.69
Staghorn Cholla	31	0.14	12	0.42	0.28	0.16	1.75
Prickly Pear	31	0.17	12	0.42	0.25	0.23	1.09
Barrel Cactus	31	0.00	12	0.08	0.08	0.05	1.60
Greythorn	31	0.13	12	0.17	0.04	0.22	0.18
Sandy Wash	31	26.56	12	23.67	2.89	4.55	0.63

Table 3. Percent cover estimates from ground sampling.

	Upland		Braided Channel				
Species or feature	*Number of Samples*	*Mean*	*Number of Samples*	*Mean*	*Difference of Means*	*Standard error of the difference*	
Mesquite	42	4.20	31	14.52	10.32	2.72	3.79**
Paloverde	42	1.10	31	3.51	2.41	1.07	2.25*
Catclaw	42	0.94	31	8.70	7.76	1.68	4.62**
Hackberry	42	0.41	31	1.91	1.50	0.71	2.11*
Chain Cholla	42	1.15	31	0.17	0.98	1.42	0.69
Staghorn Cholla	42	0.96	31	0.14	0.82	0.34	2.41*
Prickly Pear	42	0.35	31	0.17	0.18	0.28	0.64
Barrel Cactus	42	0.00	31	0.00	0.00	0.00	0.00
Greythorn	42	0.08	31	0.13	0.05	0.14	0.36
Sandy Wash	42	0.00	31	26.56	26.56	2.25	11.80**

* *Indicates Significance at* $P \leq .05$, *d.f.* 71
** *Indicates Significance at* $P \leq .01$, *d.f.* 71

Table 4. Percent cover estimates from imaginery sampling.

	Upland		Braided Channel				
Species or feature	*Number of Samples*	*Mean*	*Number of Samples*	*Mean*	*Difference of Means*	*Standard error of the difference*	
Mesquite	15	8.20	12	16.92	8.72	1.69	5.16**
Paloverde	15	0.80	12	2.33	1.53	0.63	2.43*
Catclaw	15	0.70	12	6.67	5.97	0.98	6.09**
Hackberry	15	1.10	12	2.42	1.32	0.79	1.67
Chain Cholla	15	1.90	12	0.83	1.07	0.70	1.53
Staghorn Cholla	15	0.50	12	0.42	0.08	0.28	0.28
Prickly Pear	15	0.30	12	0.42	0.12	0.19	0.63
Barrel Cactus	15	0.10	12	0.08	0.02	0.10	0.20
Greythorn	15	0.00	12	0.17	0.17	0.15	1.13
Sandy Wash	15	0.00	12	23.67	23.67	2.54	9.32**

* *Indicates Significance at* $P \leq .05$, *d.f.* 25
** *Indicates Significance at* $P \leq .01$, *d. f.* 25

Accuracy of the identification of specific individuals from imagery was checked by ground identification for selected plants. The technique of using multi-date imagery taken at different phenological stages, namely just prior to mesquite leafing out and when it was in full leaf, generally provided accurate identification of the major species except for very young plants.

The advantages of using remote sensing imagery to conduct inventories are: (1) Access to sampling points is greatly facilitated by the use of imagery. Many ground samples involved walking over a mile to the location. (2) Imagery sampling resulted in a reduction of labor and costs. Ground sampling required five trips to and from the area and ten man days in the field, while the imagery results were obtained with three man days of effort, two hours flying time and 100 feet of film. (3) The imagery provides a permanent, visual record of conditions at a point in time which can be reexamined in the future to detect changes over time.

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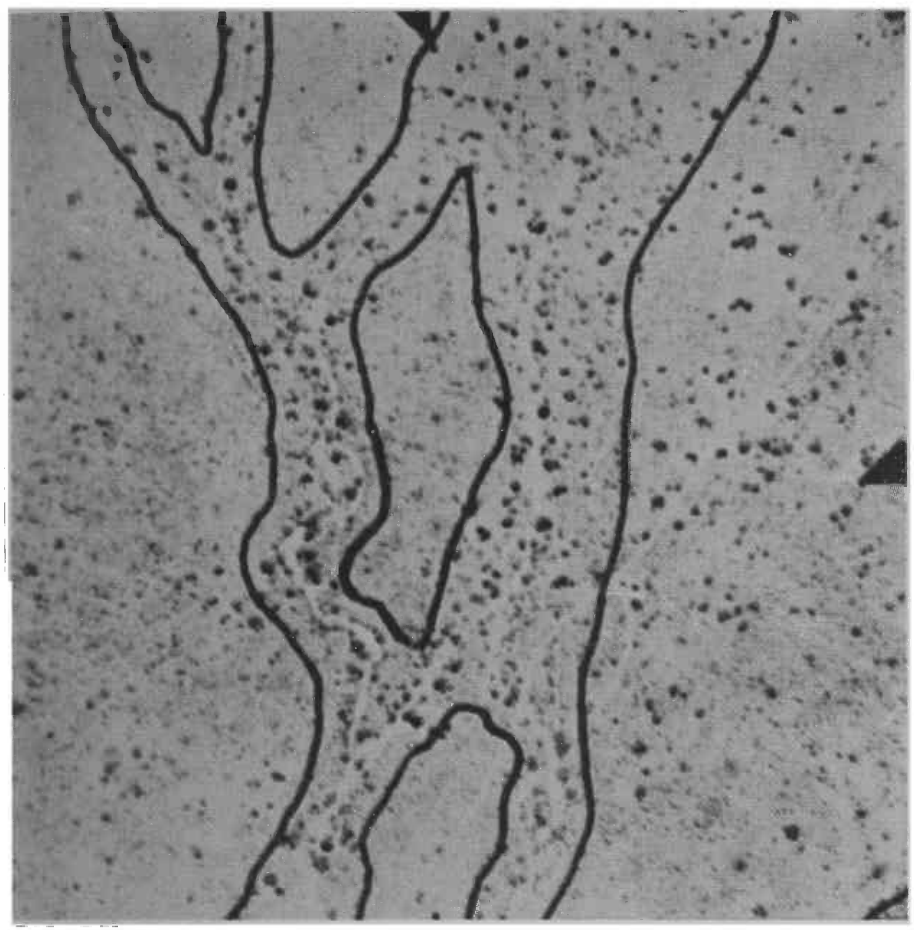

Figure 1. Study area with shrub community delineated (original photograph is 1:6000 scale.)

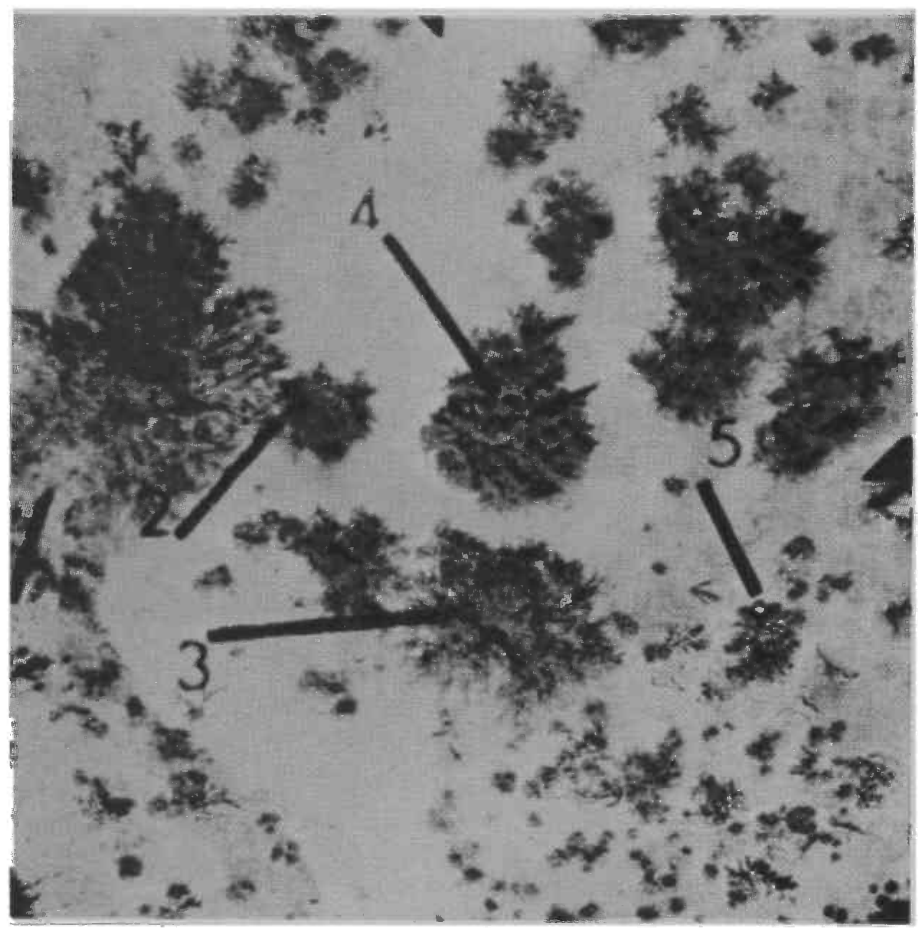

Figure 2. Shrub species annotated and identified on frame of original photograph which was shot at 1:600 scale.

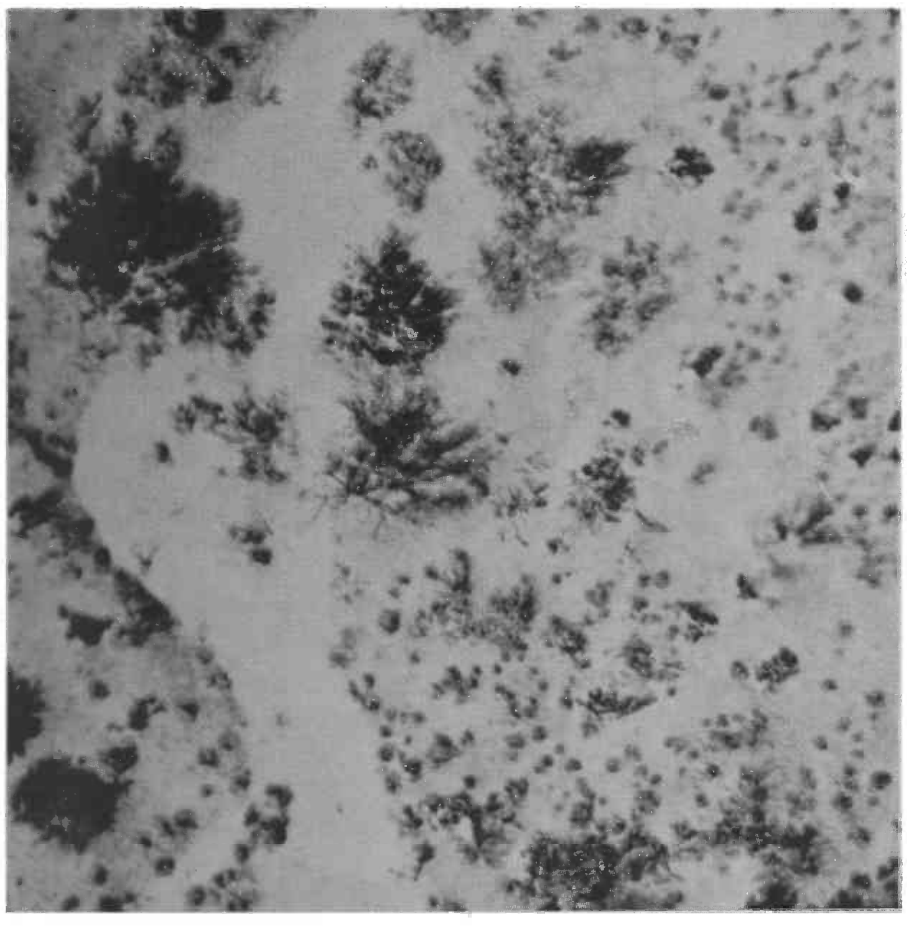

Figure 3. Same areas as Figure 2, but the picture was taken during a different season of the year. (Note that picture upper right number 1. is paloverde, 2. catclaw, 3. mesquite 4. hackberry and 5. barrel cactus.

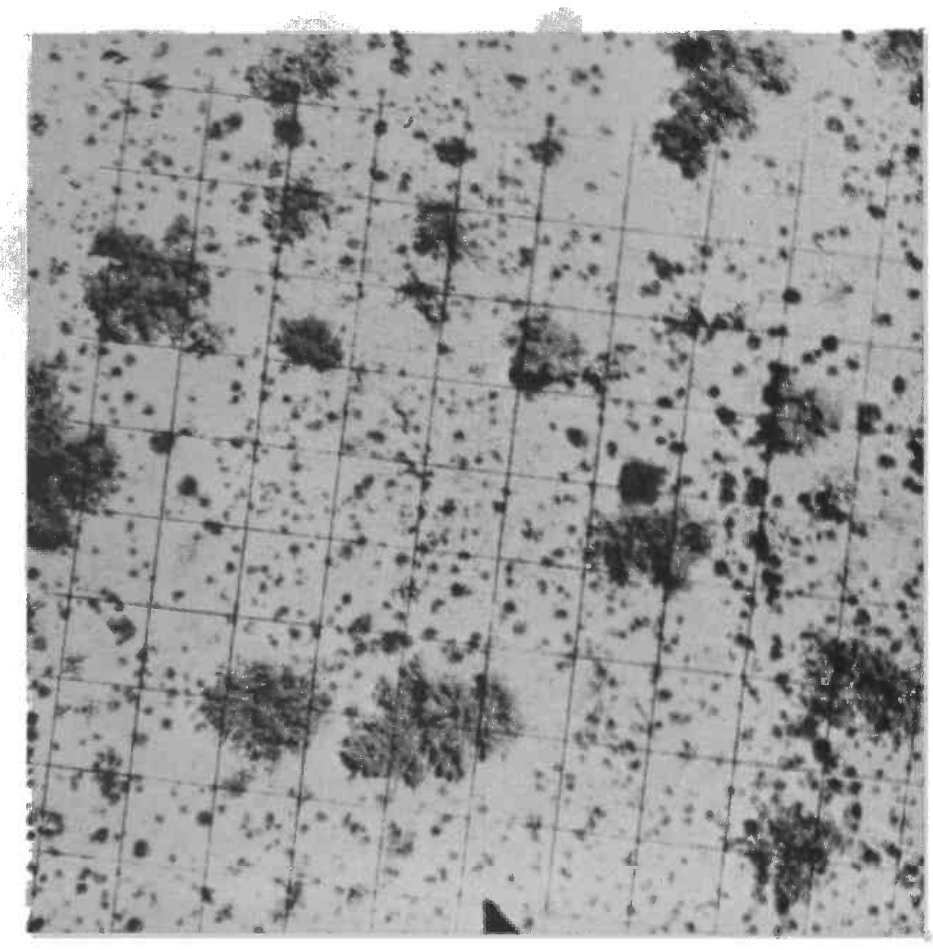

Figure 4. A frame with a 100 grid sampling device superimposed upon the photograph. The original photography was shot at 1:600 scale.

Literature Cited

Fish, E. B. and E. L. Smith. 1971. Remote Sensing for Inventory of Desert Shrub Vegetation in Southeastern Arizona. Paper presented at 47th Annual Meeting of Southwestern and Rocky Mountain Division American Association for the Advancement of Science. Tempe, Arizona.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Company Inc., New York. 481 p.