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Seed Reserves in Desert Soils

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SEED RESERVES IN DESERT SOILS

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ABSTRACT

Soil and litter samples were collected from the playa, playa fringe and bajada zones of the Jornada Validation Site. These samples were analyzed for their seed content, special attention being paid to spatial distribution. At the time of sampling, there was little litter on the soil surface, and the litter contained only a small proportion of the total seeds present.

INTRODUCTION

Numerous studies have been made of the seed reserves in arable soils and in improved grassland, but prior to this study very little information was available on reserves in desert soils, either in North American or elsewhere. This project was initiated in 1971 to develop methods for estimating seed reserves, and to inventory the seed reserves of validation sites. Previous reports have appeared under the names of Goodall et al. (1972) and Childs and Goodall (1973).

OBJECTIVES

This project has as its purpose to obtain estimates of the soil seed populations in the Desert Biome Validation Sites, and also to provide information on their spatial distribution.

METHODS

Field Work

The sampling of Jornada soils, with which this report is concerned,was completed in July, 1972; it was described in the previous progress report (Childs and Goodall, 1973). During the year under review, field work was limited to acquainting a new technician with the vegetation and topography of the sites, and to collecting samples of seed from growing plants for identification and for germination tests.

Laboratory Techniques

The laboratory techniques remained relatively unchanged from the previous year (Childs and Goodall, 1973). An occasional spot-check by microscope of the soil remaining after flotation determined the efficiency of the potassium carbonate method. A second flotation in zinc chloride solution was also used with samples from each of the three zones to check for heavier seeds missed by the potassium carbonate flotation. In no case were additional seeds discovered by this second flotation. Soaking in Calgon remained a part of the procedure although the soils were generally quite coarse and contained few aggregates.

Tests for seed recovery (DSCODE A3UGE31) continued to give results around 90%. For some species from the Jornada site, supplies of seed for recovery tests were not available, and in such instances seeds of the same genus and comparable in size to the species in question were used.

The total number of 100 cm^2 samples from the Jornada site which were analyzed was 64, of which 25 were from the bajada, 22 from the playa fringe and 17 from the playa itself. All were divided into four sub-samples representing different depths (0-1, 1-2, 2-5, and 5-10 cm), and samples of surface litter were also included where it was present.

Seed Identification

A partial seed herbarium for the Jornada site was furnished last year by Dr. W. G. Whitford, Coordinator of the Jornada validation study. Additional assistance in identification was supplied by the Intermountain Herbarium at Utah State University (Arthur Holmgren, Curator) and Richard Spellenberg at the University of Arizona, Tucson.

Three publications were found particularly helpful in identification: Kearney (1951), Musil (1963) and Parker (1972).

Table 1. Seed distribution by depth at Jornada site: Bajada (A3UGE32)

Species	Surface Litter		0-1 cm		1-2 cm		2-5 cm		5-10 cm		All Depths	
	Samples where present	Seeds counted	Samples where present	Seeds counted	Samples where present	Seeds counted	Samples where present	Seeds counted	Samples where present	Seeds counted	Samples where present	Mean seeds per dm^2
Amaranthus spp.	0	0	1	1	0	0	1	1	0	0	2	2.4
Chenopodium spp.	0	0	0	0	0	0	2	2	0	0	2	3.1
Descurainia pinnata	2	2	3	8	7	31	6	19	1	4	13	10.9
Eriogonum spp.	0	0	1	1	0	0	0	0	0	0	1	1.2
Euphorbia micromera	0	0	10	29	7	12	6	17	1	2	17	7.0
Euphorbia spp.	0	0	1	3	1	1	2	4	0	0	2	9.6
Kallstroemia parviflora	0	0	1	1	1	1	1	1	0	0	2	3.0
Larrea divaricata	0	0	4	4	0	0	0	0	0	0	4	1.2
Mentzelia spp.	1	1	2	3	4	4	2	8	0	0	6	6.4
Portulaca oleracea	0	0	0	0	0	0	1	1	0	0	1	3.6
Sida spp.	0	0	0	0	0	0	0	0	1	1	1	6.0
Sporobolus cryptandrus	0	0	1	1	2	2	0	0	1	1	3	3.2
Species A	2	4	14	79	14	97	9	37	5	17	16	28.1
Species B	0	0	1	1	0	0	0	0	1	1	2	3.6
Species C	0	0	0	0	0	0	1	1	1	6	2	19.5

Determination of Bulk Density

Bulk density data, required for conversion of seed counts to density estimates, were taken from a report on the Jornada soils by Southard (see Whitford, 1974):

Playa	1.5
Playa fringe	1.72
Bajada	1.2

RESULTS AND DISCUSSION

The present progress report is limited to the analyses of the samples taken from the Jornada site. The three distinct areas there are treated separately.

Depth Distribution

The distribution of seeds with depth (to 10 cm) is shown in Tables 1 to 3 (A3UGE32). It will be noted that two of the species have not been identified, while others have been identified only to genus. As germination tests proceed, more precise identification may become possible. In these tables, for each depth, both the number of samples in which seed of the species in question was found, and total number of seeds counted, are recorded. In the case of the surface litter samples (occurring at the season in question on the bajada only, and only in five out of the 25 areas sampled there), the whole sample was analyzed, and hence the counts refer to 100 cm^2 per sample. In the deeper samples, a sub-sample of 100 g of air-dry soil was analyzed; hence the count must be multiplied by the bulk density and by the thickness (in cm) of the soil layer in order to arrive at a comparable estimate on an area basis. The last two columns of Tables 1, 2 and 3 give the number of samples to 10 cm in which seed of the species in question were recorded at one or more depths, and an estimate of the mean number of seeds in these samples expressed for an area of 100 cm^2.

The different distribution of seeds with depth is analyzed further in Table 4. Here, the seed counts for the more abundant species are brought together for each of the three areas, and a χ^2 test (with 3 degrees of freedom) is used to

Table 2. Seed distribution by depth at Jornada site; playa fringe (A3UGE32)

Species	0-1 cm Samples where present	0-1 cm Seeds counted	1-2 cm Samples where present	1-2 cm Seeds counted	2-5 cm Samples where present	2-5 cm Seeds counted	5-10 cm Samples where present	5-10 cm Seeds counted	All Depths Samples where present	All Depths Mean seeds per dm^2
Amaranthus spp.	4	7	3	12	3	10	2	2	8	12.69
Cassia bauhinioides	0	0	1	1	0	0	0	0	2	3.44
Chenopodium spp.	18	331	19	306	16	223	16	167	19	193.79
Descurainia pinnata	5	6	4	17	4	6	0	0	6	11.75
Eriogonum spp.	1	7	1	1	1	2	0	0	2	6.88
Euphorbia micromera	5	7	6	15	2	6	1	3	9	10.15
Euphorbia spp.	5	6	3	5	2	6	4	5	6	15.88
Kallstroemia parviflora	3	3	5	6	4	6	1	1	10	5.51
Mentzelia spp.	2	2	4	5	3	4	1	1	8	5.15
Portulaca oleracea	2	2	3	6	3	4	2	4	6	11.39
Sida spp.	1	1	1	1	1	10	0	0	3	18.34
Sporobolus cryptandrus	4	20	7	35	6	25	2	2	10	24.08
Species A	3	2	4	6	2	2	0	0	6	3.15
Species B	0	0	1	2	0	0	0	0	1	3.44
Species C	0	0	4	6	2	4	3	8	7	14.17

Table 3. Seed distribution by depth at Jornada site; playa (A3UGE32)

Species	0-1 cm Samples where present	0-1 cm Seeds counted	1-2 cm Samples where present	1-2 cm Seeds counted	2-5 cm Samples where present	2-5 cm Seeds counted	5-10 cm Samples where present	5-10 cm Seeds counted	All Depths Samples where present	All Depths Mean seeds per dm^2
Amaranthus spp.	1	1	0	0	0	0	0	0	1	1.5
Cassia bauhinioides	0	0	0	0	3	3	1	2	4	7.1
Chenopodium spp.	5	41	6	69	6	75	5	44	7	118.9
Descurainia pinnata	0	0	0	0	1	1	0	0	1	4.5
Eriogonum spp.	7	66	7	36	4	14	2	4	8	64.4
Euphorbia micromera	2	2	1	1	2	2	0	0	4	2.4
Euphorbia spp.	4	7	3	7	4	5	0	0	8	5.4
Kallstroemia parviflora	1	2	0	0	0	0	0	0	1	3.0
Mentzelia spp.	1	3	1	1	1	1	1	1	2	9.0
Portulaca oleracea	5	278	5	298	4	212	5	64	6	383.0
Sida spp.	0	0	0	1	2	4	1	1	2	13.9
Sporobolus cryptandrus	5	20	8	43	7	23	5	19	10	34.1
Xanthium strumarium	1	1	0	0	0	0	0	0	1	1.5
Zinnia grandiflora	2	2	2	2	0	0	0	0	4	1.5
Species B	2	2	1	3	1	1	0	0	5	2.4

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Table 4. Seed distribution by depth at Jornada site (A3UGE32)

Species	Number of seeds in samples of equivalent weight: 0-1 cm	1-2 cm	2-5 cm	5-10 cm	χ^{2*}
BAJADA					
Descurainia pinnata	8	31	19	4	28.45
Euphorbia micromera	28	12	17	2	23.78
Species A	79	97	37	17	71.01
PLAYA FRINGE					
Amaranthus sp.	7	12	10	2	7.32
Chenopodium spp.	331	306	223	167	66.73
Descurainia pinnata	6	17	6	0	20.79
Euphorbia micromera	7	15	6	3	10.16
Euphorbia spp.	6	5	6	5	0.18
Kallstroemia parviflora	3	6	6	1	4.50
Sporobolus cryptandrus	20	35	5	2	27.95
PLAYA					
Chenopodium spp.	41	69	75	44	15.59
Eriogonum spp.	66	36	14	4	75.47
Euphorbia spp.	7	7	5	0	9.08
Portulaca oleracea	278	298	212	64	157.99
Sporobolus cryptandrus	20	43	23	19	14.58

*Significance limitis of χ^2 are:

p = .05 χ^2 = 7.82
p = .01 χ^2 = 11.34
p = .001 χ^2 = 16.27

Table 5. Proportion of seeds at different depths at Jornada site; bajada (A3UGE32)

Species	Percentage of total seeds at: Surface	0-1 cm	1-2 cm	2-5 cm	5-10 cm
Descurainia pinnata	1	7	26	49	17
Euphorbia micromera	0	27	12	51	10
Euphorbia serrula	0	18	7	75	0
Kallstroemia parviflora	0	25	25	50	0
Larrea divaricata	0	100	0	0	0
Mentzelia spp.	3	10	12	75	0
Sporobolus cryptandrus	0	12	25	0	63
Species A	1	22	26	29	22
Species C	0	0	0	8	92
All species	2	31	37	22	8

Table 6. Proportion of seeds at different depths at Jornada site; playa fringe (A3UGE32)

Species	Percentage of total seeds at: 0-1 cm	1-2 cm	2-5 cm	5-10 cm
Amaranthus spp.	12	20	51	17
Chenopodium spp.	15	15	37	39
Descurainia pinnata	15	42	43	0
Eriogonum spp.	12	12	75	0
Euphorbia micromera	12	28	33	27
Euphorbia serrula	11	9	34	46
Kallstroemia parviflora	9	19	56	16
Mentzelia spp.	8	21	50	21
Portulaca oleracea	5	15	29	50
Sida spp.	3	3	94	0
Sporobolus cryptandrus	14	25	53	8
Species A	27	55	18	0
Species C	0	10	20	70
All species	30	32	24	14

determine whether, for each species, the differences in density with depth can be regarded as real. It will be noted that, in all cases except three of the less abundant species in the playa fringe, the differences reach significance, and in most cases high significance. In almost all cases, the density below 5 cm is considerably less than nearer the soil surface. In most cases the maximum concentration is between 1 and 2 cm and in 5 cases out of 15 the difference in concentration over that in the surface soil reaches significance.

The different species do not have the same vertical distribution in the soil. Analyzing each section of Table 4 as a contingency table, we find:

Playa fringe $\chi^2 = 51.01$, 18d.f., $P<.001$
Playa $\chi^2 = 97.73$, 12 d.f., $P<.001$
Bajada $\chi^2 = 27.39$, 6 d.f., $P<.001$

Thus, in each area the depth distribution differs with the seed species.

In Tables 5 to 7, the distribution of seeds by depth is recalculated, taking the depth of the different soil layers into acount, to show the proportions of the total seed population (to 10 cm) occurring at the different depths sampled. It will be noted that, at each site, one-third of the total seeds are found between 1 and 2 cm below the surface; a little under one-third are found at a depth less than 1 cm; and only about one-tenth lie below 5 cm.

Sample Location

Comparisons of samples taken in the interspaces between shrubs, and under canopies of different shrub or tussock species, are presented in Tables 8 to 10. The number of interspace areas or canopies sampled is shown, and also the total number of 100 cm^2 samples (to 10 cm depth). The seed quantities recorded are estimates of those contained in such a one-liter

Table 7. Proportion of seeds at different depths at Jornada site; playa (A3UGE32)

Species	Percentage of total seeds at: 0-1 cm	1-2 cm	2-5 cm	5-10 cm
Cassia bauhinioides	0	0	47	53
Chenopodium spp.	7	13	41	39
Eriogonum spp.	55	30	12	3
Euphorbia micromera	40	20	40	0
Euphorbia serrula	24	24	52	0
Mentzelia spp.	25	8	25	20
Portulaca oleracea	19	19	42	42
Sida spp.	0	54	32	13
Sporobolus cryptandrus	9	19	30	42
Zinnia sp.	50	50	0	0
Species B	25	37	38	0
All species	31	34	25	10

Table 8. Estimates of seed numbers per sq. dm under different canopy species; bajada (A3UGE32)

Canopy Species:	Between shrubs	*Prosopis glandulosa*	*Fallugia paradoxa*	*Larrea tridentata*
No. of canopy individuals:		2	2	2
No. of 1 sq. dm samples:	5	8	7	5
Seed species				
Amaranthus spp.	0.0	0.4	0.2	0.0
Chenopodium spp.	0.0	0.2	0.5	0.0
Descurainia pinnata	1.7	2.1	13.3	5.0
Euphorbia micromera	10.1	4.9	4.6	1.2
Euphorbia spp.	0.0	0.0	2.7	0.0
Kallstroemia parviflora	0.7	0.0	0.3	0.0
Mentzelia spp.	6.5	0.4	0.3	0.0
Portulaca oleracea	0.0	0.0	0.0	0.7
Sporobolus cryptandrus	0.0	0.2	1.2	0.0
Species A	1.2	24.4	30.3	0.5
Total, all species	20.2	32.6	53.4	7.4

Table 9. Estimates of seed numbers per sq. dm under different canopy species; playa fringe (A3UGE32)

Canopy Species:	Between shrubs	*Prosopis glandulosa*	*Ephedra trifurca*	*Yucca elata*	*Hilaria mutica*
No. of Canopy individuals:		2	1	1	2
No. of 1 sq. dm samples:	2	8	3	3	6
Seed Species					
Amaranthus spp.	0.0	19.9	3.4	0.6	0.0
Chenopodium spp.	177.2	302.7	94.5	185.3	22.1
Descurainia pinnata	0.0	3.4	0.0	11.5	0.0
Eriogonum spp.	0.0	1.3	0.0	0.0	0.0
Euphorbia micromera	6.9	7.7	4.0	1.1	0.6
Euphorbia spp.	0.0	4.7	5.2	5.7	0.0
Kallstroemia parviflora	0.0	2.8	0.0	7.4	2.2
Portulaca oleracea	0.0	1.7	8.6	0.7	0.0
Sporobolus cryptandrus	21.4	11.6	0.0	3.2	0.0
Species A	0.9	1.9	0.0	2.3	0.0
Total, all species	206.4	357.7	115.7	217.8	24.9

Table 10. Estimates of seed numbers per sq. dm under different canopy species; playa (A3UGE32)

Canopy Species:	Between shrubs	*Prosopis glandulosa*	*Ephedra trifurca*	*Hilaria mutica*
No. of canopy individuals:		2	1	1
No. of 1 sq. dm samples:	4	8	3	2
Seed species				
Amaranthus spp.	0.0	0.2	0.0	0.0
Chenopodium spp.	112.5	0.2	0.0	199.0
Descurainia pinnata	0.0	0.6	0.0	0.0
Eriogonum spp.	0.0	25.3	14.5	0.0
Euphorbia micromera	0.4	1.5	0.0	0.0
Euphorbia spp.	1.2	3.4	0.0	0.0
Kallstroemia parviflora	0.7	0.0	0.0	0.0
Portulaca oleracea	285.4	1.5	0.0	443.3
Sporobolus cryptandrus	0.4	36.7	12.0	0.0
Species A	0.0	0.0	0.0	0.0
Total, all species	400.6	69.4	26.5	642.3

Table 11. Total seed population per sq. dm under different types of canopy -- analysis of variance (A3UGE32)

Area	Source of Variation	d.f.	S.S.	M.S.
Bajada	Bare ground vs cover	1	20.94	20.94
	Between cover types	2	30.07	15.04
	Between cover individuals^x within types	7	83.20	11.88
	Within cover individuals	14	124.88	8.92
Playa fringe	Bare ground vs cover	1	.31	.31
	Between cover types	3	840.63	280.21
	Between cover individuals^x within types	3	61.12	20.37
	Within cover individuals	14	181.74	12.98
Playa	Bare ground vs cover	1	50.51	50.51
	Between cover types	2	584.13	292.06
	Between cover individuals^x within types	4	421.94	105.48
	Within cover individuals	9	36.24	4.03

volume of soil, obtained by multiplying the numbers actually counted in sub-samples of 100 g by the bulk density, and by the thickness of the soil layer represented. Where surface litter occurred, the number of seeds found in the 100 cm^2 sample was added.

The comparisons among canopy types were tested by analysis of variance, the results of which are given in Table 11. For this purpose, seeds of all species were combined, and the density per dm^2 was subjected to a square-root transformation. It will be noted that, unlike results at other locations (Goodall et al., 1972; Goodall and Childs, 1973), there is no significant difference between the seed populations under cover and in bare ground. As between different types of cover, differences reach significance only in the playa fringe, where the ground under *Hilaria mutica* has a particularly low seed population.

Table 12. Total seed population at different distances from the center of a shrub canopy, Jornada (A3UGE32)

Canopy Species	0-10 cm		15-25 cm		30-40 cm		45-55 cm	
	No. of Samples	Seeds per sq. dm.	No. of Samples	Seeds per sq. dm.	No. of Samples	Seeds per sq. dm.	No. of Samples	Seeds per sq. dm.
Prosopis glandulosa	6	65.6	6	41.2	6	44.6	6	38.3
Fallugia paradoxa	2	32	2	48	2	17.5	1	3
Hilaria mutica	3	94	3	101	1	2	1	1
Ephedra trifurca	2	28.5	2	27	2	26	0	0
Yucca elata	1	78	1	44	1	88	0	0
Larrea divaricata	2	14	2	6.5	1	1	0	0

Table 13. Effect of position under a canopy species on seed density, Jornada site (A3UGE32)

Locality	Canopy Species	Canopy Individual	Number of 1 sq dm Samples	Number of Rankings	Significance*
Bajada					
	Prosopis glandulosa	A	4	4	.293
		B	4	6	.134
		All (2)	8	10	.170
	Fallugia paradoxa	A	4	7	.00004
		B	3	7	.373
		All (2)	7	14	.00004
	Larrea divaricata	A	3	4	.086
		B	2	3	.500
		All (2)	5	7	.076
Playa fringe					
	Prosopis glandulosa	C	4	11	.055
		D	4	14	.150
		All (2)	8	25	.042
	Ephedra trifurca	A	3	7	.718
				12	
	Yucca elata	A	3	12	.230
	Hilaria mutica	A	4	3	.036
		B	2	1	1.000
		All (2)	6	4	.068
Playa					
	Prosopis glandulosa	E	4	7	.295
		E	4	7	.243
		All (2)	8	14	.260
	Ephedra trifurca	B	3	44	.228
	Hilaria mutica	B	2	3	.875
All localities					
	Prosopis glandulosa	All (6)	24	49	.030
	Ephedra trifurca	All (2)	6	11	.470
	Hilaria mutica	All (3)	8	7	.240

Position Under Shrub (or Grass) Canopy

Comparisons were also made between the seed populations (totalled over all depths) in soil at different distances from the center of a shrub, or a grass tussock. Samples were taken within 10 cm of the center, and then at distances increasing by 15 cm until the periphery of the canopy was reached. The results are tabulated in Table 12.

A non-parametric statistical test was performed, based on the rank order of successive samples along the radius, in respect of seed population of each particular species (Childs and Goodall, 1973; Goodall, 1974). The results are reported in Table 13. Only in two canopy individuals (one of *Fallugia paradoxa*, one of *Hilaria mutica*) was there a significant positive trend from the periphery to the center, though some other series of samples also suggested a similar trend. When the data for six individuals of *Prosopis glandulosa* at the three sites were combined, the trend was significant.

We may conclude, as for the Silverbell and Rock Valley sites last year (Childs and Goodall, 1973), that under certain types of canopy there is a clear tendency of seeds to be concentrated towards the center, but that other types of canopy do not show such a tendency.

Estimates of Total Seed Population and Biomass

Figures for the biomass of seed reserves on and in the soil require estimates of the weight of individual seeds (A3UGE31, 32). These are tabulated in Table 14. It should be noted that some of these weights are based on very few seeds, and so are of low precision.

Table 14. Mean weight of individual seeds; Jornada (A3UGE31)

Species	Seed Weight (mg)
Amaranthus spp.	0.1100
Cassia bauhinioides	1.4400
Chenopodium spp.	0.0800
Descurainia pinnata	0.0110
Eriogonum spp.	0.0200
Euphorbia micromera	0.0088
Euphorbia serrula	0.1200
Kallstroemia parviflora	0.8900
Larrea divaricata	6.6300
Mentzelia spp.	0.2700
Portulaca oleracea	0.1000
Sida spp.	0.1400
Sporobolus cryptandrus	0.0090
Zinnia grandiflora	0.9100
Species A	0.1700
Species C	1.6900

Table 15. Estimates of total seed numbers and biomass; bajada (A3UGE31, 32)

Species	Per sq. m Population	Per sq. m Biomass (mg)
Descurainia pinnata	262.6	2.89
Euphorbia micromera	77.9	0.69
Mentzelia spp.	472.4	127.55
Sporobolus cryptandrus	38.4	0.35
Species A	194.2	32.98
Species C	194.5	328.70
Other Species	138.9	96.35
Total	1378.9	589.51

Table 16. Estimates of total seed numbers and biomass; playa fringe (A3UGE31, 32)

Species	Per sq. m Population	Per sq. m Biomass (mg)
Amaranthus spp.	314	34.6
Chenopodium spp.	19162	1533.0
Descurainia pinnata	192	2.1
Euphorbia micromera	681	6.0
Euphorbia spp.	92	11.0
Portulaca oleracea	55	5.5
Sida spp.	98	13.8
Sporobolus cryptandrus	1885	17.0
Species A	99	16.9
Species C	176	298.0
Other Species	118	57.7
Total	22872	1995.6

Table 17. Estimates of total seed numbers and biomass; playa (A3UGE31, 32)

Species	Per sq. m Population	Per sq. m Biomass (mg)
Cassia bauhiniodes	59	85.5
Chenopodium spp.	10823	865.8
Eriogonum spp.	462	9.2
Euphorbia spp.	171	15.2
Portulaca oleracea	26198	2619.8
Sida spp.	802	112.3
Sporobolus cryptandrus	662	6.0
Species B	225	35.6
Other Species	92	65.6
Total	39494	3815.0

In calculating the total seed reserves, for the more abundant species, separate density estimates were used for bare ground and for the main canopy types, even though in most cases the differences did not reach significance. For species with a mean density less than 0.5 seeds dm^{-2}, average densities over the whole area were used.

Canopy species included in Tables 8-10 were distinguished in the calculations. For other canopy species, the average density in all samples collected under canopies was used; in no case did their area amount to more than 5%. For each seed species, the density in that canopy type was multiplied by the cover, as given in the Progress Reports (for the bajada, Whitford, 1973, Table 13 [p. 2.2.2.4.-225]; for the playa fringe, Whitford and Ludwig, 1971, Table 1 [p. 2.2.2.3.-9] and Whitford, 1972, Table I.B.3.a.1 [p. 2.2.2.4.-38]; for the playa, Whitford and Ludwig, 1971, Table 1 [p. 2.2.2.3.-9] and Whitford, 1973, Table 16 [p. 2.2.2.4.-84]), and figures for the different canopy types were summed to give the population figures in Tables 15-17. These figures were converted to biomass (air-dry weight) by using the mean seed weights of Table 14.

LITERATURE CITED

Childs, S., and D. W. Goodall. 1973. Seed reserves of desert soils. US/IBP Desert Biome Res. Memo. RM 73-5.

Goodall, D. W. 1974. The exact probability of a set of rankings, when the alternative to the null hypothesis is a monotonic trend. Biom-Praxim (in press).

Goodall, D. W., S. Childs, and H. Wiebe. 1972. Methodological and validation study of seed reserves in desert soils. US/IBP Desert Biome Res. Memo. RM 72-8.

Kearney, T. H. 1951. Arizona flora. Univ. Calif. Press, Berkeley. 1032 pp.

Musil, A. F. 1963. Identification of crops and weed seeds. USDA Agric. Handb. 219:1-171.

Parker, K. F. 1972. An illustrated guide to Arizona weeds. Univ. Ariz. Press, Tucson. 338 pp.

Whitford, W. G.(Coordinator). 1972. Jornada Validation Site report. US/IBP Desert Biome Res. Memo. RM 72-4.

Whitford, W. G. (Coordinator). 1973. Jornada Validation Site report. US/IBP Desert Biome Res. Memo. RM 73-4.

Whitford, W. G. (Coordinator). 1974. Jornada Validation Site report US/IBP Desert Biome Res. Memo. (in press).

Whitford, W. G. (Coordinator), and J. Ludwig. 1971. The Jornada Validation Site (playa -- NMSU Ranch). US/IBP Desert Biome Res. Memo. RM 71-5.