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NITROGEN TRANSFORMATIONS IN ROCK VALLEY AND ADJACENT AREAS OF THE MOHAVE DESERT

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ABSTRACT

This progress report contains findings from studies of rates of change in the nitrogen compartments of desert soils and vegetation. An analysis of the upper 90-cm profile of soil, which was given surface applications of nitrogen in 1968 and 1970, showed that the fertilizer nitrate still remained in the root zone of plots receiving only natural rainfall. The concentrations frequently reached high levels and varied from place to place in the profiles. In contrast, the fertilizer nitrate essentially had disappeared (by 1974) from the root zone in plots given supplemental moisture by sprinkler irrigation. These results have possible implications on the denitrification process under Mohave Desert conditions. Soluble ammonium recoverable from fertilizer application decreased rapidly after wetting. Nitrogen requirements for above-ground productivity were lower than 10 $kg \cdot ha^{-1} \cdot yr^{-1}$ in both Rock Valley (1973) and Mercury Valley (1974). Acetylene reduction activity in the root zone of individual perennial shrubs was found to be highly variable. The number of species showing this activity was quite large and included several very common species, including *Larrea tridentata* and *Bromus rubens*. Cation-nitrogen balances in leaves differed significantly among species and may reflect soil conditions. Finally, collection of available data suggests nitrogen pool sizes are generally adequately known, but turnover rates and rates of input and loss have been inadequately studied.

INTRODUCTION

Previous qualitative and quantitative observations in the northern Mohave Desert have suggested that: 1) there is little or no nitrogen deficiency under normal growing conditions; 2) there is significant input of atmospheric nitrogen through semisymbiotic fixation of N_2 in the rhizospheres of many species; and 3) large amounts of nitrate-nitrogen are present in selected areas, particularly in the periodically flooded playas. In addition, the organic C:organic N ratios are uniformly low, ranging from 5 to 15, except in the surface horizons immediately under shrubs (Wallace et al., in press).

OBJECTIVES

1. To determine the rates of biological N-fixation in the desert systems studied via: a) symbiotic relationships with higher plants; b) symbiotic relationships with algal crust and lichens; c) free-living nonsymbiotic forms, including semisymbiotic forms.
2. To determine losses from the ecosystem via: a) volatilization of NH_3; b) leaching; c) runoff of litter, surface leaching or wind removal of litter; d) denitrification.
3. To determine rates of transfer of nitrogen between various soil-plant compartments as influenced by a) soil moisture, b) soil and air temperature, c) salinity and d) soil pH, and to determine relationships among various compartment sizes and other factors affecting nitrogen cycling under desert systems.
4. To determine rates of uptake of different forms of nitrogen by some desert plants.
5. To characterize and develop some reasons for variations in the C:N ratio of soils in the northern Mohave Desert.

METHODS

Soil sampling on Mercury Valley plots which earlier had received supplemental nitrogen and moisture was performed by hand excavation of 13 pits 1.3 m long and 90 cm deep. One end of each pit was situated in a shrub clump, while the other end was in an adjacent bare area. Samples were taken from the sides of these pits between November 2 and November 25, 1974. The soils were air-dry when sampled, so they were stored without further drying.

Prior to analysis these samples were vibrated on a 2-mm sieve for 30 min; rock and soil were weighed separately and the rock was discarded.

Nitrate analysis was performed on 20 g of soil with an Orion 801A digital Ionalyzer fitted with a nitrate electrode. To the weighed sample were added 40 ml of 0.01-M sodium citrate solution. The suspension was stirred occasionally during a 1-hr equilibration period, after which the liquid was poured into a 100-ml beaker. This solution was equilibrated for 3 min with an Orion nitrate electrode and a double-junction reference electrode whose outer chamber was filled with 0.01 M KCl. The nitrate concentration was calculated on a soil dry weight basis from the mV reading using a standard curve. The standard nitrate solutions were prepared with 0.01 M sodium citrate and 10 ppb phenylmercuric acetate.

Ammonia was analyzed using the same sodium citrate extract on which nitrate was measured. The solution was filtered, adjusted to high pH with 40% (w/v) NaOH, and equilibrated with an ammonia electrode using the same Orion 801A Ionalyzer. Readings were converted to ammonium concentrations using a standard curve and converted to a soil dry weight basis.

Plant tissue nitrogen contents were determined using the same ammonia electrode on a Kjeldahl digest of 100 to 300 mg of tissue.

Acetylene reduction to ethylene was measured on samples taken November 7 and December 12, 1974, and January 29, 1975. A single plant of each of 13 species was selected and sampled on those three dates. A small area near the base of each shrub was excavated; then roots and/or soil were transferred as quickly as possible to 38-ml serum bottles. These were carried to the laboratory, flushed for 15 min with an $Ar-O_2-CO_2$ mixture (79, 21 and 0.03%, respectively), and injected with 4 ml of acetylene in the gas

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phase. They were then incubated at room temperature until either run on the gas chromatograph or frozen momentarily with dry ice (to kill eukaryotes and vegetative bacteria). Ethylene evolved was measured on a Beckman model GC55 gas chromatograph with a Beckman 10-inch recorder. It was run with alumina and Poropak R columns at various temperatures and alternations in an attempt to optimize ethylene detection. The carrier gas was He. An integrator on the instrument was used to sum the peak areas for estimating ethylene concentration in the 0.5 ml samples injected.

Above-ground plant biomass in Rock Valley was obtained from the 1973 US/IBP Rock Valley validation studies (Turner and McBrayer 1974). These are based upon dimensional analyses as described in Wallace and Romney (1972). Plant tissue nitrogen was determined on the same samples used for estimation of 1973 productivity (A3UTJ2A, B).

Cation-nitrogen balances were calculated as the sum of me/100 g of K, Na, Ca and Mg minus me/100 g of N. The mineral contents were determined by emission spectrometry as described in Wallace et al. (1974b) and reported by Romney et al. (1973).

RESULTS AND DISCUSSION

The soil nitrate studies (A3UWS09) were an attempt to discover the fate of NH_4NO_3 applied in March 1968 and October 1970 (Romney et al. 1974). As can be seen in Table 1, there was extreme variability in nitrate concentration from one point to another. Nevertheless, the data suggest that, in the absence of added moisture, nitrogen fertilizer remained very persistent in Mohave Desert soils.

Extractable ammonium concentrations on selected samples ranged from 0.1 to 1.6 ppm and averaged near 0.5 ppm. There was no correlation between ammonium concentrations as determined and soil nitrate concentration or soil depth. Hence we feel there is a fixed-extractable equilibration of ammonia in soil that requires different measurement techniques.

Table 1 suggests also an increasing concentration of nitrate nitrogen with depth. Figure 1 shows quantities of NO_3-N in kg/ha before and after correction for rock percentage (Table 2). Assumptions for the correction are that soil bulk density is 1 g/cm^3. The apparent increase in concentration with depth was much reduced by this correction, but due to high variability it is not statistically significant either with or without the correction.

High concentration of nitrate underneath shrub clumps has been observed several times in the Mohave Desert (Garcia-Moya and McKell 1970, Fireman and Hayward 1952, Nishita and Haug 1973, Wallace and Romney 1972). Work in progress is confirming this trend for surface horizons, but data in Table 1 suggest it may not be limited to the surface. The extreme variability with depth in both bare and shrub areas is thus more likely to be due to physical factors than to biological ones.

Table 1. NO$_3$-N concentrations in bare areas and under shrubs as affected by irrigation and fertilizer application. For irrigation treatments, see Romney et al. (1974). Fertilizer was applied in two applications as ammonium nitrate, February 1968 and November 1970 (A3UWS09)

A. Irrigated Plots:

Profile Depth (cm)	Control			+448 kg N/ha		
	Bare 1	Bare 18	Bare 39	Bare 10	Bare 39	Bare 113
	(ppm NO$_3$-N)			(ppm NO$_3$-N)		
0.0 - 7.5	1.7	4.2	1.9	1.3	2.8	0.9
7.5 - 15.0	10.8	2.0	10.4	8.1	2.3	1.5
15.0 - 22.5	8.4	6.3	9.3	1.9	2.3	4.5
22.5 - 30.0	5.6	3.8	5.2	0.5	2.8	0.9
30.0 - 37.5	0.9	2.2	65.7	0.9	1.0	0.6
37.5 - 45.0	0.5	0.5	25.7	0.8	3.6	0.6
45.0 - 52.5	0.5	1.0	49.7	7.5	3.1	0.6
52.5 - 60.0	0.9	8.1	5.6	34.8	2.0	1.0
60.0 - 67.5	2.9	5.6	39.3	48.5	0.2	0.9
67.5 - 75.0	0.9	5.4	15.8	19.0	0.5	---
75.0 - 82.5	1.7	7.7	8.8	8.1	0.9	---
82.5 - 90.0	6.5	5.4	---	5.0	---	---
average:	3.5	4.3	21.6	11.3	1.9	1.3

Profile Depth (cm)	Shrub 1	Shrub 18	Shrub 39	Shrub 10	Shrub 39	Shrub 113
	(ppm NO$_3$-N)			(ppm NO$_3$-N)		
0.0 - 7.5	14.9	3.5	1.7	16.3	8.1	16.7
7.5 - 15.0	36.1	0.5	2.3	8.1	36.1	19.0
15.0 - 22.5	36.1	1.0	5.9	2.3	24.6	11.7
22.5 - 30.0	14.5	0.8	5.9	4.5	42.5	6.3
30.0 - 37.5	11.7	0.8	3.1	3.0	76.8	6.3
37.5 - 45.0	37.0	0.8	7.7	0.5	99.4	5.4
45.0 - 52.5	28.0	0.9	3.4	0.7	38.4	11.7
52.5 - 60.0	62.3	1.1	4.1	0.2	121.9	19.0
60.0 - 67.5	33.9	3.2	3.7	0.2	30.7	13.5
67.5 - 75.0	14.5	4.3	5.5	0.7	39.7	---
75.0 - 82.5	14.9	2.4	0.9	3.2	45.2	---
82.5 - 90.0	16.0	5.6	5.0	8.1	56.5	---
average:	26.6	1.8	3.9	4.0	51.7	12.2

B. Dry Plots

Profile Depth (cm)	Control			+448 kg-N/ha		
	Bare 22	Bare 49	Bare 103	Bare 4	Bare 10	Bare 87
	(ppm NO$_3$-N)			(ppm NO$_3$-N)		
0.0 - 7.5	1.5	1.6	0.7	16.2	2.6	7.7
7.5 - 15.0	1.2	4.2	0.7	85.8	1.6	196.5
15.0 - 22.5	3.0	3.3	5.2	115.2	5.2	280.0
22.5 - 30.0	1.0	8.1	2.4	135.5	3.5	127.8
30.0 - 37.5	0.7	8.6	1.4	223.5	13.5	108.4
37.5 - 45.0	0.3	12.6	2.6	207.7	45.2	145.6
45.0 - 52.5	0.4	27.5	3.2	140.0	56.9	144.5
52.5 - 60.0	0.6	45.2	5.9	112.9	135.5	169.4
60.0 - 67.5	0.5	39.3	7.7	74.5	119.7	168.2
67.5 - 75.0	0.4	52.8	5.0	124.2	136.8	167.3
75.0 - 82.5	0.7	42.0	5.4	121.9	38.8	113.8
82.5 - 90.0	2.6	34.3	6.3	81.3	21.7	54.2
average:	1.1	20.3	3.9	119.9	48.4	140.3

| Profile Depth (cm)	Shrub 22	Shrub 49	Shrub 103	Shrub 4	Shrub 10	Shrub 87
	(ppm NO$_3$-N)			(ppm NO$_3$-N)		
0.0 - 7.5	5.4	8.1	4.2	3.8	19.9	11.7
7.5 - 15.0	10.4	5.0	3.5	5.2	10.8	5.0
15.0 - 22.5	7.2	13.1	11.1	28.0	13.5	8.6
22.5 - 30.0	0.6	3.4	2.3	11.1	5.4	27.5
30.0 - 37.5	0.6	2.3	2.4	10.4	6.3	5.9
37.5 - 45.0	0.5	3.3	3.8	6.3	16.3	7.9
45.0 - 52.5	2.0	2.7	3.9	5.4	70.0	12.0
52.5 - 60.0	1.3	2.5	6.3	19.6	112.9	6.5
60.0 - 67.5	2.6	3.8	4.0	6.5	97.1	11.3
67.5 - 75.0	2.8	6.8	8.6	67.7	115.2	10.2
75.0 - 82.5	4.5	8.1	11.7	88.1	83.5	29.3
82.5 - 90.0	6.8	6.8	19.9	155.8	38.0	28.5
average:	3.7	5.5	6.8	34.0	49.1	13.7
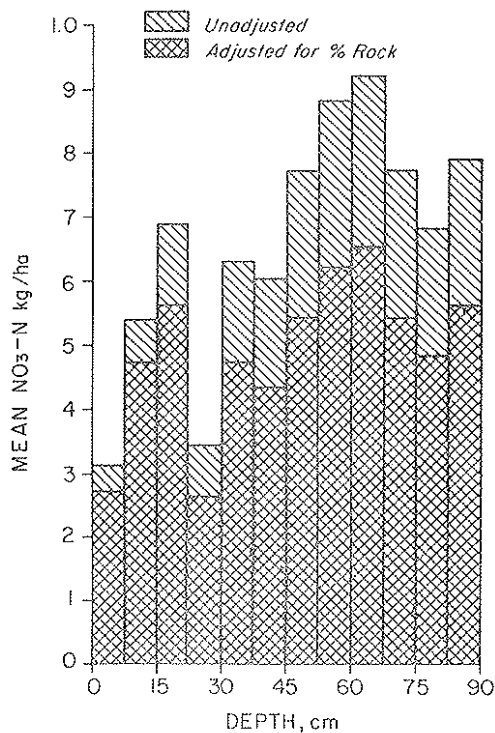
Figure 1. An example illustrating soil NO₃-N reserves in Mercury Valley, taken from control plot data in Table 1.

Table 2. Percent of soil particles larger than 2 mm in 12 soil profiles as a function of depth

Profile Depth, cm	Bare Area % ± sem*	Shrub Clump % ± sem*
0.0 - 7.5	37 ± 4	29 ± 3
7.5 - 15.0	39 ± 4	36 ± 2
15.0 - 22.5	52 ± 5	48 ± 6
22.5 - 30.0	64 ± 6	54 ± 6
30.0 - 37.5	72 ± 3	65 ± 4
37.5 - 45.0	72 ± 2	71 ± 3
45.0 - 52.5	81 ± 1	78 ± 2
52.5 - 60.0	80 ± 2	79 ± 2
60.0 - 67.5	78 ± 2	74 ± 2
67.5 - 75.0	77 ± 3	77 ± 2
75.0 - 82.5	74 ± 2	79 ± 2
82.5 - 90.0	75 ± 2	74 ± 3

* standard error of the mean, n = 12

Plant demand for nitrogen is quite low in both Rock Valley and Mercury Valley. Table 3 shows the amount of N required for above-ground growth of major shrubs in Rock Valley during 1973 (A3UWS11), a relatively wet year. Data are calculated from tissue nitrogen analyses reported in Table 4. Lower increases in biomass were found in Mercury Valley in 1974 (Hunter et al. 1975). Data for Rock Valley in 1974 are not yet available.

It should be borne in mind that not all the 10-20 kg/ha of nitrogen required for new growth would be derived from the soil. There is considerable evidence that minerals are withdrawn from leaves prior to abscission and presumably the nitrogen withdrawn is available for growth in following years (Wallace et al. 1974a).

Results of repeated sampling of individual shrubs for acetylene reduction assays are recorded in Table 5 (A3UWS12). The results are erratic with respect to both time and species. We are attempting to develop techniques more suited to these circumstances.

When moisture was present, lichen crust was the most consistently active organism in acetylene reduction assays. However, the soil surface is rarely wet in the Mohave Desert, and lichen crust is not common. Table 6 is derived from a short expedition attempting to estimate the density and percent coverage of Mohave soil by lichens.

The source of nitrogen, whether nitrate or ammonium, has a large effect on the cation-anion ratios of glasshouse-grown plants (Blevins et al. 1974, Dijkshoorn 1971, Kirkby 1969, Pierre and Banwart 1973). The possibility arises, therefore, that the leaf cation-anion status of field-grown plants may reflect their source of nitrogen. Data were available to calculate cation-nitrogen balances of many shrubs from the northern Mohave Desert (Romney et al. 1973). Table 7 shows there are significant species differences in cation-nitrogen balances which could indicate their nitrogen sources. Confirming data from glasshouse and field studies are necessary, however, before firm conclusions can be drawn.

It is evident, at least in theory, that soil nitrogen conditions should be reflected in leaf mineral composition. We calculated regression lines and correlation coefficients for cation relationships to leaf N and soil saturation extract pH (Table 8). Soil NO_3^- and NH_4^+ data are not presently available. Considering the small range in pH (8.0-8.7), the relatively high correlation coefficients of *Larrea tridentata* and *Mirabilis pudica* were rather surprising. Leaf N and cation correlations correspond fairly well to laboratory experiments, and regression lines and cation-nitrogen balances are consistent with each other. However, further experimental data would be valuable in confirming our interpretations.

We have collected available information on nitrogen pool sizes and inputs and losses of nitrogen in the northern Mohave Desert. This summary is presented in Tables 9 and 10. There are fairly adequate data on most pool sizes, but much of the data would profit from further analysis because inputs and losses of nitrogen and transport between pools are inadequately studied.

Table 3. Estimated N content of above-ground biomass compartments (kg-N/ha) in 1973. Sample dates are peak of flowering and fruiting period (A3UWS11)

Species	Zone	Date	Leaves	New Stems	Flowers	Fruit	Total New N	Old Stems	Old Leaves	Total Old N
Amb.dum.	20	5/21	0.53	0.12	0.35	0.00	1.00	0.51	----	0.51
	20	5/30	0.52	0.12	0.00	0.43	1.05	0.40	----	0.40
	25	5/21	1.01	0.22	0.96	----	2.19	0.72	----	0.72
	25	5/30	0.94	0.20	----	0.68	1.82	0.78	----	0.78
Atr.con.	25	5/07	0.28	0.05	0.03	----	0.36	0.14	0.02	0.16
Cer.lan.	25	4/26	0.13	0.05	0.01	----	0.19	0.15	0.03	0.18
	25	5/17	0.17	0.08	----	0.06	0.31	0.14	----	0.14
Eph.nev.♂	20	5/01	----	0.33	0.04	----	0.37	0.35	----	0.35
♀	20	5/01	----	0.20	0.05	----	0.25	0.23	----	0.23
♂ + ♀	20	5/30	----	0.71	----	0.15	0.86	0.94	----	0.94
♂	25	5/07	----	0.67	0.03	----	0.70	0.54	----	0.54
♀	25	5/07	----	0.48	0.17	----	0.65	0.54	----	0.54
♂ + ♀	25	5/30	----	0.87	----	0.25	1.12	1.06	----	1.06
Gra.spi.	25	4/20	1.04	0.28	0.03	----	1.35	0.97	----	0.97
	25	5/01	0.85	0.23	----	0.46	1.54	0.85	----	0.85
Kra.par.	20	5/24	1.63	0.22	0.65	0.05	2.00	0.94	----	0.94
	20	6/15	1.49	0.31	0.02	0.17	1.98	1.21	----	1.21
	25	5/24	0.63	0.13	0.35	0.07	1.18	0.58	----	0.58
	25	6/15	1.03	0.25	----	0.29	1.57	0.74	----	0.74
Lar.tri.	20	5/29	0.56	0.15	0.07	0.08	0.87	1.48	0.67	2.15
	20	6/27	0.74	0.22	----	0.18	1.14	2.06	0.20	2.26
	25	5/29	0.43	0.18	0.06	0.07	0.74	1.52	0.50	2.02
	25	6/27	0.47	0.13	----	0.12	0.72	1.91	0.11	1.02
Lyc.and.	20	4/26	2.44	0.21	0.44	0.03	3.11	5.21	----	5.21
	20	6/05	1.35	0.61	----	0.51	2.46	3.89	----	3.89
Lyc.pal.	25	4/09	1.13	0.01	0.45	----	1.59	1.52	----	1.52
	25	6/05	0.75	0.19	----	0.30	1.24	1.46	----	1.46
Sum	25	peak flower	4.65	2.07	2.09	0.14	8.95	6.68	0.55	7.19
		peak fruit	4.49	2.00	----	2.16	8.68	6.08	0.13	6.21

Table 4. Nitrogen concentrations in above-ground shrub parts at date of peak flowering, peak fruiting and dormancy (as percentage of dry weight). From Rock Valley samples taken in 1973 (A3UTJ2A, B)

Species	Zone	Sample Date	New Leaf	New Stem	Flower	Fruit	Old Live Stem	Old Live Leaf	Dead Stem
Amb.dum.	24	5/21	2.47	0.78	2.10	----	0.80	----	0.80
	20	5/30	2.16	0.63	----	2.29	0.63	----	0.69
	25	5/30	2.20	0.69	2.00	2.15	0.67	----	0.81
	20	11/07	----	----	----	----	0.89	----	----
	25	11/07	----	----	----	----	0.73	----	----
Atr.con.	25	5/07	1.75	1.31	1.79	----	0.48	0.87	1.20
Cer.lan.	25	4/26	2.45	1.11	2.16	----	0.65	----	0.51
	25	5/17	1.88	0.82	2.14	----	0.60	----	0.51
Eph.nev.♂	20	5/01	----	2.58	2.58	----	0.93	----	0.84
♀	20	5/02	----	1.85	2.71	----	0.62	----	0.94
♂ + ♀	20	5/30	----	1.95	----	2.18	1.26	----	0.72
	20	11/07	----	----	----	----	----	----	1.21
♂	25	5/07	----	2.18	1.54	----	0.84	----	0.77
♀	25	5/07	----	----	2.55	----	----	----	----
♂ + ♀	25	5/30	----	1.20	----	2.47	0.83	----	0.88
	25	11/07	----	----	----	----	0.92	----	----
Gra.spi.	25	4/20	1.65	1.56	----	----	0.57	----	----
	25	5/01	1.49	0.99	----	1.72	0.50	----	0.53
	25	11/07	----	----	----	----	0.82	----	----
Kra.par.	20	5/24	1.85	1.63	2.21	2.52	0.63	----	0.91
	20	6/15	2.08	1.82	----	1.80	0.81	----	1.07
	20	11/07	----	----	----	----	0.95	----	----
	24	5/24	1.85	2.12	2.33	2.62	0.75	----	1.22
	25	6/15	2.19	1.66	----	2.07	0.81	----	1.06
	25	11/07	----	----	----	----	1.07	----	----
Lar.tri.	20	5/29	2.15	1.58	1.54	2.01	1.06	1.62	0.87
	20	6/27	2.17	1.88	----	2.07	1.48	1.71	1.14
	25	5/29	2.34	1.66	2.06	2.67	1.28	2.15	1.25
	25	6/27	1.80	1.46	----	1.92	0.77	1.36	1.09
Lyc.and.	20	4/26	2.36	1.98	2.50	----	1.07	----	1.04
	20	6/05	1.30	1.27	----	2.27	0.80	----	1.04
	20	11/07	----	----	----	----	1.25	----	----
Lyc.pal.	25	4/09	3.01	----	3.40	----	1.11	----	1.34
	25	6/05	1.42	1.19	----	2.43	1.07	----	----
	25	11/07	----	----	----	----	1.29	----	----

As we presently envision nitrogen relationships, the main input is biological fixation of atmospheric N_2. Primary evidence is the acetylene reduction activity associated with many nonleguminous species (Table 11). The concentration of nitrate under shrubs is indicative of biological involvement. If nonbiological factors predominate we would expect a much more even distribution of nitrate nitrogen. Ammonia distribution is apparently quite even, which suggests nonbiolgoical controlling factors. Its distribution may reflect its origin as parent material or its equilibration with the earth's atmosphere.

Many of the species whose roots are associated with acetylene reduction activity are both widespread and evenly distributed over large areas. *Larrea tridentata* and the annual grass *Bromus rubens* fit these criteria particularly well. In the spring of 1974, *B. rubens* varied in density on 10-m^2 areas from 16.9 to 145.6 g/m^2 (Hunter et al. 1975). Indeed, during the spring months of 1975 nearly every shrub clump had a significant population of *B. rubens.*

In many places we find an unusual abundance of nitrate-nitrogen (Table 1, Romney et al. 1973). We suspect in these areas nitrate does not equilibrate with other forms, but accumulates with time. The data involved, however, rarely extend below 1 m, so that we do not know if these concentrations are limited to near-surface horizons. It is possible there are more concentrated deposits at greater depths, or that concentration becomes more uniform at greater depths.

If nitrate nitrogen does build up with time, and if biological fixation is the major input, we can then put rather low estimates on nitrogen losses through denitrification, ammonia volatilization and erosion. Total requirements of nitrogen for plant use in the area studied are on the order of 10 to 20 kg-N·ha^{-1}·yr^{-1}. Since soil mineral nitrogen and that stored in stems and roots must meet a large portion of that demand, requirements for fixation would be considerably less than 10 kg-N·ha^{-1}·yr^{-1}.

Table 5. Acetylene reduction by root and soil samples associated with twelve shrub species and lichen crust (A3UWS12)

Sample Date:	11/07/74		12/10/74	1/29/75*
Species	Root	Soil	Root	Root
		(ppm C$_2$H$_4$)		
Aca. sho.	14	12	10	1.9
Amb. dum.	15	12	10	> 0
Atr. con.	12	11	13	> 0
Bro. rub.	18**	50**	13	> 0
Cactus	15	12	11	0
Eph. nev.	11	12	10	1.6
Lar. tri.	9	12	5	8.4**
Men. spi.	10	16**	10	> 0
Sph. amb.	8	12	13	110
Sti. spe.	20**,15	12	9	0
Tha. mon.	9	12	1210**	1.6
Yuc. sch.	7,16**	10	18**	> 0
Lichen crust	40**	--	1170**	445**

* Samples from this date were run at a higher attenuation and lower column temperature, hence the difference in sensitivity.

** Samples considered to qualitatively indicate acetylene reduction activity.

Table 6. Estimation of lichen crust cover. Sample sites are .16 km apart along the Mercury-Rock Valley road, 35 paces from the road edge. Two 0.1-m² areas were examined at each site. There are 8 km between sites 12 and 13

	Quadrant	
Sample Site #	First	Second
1	0 %	0 %
2	0 %	0 %
3	0 %	0 %
4	0 %	0 %
5	0 %	0 %
6	0 %	0 %
7	0 %	0 %
8	0 %	0 %
9	0 %	0 %
10	0 %	0 %
11	0 %	0 %
12	0 %	0 %
13	<1 %	<1 %
14	1 %	1 %
15	<1 %	2 %
16	<1 %	<<1 %
17	0 %	0 %
18	<15 %	<30 %
19	0 %	0 %
20	0 %	0 %
	Average coverage <1.35%	

Table 7. Cation-nitrogen balances of desert shrub foliage. The chart shows numbers of plants from 50 sites fitting into each category*

			NO$_3^-$ or HCO$_2^-$ Uptake	
Species	NH$_4^+$ Uptake	Intermediate	High K$^+$	High Ca^{2+}
Aca. sho.	10	5	6	9
Amb. dum.	11	3	6	
Atr. can.			11	
Atr. con.			16	2
Cer. lan.	10	7	1	
Dal. fre.	5	1	1	
Eph. fun.	4			
Eph. nev.	11	1		
Gra. spi.			18	
Hym. sal.	1			
Kra. par.	7			
Lar. tri.	34			
Lep. fre.	3			
Lyc. and.			1	25
Lyc. pal.	1		3	2
Lyc. sho.			2**	
Men. spi.	3			
Mir. pud.	3	3	7	
Sal. mex.	1			
Sph. amb.		2	3	3
Sta. pin.	3	1	2	2

* Plants with Σ cations minus N less than 50 me/100 g were assigned to the ammonia type, while those >100 me/100g were placed in the NO$_3^-$, HCO$_3^-$ group.
** High sodium.

Table 8. Regression lines relating cation contents of leaves to leaf N, expressed as me/100 g dry weight, and to soil pH

Species	Regression Line	No. of Samples	r
Aca. sho.	Σ c = 272.6 − 0.258 N	21	−0.33
Amb. dum.	Σ c = 489.2 − 0.64 N	29	−0.55
Atr. con.	Σ c = 750.6 − 1.10 N	18	−0.63
Eph. nev.	Σ c = 144.0 − 0.023 N	12	−0.12
	Σ c = 296.4 − 18.0 pH		−0.28
Gra. spi.	Σ c = 421.9 − 0.19 N	18	+0.11
	Σ c = 90.2 − 43.2 pH		+0.10
Kra. par.	Σ c = 119.1 − 0.32 N	7	+0.28
Lar. tri.	Σ c = 18.0 + 0.78 N	34	+0.48
	Σ c = −590.5 + 87.5 pH		+0.63
Lyc. and.	Σ c = 920.2 − 1.13 N	26	−0.51
	Σ c = −737.4 + 158.7 pH		+0.29
Mir. pud.	Σ c = 466.3 − 0.17 N	13	−0.15
	Σ c = −1022.9 + 168.1 pH		+0.49
Ory. hym.	Σ c = 65.8 + 0.40 N	18	+0.74
	Σ c = 362.0 − 29.4 pH		−0.26

Table 9. Nitrogen compartment sizes in the northern Mohave Desert

Compartment	Size Range (kg-N/ha-90cm)	Reference
Organic N	500 to 1500	Nishita, 1972 Romney et al., 1973.
Undecomposed litter	1 to 5	Turner, 1974.
Soil nitrate	10 to 300	Nishita, 1972 Table 1
Extractable ammonia	5 to 15	Nishita, 1972
Fixed ammonia	450 to 650	Nishita, 1972
Plant roots	10 to 20	Turner, 1974.
Plant branches and stems	5 to 20	Turner, 1974; Wallace and Romney, 1972; Table 3.
Leaves, spring	1 to 10	Table 3.
Animals	0.2 to 0.3	Turner, 1974.

Table 10. Estimated inputs and losses of N in the northern Mohave Desert

Types	Rate (kg-N/ha/yr)	Possible Limiting Factors
Semisymbiotic fixation	+3 to 5	host density, inorganic soil N
Free living fixers	+0.005 to 0.20	soil carbon
Lichen crust	+0.009	moisture
Nodulated legumes	+0.3 to 0.6	host density
Nodulated non-legumes	0	host density
Precipitation, rain and snow	+2 to 4	precipitation
Ammonia volatilization	+50 to -50	temperature and atmospheric NH_3 concentration.
Denitrification	?	pH, soil carbon
Run-off	?	rain and wind intensity

Table 11. Nonleguminous species whose roots or rhizospheres have been qualitatively positive in acetylene reduction assay

Species	Reference
Atriplex canescens	Wallace et al., 1974.
Atriplex confertifolia	Wallace et al., 1974.
Bromus rubens	Wallace et al., 1974, Table 5.
Coleogyne ramosissima	Wallace and Romney, 1972.
Hymenoclea salsola	Wallace and Romney, 1972.
Krameria parvifolia	Wallace and Romney, 1972.
Larrea tridentata	Table 5.
Lichen crust	Wallace and Romney, 1972, Wallace et al., 1974, Table 5.
Lycium pallidum	Wallace et al., 1974.
Lycium shockleyi	Wallace et al., 1974.
Menodora spinescens	Table 5.
Stipa speciosa	Table 5.
Tetradymia canescens	Wallace and Romney, 1972.
Thamnosma montana	Table 5.
Yucca schidigera	Wallace et al., 1974, Table 5.

The low organic C:organic N ratios found in the Mohave Desert soils argue against nitrogen being required for soil microbial populations in any significant amounts. Limiting factors for growth and metabolism of soil microbes are more likely carbon and water.

Loss of nitrate through leaching from normal rainfall must be quite rare. The yearly average precipitation is insufficient to wet the soil much below the root zone. (We find small rootlets at 90 cm in most sites tested.) The development of limestone and caliche layers, frequently observed at 40- to 100-cm depths, must also limit loss of nitrate through leaching. Loss from surface runoff could be significant under conditions of flash flooding; however, most of the time runoff from an area upslope would be runon to an area downslope. This process probably contributes to the buildup of nitrate in the soil profile of closed basin playas.

The presence of caliche layers suggests the presence of a drying front at shallow depths in addition to the surface front. The presence of a submerged drying front may play a role in preventing salt buildup at the surface.

There is sufficient ammonia in the Mohave Desert soils to supply many years of growth. However, soil adsorption equilibria evidently maintain it at a low concentration in the soil solution. Our measurements vary normally from 0.1 to 1 ppm NH_4^+—N, while nitrate concentrations range from 1 to 100 ppm—N. Although desert shrubs we have tested can make use of both forms of nitrogen (Romney et al. 1974), it is likely that nitrate is the major source due to its greater concentration in the soil solution.

It would be valuable to further investigate fixed/extractable ammonia equilibria to determine how much is truly available to plants. The low concentrations we measure would not allow sufficient uptake unless flow of moisture up plant stems is about five times the annual precipitation.

Organic-N is the major nitrogen pool (Table 9). Mineralization of 1% per year would supply ample nitrogen for shrub growth. Actual rates of mineralization have not yet been measured.

EXPECTATIONS

During 1975 we shall concentrate on experiments to estimate turnover of nitrogen in the Mohave Desert. We now have an operable optical emission system for measuring the ^{15}N and ^{14}N ratios in plant tissues that we hope to extend to soil assays for nitrogen balance studies. Experiments are expected to provide ^{15}N-tagged litter useful for decomposition and mineralization studies which are planned.

Seasonal fluctuations in soil nitrate levels are being studied, as are nitrogen relations of *Ambrosia dumosa*.

Acetylene reduction work will continue, even though it is difficult to obtain measurements under the environmental conditions found in the field.

We are looking forward to measuring soil-to-air ammonia gradients; to initiating balance studies in field-incubated samples; and to using N-Serve in experiments for determining rates of conversion of NH_4^+ to NO_3^- and subsequent uptake rates.

If the studies can be extended into 1976, more precise rate information for the northern Mohave Desert can be developed for ammonia volatilization and fixation in soil, biological nitrogen reduction, organic matter decomposition, nitrification, denitrification, ammonification and leaching losses. We believe that the Desert Biome to date is far from the correct answers to nitrogen cycling in the Mohave Desert, but that necessary information can become available and synthesized by the end of 1976.

LITERATURE CITED

BLEVINS, D. G., A. J. HIATT, and R. H. LOWE. 1974. The influence of nitrate and chloride uptake on expressed sap pH, organic acid synthesis, and potassium accumulation in higher plants. Plant Physiol. 54:82-87.

DIJKSHOORN, W. 1971. Partition of ionic constituents between organs. Pages 447-476 *in* R. M. Samish, ed. Recent advances in plant nutrition. Vol 2. Gordon and Breach Sci. Publ. New York.

FIREMAN, M., and H. E. HAYWARD. 1952. Indicator significance of some shrubs in the Escalante Desert, Utah. Bot. Gaz. 114:143-155.

GARCIA-MOYA, E., and C. M. McKELL. 1970. Nitrogen economy of a desert-wash plant community. Ecology 51:81-88.

HUNTER, R. B., E. M. ROMNEY, A. WALLACE, J. W. CHILDRESS, and J. E. KINNEAR. 1975. Responses and interactions in desert plants as influenced by irrigation and nitrogen applications. US/IBP Desert Biome Res. Memo. 75-13. Utah Sate Univ., Logan. 14 pp.

KIRKBY, E. A. 1969. Ion uptake and ionic balance in plants in relation to the form of nitrogen nutrition. Pages 215-235 *in* I. H. Roison, ed. Ecological aspects of the mineral nutrition of plants. Blackwell Sci. Publ., Oxford and Edinburgh.

NISHITA, H., and R. M. HAUG. 1973. Distribution of different forms of nitrogen in some desert soils. Soil Sci. 116:51-58.

PIERRE, W. H., and W. C. BANWART. 1973. Excess-base and excess-base/nitrogen ratio of various crop species and parts of plants. Agron. J. 65:91-96.

ROMNEY, E. M., V. Q. HALE, A. WALLACE, O. R. LUNT, J. D. CHILDRESS, H. KAAZ, J. E. KINNEAR, and T. L. ACKERMAN. 1973. Some characteristics of soil and perennial vegetation in Northern Mohave Desert areas of the Nevada Test Site. USAEC Rep., UCLA # 12-916. 340 pp.

ROMNEY, E. M., A. WALLACE, J. D. CHILDRESS, J. E. KINNEAR, H. KAAZ, P. A. T. WIELAND, M. LEE, and T. L. ACKERMAN. 1974. Responses and interactions in desert plants as influenced by irrigation and nitrogen applications. US/IBP Desert Biome Res. Memo. 74-17. Utah State Univ., Logan. 12 pp.

TURNER, F. B., and J. F. McBRAYER, eds. 1974. Rock Valley Validation Site report. US/IBP Desert Biome Res. Memo. 74-2. Utah State Univ., Logan. 64 pp.

WALLACE, A., and E. M. ROMNEY. 1972. Radioecology and ecophysiology of desert plants at the Nevada Test Site. USAEC Rep. TID-25954. 439 pp.

WALLACE, A., E. M. ROMNEY, J. W. CHA, and S. M. SOUFI. 1974a. Nitrogen transformations in Rock Valley and adjacent areas of the Mohave Desert. US/IBP Desert Biome Res. Memo. 74-36. Utah State Univ., Logan. 25 pp.

WALLACE, A., E. M. ROMNEY, and G. V. ALEXANDER. 1974b. Variation in the simultaneous analysis by emission spectrography of twenty-four elements in plant material. Comm. in Soil Sci. and Plant Analysis 5:45-50.

WALLACE, A., E. M. ROMNEY, G. E. KLEINKOPF, and S. M. SOUFI. Plant uptake of mineral forms for nitrogen. *In* N. E. West and J. Skujins, eds. Nitrogen processes in desert ecosystems. Dowden, Hutchinson and Ross, Inc., Stroudsburg, Pa. (In press)