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

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ABSTRACT

This progress report summarizes additional investigations concerning the nitrogen cycle in the northern Mohave Desert. A point transect method was used to estimate lichen crust cover. Lichen crust covers only a very small part of the northern Mohave Desert and could account for much less than 1 kg/ha of fixed nitrogen per year. Free-living organisms may be more important. Acetylene reduction studies were continued. Findings of other years in relationship to specific plant species were not always reproducible. The semisymbiotic and rhizosphere nitrogen fixation appeared to be very irregularly distributed. Nitrogen applied one year previously was not found as mineral nitrogen in the soil surface in the subsequent analysis. Soil nitrate analyses for five different shrub clumps and adjacent bare areas were determined periodically (about three-week intervals) for a year at three different soil depths (0-7.5, 7.5-15, 15-22.5 cm). The values consistently decreased with depth and generally were highest in the March-April period, although the December-February period was almost as high. These results indicate that sufficient nitrogen is mineralized to meet the needs of plant growth in the spring. *Ambrosia dumosa* was used as a test plant to determine yearly changes in nitrogen concentrations. The rate of turnover of nitrogen in litter measured by plant uptake of various kinds was studied when ^{15}N-containing plant materials had been incorporated in soil. Considerable differences were observed for different kinds of plant material. Field plots were established to study nitrogen transfer rates and movement using ^{15}N as a tracer. Isotope ratio techniques were used to estimate soil pools of nitrogen and the root space for a given plant. All studies reported are being continued.

INTRODUCTION

Studies in the northern Mohave Desert have suggested that there are ample supplies of nitrogen for normal growth (Wallace and Romney 1972; Romney et al. 1974; Wallace et al. 1974; Hunter et al. 1975; R. B. Hunter et al., unpublished data). There are also indications of N inputs through lichen-algal crust and symbiotic plant-bacterial fixation (Hunter et al., unpublished data; Wallace and Romney 1972).

Estimates of rates of utilization of N are on the order of 4-10, and sometimes more, kilograms per hectare per year for above-ground plant productivity (Hunter et al., unpublished data; Wallace and Romney 1972). It appears that there is a store of nitrate sufficient for at least two years' growth, but soil NO_3 concentrations are very variable and NO_3 is present in marked concentrations at some points in the soil.

OBJECTIVES

1. To determine rates of biological N fixation in the desert systems studied via: a) symbiotic relationships with higher plants; b) symbiotic relationships with algal crusts and lichens; c) free-living nonsymbiotic forms including semisymbiotic forms.
2. To determine losses from the ecosystem via: a) volatilization of NH_4^+; b) leaching; c) runoff of litter, surface leaching or wind removal of litter; d) denitrification; e) erosion of soil organic matter.
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 to 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

ESTIMATION OF LICHEN COVER

A point-transect technique was used to estimate lichen-crust cover. A 50-m steel tape marked every 0.5 m was stretched out and the soil surface where each mark touched the edge was categorized and recorded. A point on the north edge of the IBP validation site was selected and ten 500-m transects run in random directions, with a new one starting where the previous transect ended. The area varied from sandy wash to mature desert pavement.

ACETYLENE REDUCTION ASSAY

Techniques were reported last year. A modification made during 1975 was incubation of serum bottles for a period of hours to days in the soil at the site of root harvest in the field. Activity was stopped with ethanol or $CuSO_4$—H_2SO_4 mixtures when the bottles were unearthed. They were then sent to UCLA for analysis. Data are stored under DSCODE A3UWS12.

PERSISTENCE OF NH_4NO_3 FERTILIZER IN SOIL

Samples of soil from plots which received NH_4NO_3 (0, 25 and 100 kg N/ha in March 1974) were taken June 6, 1975. Depths sampled were 0-7.5, 7.5-15 and 15-22.5 cm. Analysis for NO_3 was as previously reported. Analysis for NH_4 was by two techniques, the first as reported in 1974 and the second a similar assay performed on a 10X dilution of soil with 2 N KCl (Bremner 1965). The soil was incubated in 10 N KCl for 0.5 hr and stirred every 15 min, then centrifuged and NH_4 analyzed on the supernatant with an Orion NH_4 electrode. Data are stored under A3UWS09.

SEASONAL NO_3 CHANGES

Five shrub clumps were selected on a control plot established in 1967 near Mercury, Nevada, sewage ponds. The top 22.5 cm of soil was periodically sampled (three cores), both in the clumps and in the adjacent bare areas throughout 1975. Nitrate analysis was by an Orion nitrate electrode on a dilution of 20 g soil with 40 ml of 0.1 M Na

citrate and 1 ppm NO_3—N as $NaNO_3$. Analysis was performed on sieved soil (2 mm) the same day as samples were taken (A3UWS09).

CHANGES IN *Ambrosia* N POOLS

In January 1975, a group of 30 *Ambrosia dumosa* plants was selected and divided into those with no visible buds, partially developed buds, and visible leaflets. Those with no buds were harvested in random groups of three at biweekly intervals until exhausted, followed by partially developed and well-developed plants. This was an attempt to provide equivalent physiological leafing-out stages. From June through December other plants were selected at random from the same area from which the 30 original plants were taken. The plants were harvested, oven-dried (68 C for > 3 days) and separated into component parts. Root crowns were harvested, but not the entire root system (root:shoot ratios were reported for *Ambrosia* by Wallace et al. 1974). Soil samples were taken from below the plant at 0->7.5 cm, 7.5-22.5 cm and the "root zone" (0.5-30 cm in most cases). Soil NO_3 was determined on those soil samples the day of harvest using the technique recorded above.

LITTER DECOMPOSITION RATES

Ground plant material tagged with ^{15}N by hydroponic culture of four desert species (*Lycium andersonnii*, *Larrea tridentata*, *Atriplex hymenelytra* and *Ambrosia dumosa*) was added to pots of a sieved mixture of several Rock Valley soils. Uptake of N and ^{15}N into plants grown from January 1975 to the present on these soils in the greenhouse was measured by optical emission spectroscopy. A-values for available soil N were calculated as descibed by Smith and Legg (1971). Pots were watered with deionized water containing less than 0.1 ppm NH_4 and NO_3.

UPTAKE OF FIELD-APPLIED ^{15}N

Nitrate salts enriched in ^{15}N were applied to two shrub clumps on January 29, 1975, at rates of 1.76 and 4 kg N/ha to a 5-m^2 area centered on the clump. Soil and plant samples were taken prior to addition of NO_3 and on March 27 and June 23, and plant samples on October 1, 1975. On March 21, two similar plots were treated with $^{15}NH_4$ salts with and without N-Serve (2-chloro-6 [trichloromethyl] pyridine). Litter traps were constructed around each plot. Samples were separated into tissues and analyzed by optical emission spectroscopy. Analyses of soil samples and the October plant samples have been recently completed, but the data are not yet analyzed.

RESULTS

LICHEN CRUST

Table 1 shows the surface characteristics of Rock Valley soil. Rock, bare soil and litter cover 97.4% of the surface. Lichen-algal crust was not observed at any of the 10,000 points examined. This is in good agreement with the report of Nash et al. (1974) who found approximately 0.1% of the soil covered by N-fixing lichen. This survey included north slope areas lying south of the IBP validation site not penetrated by our 0.5-km transects. This sparseness of lichen-algal crust is not universal in the northern Mohave, as there are areas in west Mercury Valley (adjacent to Rock Valley) which show considerable lichen-algal crust. We have not yet determined a reasonable technique for estimating such large area percent coverage. It is possible that the albedo change in populated bare areas would be apparent in aerial photographs. Present estimates of coverage indicate a very low level of N fixation. We estimate temperature and moisture regimes would be suitable for active lichen metabolism only a few days a year, 10 to 20 being a maximum. Using our highest greenhouse rates for acetylene reduction, we estimate less than 0.2 g of N_2 would be fixed per year per hectare.

ACETYLENE REDUCTION

Table 2 shows seasonal changes in ethylene production rates by roots of *Yucca*, *Bromus*, *Larrea* and lichen crust. Table 3 lists average ethylene production by roots of various species. In 1975 we experimented with several incubation times and sites in an attempt to improve our results and the ease of detection of ethylene. The results suggest there is a seasonal peak in *Larrea* around May 15, and that lichen activity increases with temperature (all samples had water added).

In *Larrea* the longer incubation times had a disproportionately large effect on reduction of ethylene production rate. It is possible that the ethylene produced is not a result of acetylene reduction, but rather endogenous production from methionine. It is also possible that ethylene is metabolized by the roots or associated microorganisms after its production.

We have moved a gas chromatograph to Mercury for this year's work and are examining procedural effects on acetylene reduction. A cursory examination of the 1976 data shows a very complex relationship that seems to include lag times for acetylene reduction, seasonal and species changes in endogenous ethylene production, acetylene adsorption by soils and ethylene production by soils and litter. True cases of ethylene production by acetylene reduction are evident in only a few species, and then not consistently. Hence, we do not now have the data to estimate nitrogen fixation by either root or soil-litter microorganisms. Present evidence indicates the occurrence of active nitrogenase is probably very rare in the northern Mohave Desert.

Table 1. Surface characteristics of Rock Valley soil. Mean percent coverage by particulates, July 1975

Particle type	Mean %	SD	SEM
Bare soil	60.2	9.9	1.0
Rock	25.0	10.2	1.0
Litter	12.2	4.4	0.4
Live plant	1.3	1.0	0.1
Standing dead wood	0.95	1.1	0.1
Animal holes	0.25	0.54	0.05
Lichen on rock	0.09	0.35	0.04
Insect holes	0.03	0.17	0.02
Lichen-algae crust	0.00	0.00	0.00
Algae on rock	0.00	0.00	0.00

Table 2. Seasonal changes in ethylene production in argon-acetylene-CO_2-O_2 atmosphere by excised roots and soils, April 9-July 21, 1975. Parentheses enclose number of values averaged. Units are $nl \cdot g^{-1} \cdot hr^{-1}$

Date:	Apr 9-10	Apr 17	Apr 25	May 1		May 15		June 25		July 25	July 21
Incubation period:	24 h	24 h	72 h	4 h	24 h	24 h	74 h	24 h	74 to 98 h	285 hr	360 h
Incubation site:			Laboratory						Field		Laboratory
Species											
Yucca schidigera	2.3 (1)			8.2 (2)	0.2 (4)	0.2 (2)	0.7 (2)		2.8 (4)		
Bromus rubens	0.7 (3)	5.2 (6)	4.4 (2)	43.1 (4)	2.7 (2)						
Lichen	5.7 (3)		9.2 (1)	89.0 (2)	141.5 (2)	52.2 (1)	1071.6[a] (1)		364.6[a] (2)		
Larrea tridentata	140.4 (2)		1.5 (1)	28.0 (3)	67.0 (3)	77.1 (2)	10.4 (2)	25.8 (2)	2.7 (2)	1.2 (16)	0.7[b] (4)
Thamnosma montana	2.7 (1)										
Oryzopsis hymenoides	1.4 (1)										
Tridens pulchellus	6.8 (1)										
Festuca octoflora	3.1 (2)										
Atriplex confertifolia	19.7 (2)					36.8 (2)	14.2 (2)		13.8 (2)		
Hymenoclea salsola	1.4 (2)										
Lepidium fremontii	3.9 (1)										
Lycium pallidum				35.5 (2)	40.8 (4)			32.7 (2)	8.1 (2)		
Soil					0.2 (10)	0.02 (6)	0.01 (6)	0.01 (4)	0.004 (12)		0.001 (7)

[a] Incubated in glasshouse ·

[b] No acetylene added to 2 or 4 samples. It did not affect ethylene production significantly.

Table 3. Average ethylene production in an argon-acetylene-CO_2-O_2 atmosphere by excised roots, several assays between April 9 and June 5, 1975

Species	Ethylene production nl/g dw/h	n	Species	Ethylene production nl/g dw/h	n
Atriplex confertifolia	17.7	8	Lepidium fremontii	3.9	1
Bromus rubens	12.6	17	Lycium pallidum	31.6	10
Festuca octoflora	3.1	2	Oryzopsis hymenoides	1.4	1
Hymenoclea salsola	1.4	2	Thamnosma montana	2.7	1
Larrea tridentata	48.1	17	Tridens pulchellus	6.8	1
Yucca schidigera	2.2	14	Lichen-algae crust	195.0	12
Soil	0.05	38			

Table 4. Nitrate and ammonia concentrations in soils treated in March 1974 with NH_4NO_3 and sampled June 1975

Water treatment	NH_4NO_3 added	n	NO_3-N	NH_4-N
	kg-N/ha		ppm	ppm
Rainfall (13 cm)	0	24	2.5 ± 0.4	11.8 ± 1.2
	100	12	2.8 ± 0.6	12.3 ± 4.0
Rainfall and irrigation (40-50 cm) (total)	0	48	4.3 ± 1.4	13.2 ± 1.3
	100	48	7.5 ± 2.9	10.4 ± 1.0

PERSISTENCE OF NH_4NO_3 FERTILIZER

A summary of analyses of soil samples taken from 33 plots receiving 0, 25 and 100 kg N/ha as NH_4NO_3 in February 1974 is recorded in Table 4. Neither the NO_3 nor NH_4 were apparent when the samples were taken in June 1975. This is somewhat surprising in light of the large residue found in June 1974, and the effect on growth of *Bromus* in the spring of 1975. We presume the NO_3 was either washed below the depth sampled or converted to organic N and the ammonia either fixed or lost by volatilization. The nitrate distribution is somewhat unusual in that soils from bare areas tended to have higher nitrate concentrations than those from under shrubs. This was also found in areas treated with N in 1968 (Hunter et al. 1975), but was then more strongly apparent. The area does not have well-developed shrub clumps which may also tend to reduce the difference between shrub and bare soil. The commonly observed tendency for NO_3 to be most concentrated in the surface horizons is evident (Hunter et al., unpublished data; Wallace and Romney 1972).

Ammonia distribution does not vary significantly with depth or between bare and shrub soils. This is consistent with the findings of Nishita and Haug (1973). Pairing NH_4 values among adjacent plots (not presented) suggests there are natural two- to fivefold variations in ammonia concentrations over distances of tens of meters. These may be related to soil factors such as clay content, CEC and potassium content (Nishita and Haug 1973).

SEASONAL FLUCTUATIONS IN SOIL NO_3

Table 5 shows results of nitrate determinations made on soils from five shrub clumps and the adjacent bare areas throughout 1975. There are a few statistically significant differences between averages on some dates. We believe the point-to-point variability masks any real nitrate fluctuations. Table 6 gives the minimum detectable fluctuations assuming five replicate clumps and that the fluctuations occur simultaneously in each of the five samples. These values place an upper limit on temporal changes in NO_3 concentration with time during 1975.

Table 5a. Nitrate-nitrogen concentrations in surface samples under five shrub clumps and in the adjacent bare areas for 1975. Each value was determined on a composite of two or three cores. Error estimates are standard errors of the mean. Units are μ g NO_3—N g/dry wt

Clump	Depth (cm)	Feb 3	Feb 19	Mar 3	Mar 17	Mar 31	Apr 14	May 6	May 12	May 27	Jun 12	Jul 7	Aug 18	Oct 21	Nov 20	Dec 18	Mean	Standard Error
1	0-7.5	1.9	2.0	7.2	4.2	3.6	20.8	14.2	10.0	18.0	9.0	31.	2.0	16.4	12.4	2.0	10.31	±2.21
	7.5-15	1.3	1.5	4.3	2.4	3.5	3.7	2.2	4.6	10.4	4.0	7.6	0.8	7.0	7.5	12.4	4.88	±0.89
	15-22.5	1.9	2.6	3.4	3.3	4.2	1.1	1.3	1.8	4.6	2.2	2.2	12.9	5.8	5.0	2.3	3.73	±0.75
8	0-7.5	1.3	3.9	2.7	26.1	28.9	13.1	7.5	3.9	14.2	1.2	7.5	5.6	14.2	13.2	14.4	10.51	±2.18
	7.5-15	5.1	1.5	2.2	61.9	19.9	30.7	7.9	10.8	9.2	2.8	7.4	3.0	4.6	7.4	11.9	12.42	±4.04
	15-22.5	3.4	2.2	1.1	40.2	1.9	4.3	1.4	12.1	16.2	0.8	3.1	13.3	4.0	6.2	14.8	8.33	±2.66
65	0-7.5	4.3	7.0	3.3	6.5	19.4	12.6	9.4	2.2	10.0	4.4	11.0	24.	9.7	3.5	27.6	10.33	±2.00
	7.5-15	4.7	0.6	2.3	5.0	4.6	19.9	3.4	3.8	6.2	4.6	3.3	1.8	3.7	4.0	10.0	5.19	±1.18
	15-22.5	4.5	2.3	3.0	4.3	2.9	5.0	5.4	1.3	2.5	5.0	1.1	13.2	10.2	2.7	8.0	4.63	±0.83
96	0-7.5	1.2	45.2	2.3	70.9	4.5	14.9	3.6	1.5	15.2	9.6	2.5	26.	20.	27.0	4.8	16.61	±5.05
	7.5-15	1.3	7.2	0.8	11.1	1.9	0.4	2.4	0.4	3.2	5.3	3.2	5.4	4.6	8.4	4.4	4.00	±0.80
	15-25	1.2	2.3	1.0	6.3	0.7	0.7	3.0	0.1	1.5	2.5	2.0	1.8	2.7	5.3	3.4	2.30	±0.44
97	0-7.5	4.6	7.9	44.2	17.6	76.8	21.2	30.0	5.5	27.0	10.1	23.6	22.	13.4	8.5	10.2	21.51	±4.84
	7.5-15	1.3	24.8	6.8	4.3	21.9	6.1	13.5	3.0	12.0	7.9	10.6	13.6	8.8	34.0	15.6	12.28	±2.29
	15-22.5	1.4	23.4	6.1	3.2	8.1	2.7	3.3	0.3	4.6	6.3	1.5	8.4	8.6	12.8	10.5	6.74	±1.51
Overall Average		2.63	8.96	6.05	17.82	13.52	10.48	7.23	4.09	10.32	5.13	7.84	10.25	8.91	10.53	10.15		
		±.41	±3.24	±2.77	±5.78	±5.08	±2.42	±1.94	±1.01	±1.81	±0.76	±2.23	±2.20	±1.33	±2.28	±1.72		
	0-7.5	2.66	13.20	11.94	25.06	26.64	16.52	12.94	4.62	16.88	6.86	15.12	15.92	14.74	12.92	11.80		
		±.74	±8.07	±8.11	±12.12	±13.41	±1.87	±4.59	±1.51	±2.84	±1.74	±5.28	±5.02	±1.70	±3.29	±4.49		
	7.5-15	2.74	7.12	3.28	16.94	10.36	12.16	5.88	4.52	8.20	4.92	6.42	4.92	5.74	12.26	10.86		
		±.88	±4.57	±1.04	±11.33	±4.34	±5.70	±2.17	±1.72	±1.57	±0.85	±1.41	±2.30	±0.94	±5.49	±1.85		
	15-22.5	2.48	6.56	2.92	11.46	3.56	2.76	2.88	3.12	5.88	3.62	1.98	9.92	6.26	6.40	7.80		
		±.64	±4.21	±.93	±7.20	±1.27	±0.85	±0.75	±2.26	±2.65	±0.96	±0.34	±2.22	±1.40	±1.70	±2.30		

Table 5b. Nitrate-nitrogen concentrations in surface samples in the adjacent bare areas of the five shrub clumps shown in Table 5a. Each value was determined on a composite of two or three cores. Error estimates are standard errors of the mean. Units are μ g NO_3—N g/dry wt

Adjacent Clump	Depth (cm)	Feb 3	Feb 19	Mar 3	Mar 17	Mar 31	Apr 14	May 6	May 12	May 27	Jun 12	Jul 7	Aug 18	Oct 21	Nov 20	Dec 18	Mean	Sem
1	0-7.5	1.7	0.6	0.8	1.9	3.4	0.4	1.7	2.5	3.8	1.8	0.7	12.8	0.7	2.3	3.6	2.58	.78
	7.5-15	0.9	0.7	0.6	1.6	0.4	0.6	0.8	1.0	7.0	1.4	1.0	0.8	0.6	2.1	2.0	1.43	.42
	15-22.5	1.6	1.1	0.8	1.1	0.4	0.7	0.3	0.8	2.8	5.1	0.6	1.0	1.5	0.2	0.0	1.20	.33
8	0-7.5	2.3	0.9	0.6	3.3	2.6	2.3	3.6	1.6	3.8	1.2	1.2	4.2	0.1	2.4	3.4	2.23	0.33
	7.5-15	1.8	0.2	17.1	3.8	0.6	0.8	0.3	0.5	2.2	2.8	0.8	62.	1.8	1.7	5.4	6.79	4.09
	15-22.5	2.4	0.5	0.5	2.6	1.6	1.1	0.2	0.5	1.1	0.7	0.8	12.4	1.0	1.5	1.5	1.89	0.77
65	0-7.5	1.3	0.6	1.0	2.9	2.2	0.5	4.4	0.7	1.6	0.5	1.0	2.2	0.7	1.8	1.0	1.49	0.28
	7.5-15	1.1	0.9	2.3	1.6	0.9	0.6	2.9	0.6	3.0	0.2	1.3	0.5	1.3	2.1	2.4	1.45	0.23
	15-22.5	2.0	1.0	0.9	10.8	1.0	0.7	2.4	0.2	1.7	2.0	0.6	2.2	3.1	2.5	1.6	2.18	0.65
96	0-7.5	1.0	1.1	3.1	1.9	0.6	0.3	2.6	0.4	1.6	0.5	0.8	1.6	0.8	1.7	2.2	1.35	0.22
	7.5-15	1.0	1.0	0.7	1.6	0.6	0.5	0.8	0.1	1.3	0.3	0.6	0.6	0.7	0.5	0.5	0.72	0.10
	15-22.5	1.3	0.6	0.5	1.1	0.5	0.4	0.3	0.4	0.5	0.2	0.8	1.0	1.0	0.0	2.0	0.71	0.13
97	0-7.5	1.4	0.8	2.3	2.2	2.3	0.8	1.7	0.4	1.5	0.9	0.8	1.8	0.8	0.3	0.2	1.21	0.19
	7.5-15	1.3.	0.8	0.5	1.2	1.4	0.6	0.8	1.7	1.0	0.5	0.6	0.5	0.2	2.9	3.0	1.13	0.22
	15-22.5	1.7	0.9	1.4	0.9	1.0	1.9	2.5	0.3	0.4	1.2	0.4	3.2	1.2	0.3	0.8	1.21	0.22
Overall Average		1.52	0.78	2.21	2.57	1.30	0.81	1.68	0.78	2.22	1.15	0.80	7.12	1.04	1.69	1.97		
		±.12	±0.06	±1.08	±0.63	±0.24	±0.15	±0.34	±0.17	±0.44	±0.34	±0.06	±4.05	±.19	±.25	±0.38		
	0-7.5	1.54	0.80	1.56	2.44	2.22	0.86	2.80	1.12	2.46	0.98	0.90	4.52	0.62	1.70	2.08		
		±.22	±0.09	±0.48	±0.63	±0.46	±0.37	±0.53	±0.41	±0.55	±0.24	±0.09	±2.12	±.13	±0.38	±0.66		
	7.5-15	1.22	0.72	4.24	1.96	0.78	0.62	1.12	0.78	2.90	1.04	0.86	12.88	0.94	1.88	2.64		
		±.16	±0.14	±3.23	±0.47	±0.17	±0.05	±0.46	±0.27	±1.08	±0.49	±0.13	±12.28	±0.29	±0.40	±0.80		
	15-22.5	1.80	0.82	0.82	3.30	0.90	0.96	1.14	0.44	1.30	1.84	0.64	2.10	1.56	0.90	1.18		
		±0.19	±0.12	±0.17	±1.90	±0.21	±.26	±0.54	±0.10	±0.44	±.87	±0.07	±1.10	±.40	±0.48	±0.35		

Table 6. Minimum detectable seasonal fluctuations in nitrate concentrations in the northern Mohave Desert. Values are 2 x SEM for five replicates. Actual average fluctuations were smaller than these values in 1975

Depth	Clump soil ppm NO_3-N	Bare soil ppm NO_3-N
0-7.5 cm	10.0	1.0
7.5-15	6.2	2.7[a]
15 -22.5	4.0	1.0

[a]This high value is due to one sample of (1975) containing 62 ppm NO_3-N.

The decrease in nitrate concentration with depth is statistically significant ($P = 0.05$) in clumps 96 and 97. Both of these clumps had very dense shrub cover (Table 7) and, consequently, more litter on the soil surface.

Ambrosia N

We hope to show changes in nitrogen and mineral apportionment among plant tissues with time. This will allow a better estimate of nitrogen lost with leaf fall (stored in stem and root and used in fruit production) than is currently available. Figure 1 shows the weight apportionment among tissues during 1975. Nitrogen and mineral analyses are in progress.

LITTER DECOMPOSITION

Nitrogen absorbed from ground litter by pot-grown greenhouse plants is shown in Table 8. This shows both relative availabilities of litter N among species and also provides a test of our ^{15}N assay system and the A-value analysis techniques.

The majority of N absorbed by plants grown in soil amended with litter comes from the litter itself. Since the soil used in all 15 pots was thoroughly mixed, we can interpret differences in A-value (indigenous available N) to differences in actual availability of the litter N added. By this reasoning, it appears that *Ambrosia* roots have unusually available litter N; *Larrea* leaves are unusually resistant to release of N; and other materials are about equal in the availability of N from their litter.

In pot 3, which contained added ground *Atriplex hymenelytra* leaves, we were not able to establish *Salsola* seedlings until June. In the remaining pots, there is a significant correlation ($r = 0.72$, for last 8 pots $P \geqslant 0.95$) between total nitrogen (soil + added litter) and harvest weight. Hence, the litter N is controlling growth. In the fall and winter of 1975 we have been growing *Bromus rubens*, suspected of fixing N, and will be able to compare its growth and litter-N utilization to that of *Salsola*.

FIELD APPLICATION OF ^{15}N SALTS

Data available from ^{15}N-enriched fertilizer plots are very preliminary; valid conclusions require more ^{15}N analyses. However, it is possible with present data and certain assumptions to demonstrate the value of the technique. Table 9 shows the ^{15}N enrichment in tissue of plants growing on the 5-m^2 treated plots. Soil samples and samples from plants adjacent to the plots have not yet been analyzed.

Enrichment by ^{15}N is a function of depth of penetration of the applied ^{15}N, N stored in the plant tissues, area and depth of soil from which a plant obtains N, and the concentration of available indigenous soil N. The calculated A-values (Table 10) do not represent merely soil-available N, as would be the case in a crop of annual plants, but are a composite function of these three nitrogen sources and the percentage of the root zone within the 5-m^2 treated area. Hence, there is, at present, considerable confounding in the experiment, but it will be possible to independently estimate

three of the four variables (all but N in plant tissue) when all samples are analyzed.

It is evident that new structures (leaves and flowers) are more heavily enriched than old ones (Table 9). If we lump soil-available N and tissue-stored N, and assume that the NO_3 fertilizer was washed by rainfall throughout the 1975 wetting zone, then we can presume variations in A-value are due to sizes of root zone. Root zone estimates in Table 8 are made with the further assumption that the most enriched sample represents new growth of a plant whose root zone is entirely within the treated area. Work is in progress to evaluate these assumptions.

These preliminary results are consistent with our expectations. The amount of ^{15}N applied is sufficient to be absorbed in quantities detectable by our newly installed optical emission assay, sensitive to about 0.1 atom percent excess ^{15}N. This system requires less time than the more sensitive mass spectrometric method. Results show that the NO_3 and NH_4 applied without N-Serve reach the root zone with surface application in solution, and suggest that NH_4 with N-Serve does not. The estimated root zone radii are consistent with previous estimates (Wallace and Romney 1972) obtained by excavation in a sandy wash area.

The indicated soil-plant available N is of the same order of magnitude one would expect from NO_3 analyses (Hunter et al. 1975).

Tissue analyses over the season show a pooling of newly absorbed N in new tissues. The drop in N enrichment of live stem from March to June (Table 9) may be explained as due to separation of new and old growth in June, but inclusion of new growth (buds) with the live stem in March (leaf values in March are available only from *Larrea*).

Table 7. Characteristics of clumps sampled for seasonal fluctuations in NO_3^- concentration

Clump	Species composition	Total biomass kg/clump	Biomass kg/m^2	Mean surface NO_3-N** ppm
1	Acamptopappus shockleyi (2) Ephedra funerea (1) Ceratoides lanata (3) Larrea tridentata (3)*	3.55	1.44	10.3
8	Ceratoides lanata (1) Grayia spinosa (1) Larrea tridentata (3)*	3.93	1.13	10.5
65	Acamptopappus shockleyi (1) Ambrosia dumosa (1) Ceratoides lanata (5)* Lycium andersonii	2.13	1.00	10.3
95	Acamptopappus shockleyi (3) Ambrosia dumosa (1) Ceratoides lanata (4)* Lycium andersonii (1)*	3.75	1.15	16.6
96	Acamptopappus shockleyi (4) Ceratoides lanata (4)* Krameria parvifolia (1) Larrea tridentata (1) Oryzopsis hymenoides (1)	7.11	1.88	21.5

*Indicates dominant species in the clump.
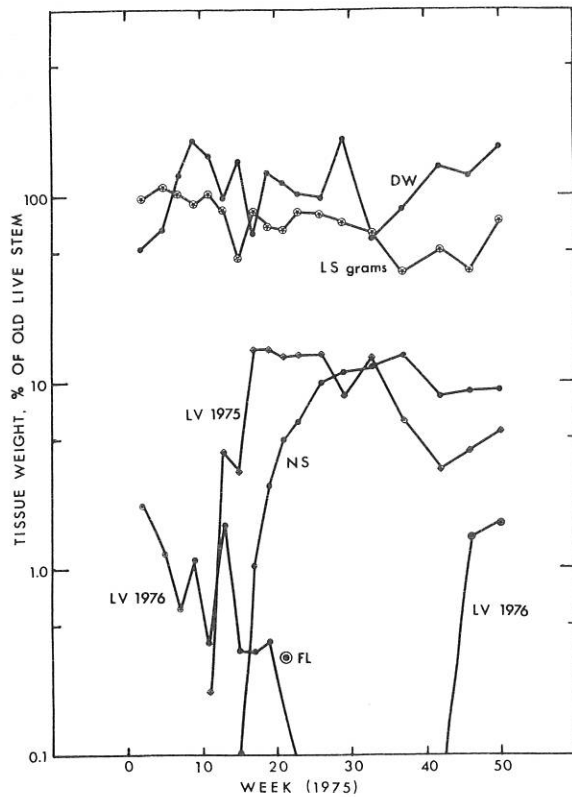
**For 0 to 7.5 cm depth of soil.

Figure 1. Weight distribution of above-ground plant parts in *Ambrosia dumosa* during 1975. Tissue code is LV = leaves -- live and dead; FL = flowers; NS = new stem; LS = old live stem; DW = dead wood. (Grams of old live stem are on the same scale as percentage of old live stem.)

Table 8. A-values determined from plants (*Salsola* spp.) grown in pots on soils amended with ^{15}N-tagged litter[a]

Pot #	Soil weight kg	Litter N remaining mg	Harvest date	Litter N harvested mg	Litter N in harvest %	A-value mg N/ kg soil	Average A-value mg N/ kg soil
			Atriplex hymenelytra[b] Roots				
1.	3.50	912	Mar 4	4.8	72	103	
		907	May 5	19.4	78	72	104
		888	June 7	19.3	77	77	
		868	June 17	29.4	60	165	
			Stems				
2.	3.45	732	Mar 4	2.3	72	84	
		730	May 5	10.8	72	84	83
		719	June 7	20.6	99	2	
		698	June 17	25.1	55	160	
			Leaves				
3.	3.45	No plants established through June 17					
			Lycium andersonii[b] Leaves				
4.	3.70	802	Mar 4	1.5	63	126	
		800	May 5	13.6	60	144	131
		788	June 17	180.7	63	124	
			Roots				
5.	3.30	1950	Mar 2	6.6	87	91	
		1943	May 5	23.3	86	99	135
		1920	Jun 7	19.3	78	166	
		1901	June 17	49.5	76	186	
			Stems				
6.	3.25	2345	Mar 4	3.6	99	7	
		2341	May 5	15.1	89	90	132
		2316	June 17	50.9	89	89	
			Larrea tridentata[b] Stems				
7.	3.60	708	Mar 4	2.1	66	103	
		706	May 5	9.3	61	128	124
		697	June 17	55.0	58	142	
			Leaves				
8.	3.65	655	Mar 4	0.0	11	1452	
		655	May 5	10.8	47	199	578
		644	June 7	1.7	28	458	
		643	June 17	21.2	46	202	
			Roots				
9.	3.35	547	Mar 4	2.8	63	96	
		544	May 5	33.3	70	71	125
		511	June 7	4.6	66	78	
		506	June 17	8.5	37	256	
			Ambrosia dumosa[b] Roots				
10.	3.40	386	Mar 4	1.8	69	52	
		384	May 5	47.4	69	50	55
		337	June 7	3.8	51	94	
		333	June 17	44.2	80	24	
			Leaves				
11.	3.50	1180	Mar 4	0.4	56	261	
		1180	May 5	36.7	70	147	218
		1143	June 7	9.3	53	288	
		1133	June 17	87.8	65	176	
			Stems				
12.	3.45	452	Mar 4	3.8	59	93	
		448	May 5	21.9	56	102	101
		426	June 7	5.3	58	89	
		421	Jun 17	22.6	50	122	

[a]Control pots had no litter N added, hence no values can be calculated for this table. Total N harvested from them was considerably lower than from litter amended pots.

[b]Species from which litter was obtained.

Table 9. Apportionment of N and ^{15}N to tissues by fertilizer type and date. Parentheses indicate single assay only

Tissue	Plot 1 NO$_3$ 3/27	Plot 1 NO$_3$ 6/23	Plot 2 NO$_3$ 3/27	Plot 2 NO$_3$ 6/23	Plot 3 NH$_4$ + N-Serve 6/23	Plot 4 NH$_4$ 6/23
			A. % N			
Dead wood	0.53	0.62	0.64	0.51	0.62	0.67
Live stem	1.39	0.80	1.79	1.31	1.06	0.94
Live leaves	(1.60)	1.46	(2.00)	1.90	1.88	1.45
Fruit				2.14	1.75	
			B. % ^{15}N excess			
Dead wood	0.06	0.15	0.18	0.15	0.18	0.12
Live stem	1.12	0.52	1.52	1.04	0.14	0.15
Live leaves	(.02)	1.05	(0.29)	1.98	0.11	0.25
Fruit				0.96	0.85	

DISCUSSION

Our attempts to quantitate nitrogen dynamics in the Mohave Desert were considerably affected by high point-to-point variability. The more closely we look at the various factors, the more difficult it becomes to provide statistically valid estimates.

In particular, high nitrate variations have limited our attempts to evaluate in situ fluctuations of nitrate and our attempts to find fertilizer nitrate. It is likely that nitrate fertilizer was leached below the 22.5-cm depth sampled. We intend to sample to greater depths in 1976, which will entail more disruption of the plots than we thought advisable in 1975.

We are convinced that variability in lichen crust cover is higher than indicated by our transect data, but it occurs over distances of kilometers which makes determination of its true abundance very difficult. Nevertheless, we feel that at the Rock Valley IBP Validation Site we can say that lichen crust provides less than 1 g of available nitrogen through fixation per year per hectare.

High variability in results of our acetylene reduction assay inhibits quantitation of that source of nitrogen. We have not found any consistently active higher plants, though lichen crust, when wet, is consistently active. Several higher plant samples are sporadically active -- *Yucca schidigera* being the best example (Hunter et al. 1975). *Bromus rubens*, which showed a strongly positive reaction in previous studies (Wallace and Romney 1972) was not strongly active in any of 17 assays in 1975.

Table 10a. Plot 1, treated January 29, 1975, with 4 kg $^{15}NO_3$—N/ha, 33.6 atom percent excess ^{15}N

Species	Tissue[a]	Jan. 29 N %	Jan. 29 Excess ^{15}N %	March 27 N %	March 27 Excess ^{15}N %	March 27 Uptake of applied N %	March 27 A Value[b] kg-N/ha	June 23 N %	June 23 Excess ^{15}N %	June 23 Uptake of applied N %	June 23 A Value[b] kg-N/ha	Root zone estimates[b] Area m²	Root zone estimates[b] Radius m
Aca sho	DW			0.41	0.11			0.56	0.40				
	LS	0.72	-0.04	0.83	2.87	10.7	43	0.73	1.43	4.3	94	<5	<1.3
	LL			1.29	2.43			1.29	2.43	7.2	55	<5	<1.3
Amb dum	DW	0.53	-0.03	0.52	0.00			0.65	0.22				
	LS	0.89	-0.08	1.55	0.39	1.2	341	0.82	0.23	0.7	580	39.6	3.6
	LL							1.84	0.66	2.0	200	18.0	2.4
Cer lan	DW			0.44	0.07			0.53	0.06				
	LS	1.03	0.00	2.35	1.66	4.9	77	0.75	0.43	1.3	309	9.0	1.7
	LL	2.77	-0.02					1.74	1.04	3.1	125	11.3	1.9
Gra spi	DW			0.52	0.19			0.73	0.02				
	LS	0.77	0.01	1.18	1.43	4.3	90	0.52	0.60	1.8	220	10.7	1.8
	LL							0.92	1.35	4.0	96	8.6	1.7
Kra par	DW			0.75	0.00			0.73	0.02				
	LS	0.80	0.01	1.08	0.31	0.9	430	0.76	0.31	0.9	430	49.9	4.0
	LL							1.42	0.46	1.4	288	26.1	2.9
Lar tri	DW	0.52	-0.02	0.55	0.02			0.64	0.05				
	LS	1.18	0.02	1.38	0.03	0.1	4476	1.25	0.15	0.4	892	103.7	5.7
	LL	1.55	0.01	1.60	0.02	0.1	6716	1.53	0.35	1.0	380	34.3	3.3

[a]Tissue code - DW = dead wood, LS = live stem, LL = live leaves.
[b]See text for significant qualifications.

Table 10b. Plot 2, treated January 29, 1975, with 1.76 kg $^{15}NO_3$—N/ha on 5 m², 94.6 atom percent excess ^{15}N

Species	Tissue[a]	Jan 29 N %	Jan 29 Excess ^{15}N %	March 27 N %	March 27 Excess ^{15}N %	March 27 Uptake of applied N %	March 27 A value[b] kg-N/ha	June 23 N %	June 23 Excess ^{15}N %	June 23 Uptake of applied N %	June 23 A value[b] kg-N/ha	Root zone estimates[b] Area m²	Root zone estimates[b] Radius m
Aca sho	DW	0.36	-0.02					0.54	0.99				
	LS	1.58	0.02	1.33	0.86	0.9	192	0.75	2.06	2.2	79	12.0	2.0
	LL							1.65	4.01	4.2	40	6.0	1.4
Amb dum	DW			0.59	0.63	0.7	263	0.46	0.37			39.8	3.6
	LS	1.04	-0.04					2.81	0.34	0.3	488	19.5	2.5
	LL							2.76	1.27	1.3	129		
Eph fun	DW			0.45	-0.02			0.48	0.03				
	LS	0.87	0.02	1.32	0.58	0.6	285	1.22	1.17	1.2	140	21.3	2.6
Cer lan	DW							0.52	0.09				
	LS/LL			2.85	4.79	5.1	33						
	LS							0.99	0.90	0.9	183		
	LL							1.68	1.52	1.6	108	16.3	2.3
	FR							2.38	1.00	1.1	165	25.0	2.8
Gra spi	DW			0.50	0.07								
	LS	1.00	-0.03										
	LS/LL			0.96	1.12	1.2	147						
	LL							1.49	2.30	2.4	71	10.7	1.8
Kra par	DW	0.56	0.03										
Lar. tri	DW	0.48	0.00	1.00	0.03			0.54	0.16				
	LS	1.62	-0.04	1.66	0.17	0.2	978	1.38	0.40	0.4	414	62.8	4.5
	LL	1.67	-0.02	2.00	0.29	0.3	572	1.91	0.79	0.8	209	31.7	3.2
	FR							1.89	0.92	0.9	179	27.2	2.9

Table 10c. Plots 3 and 4, each treated March 21 with 4.3 kg $^{15}NH_4$—N/ha, 56.8 atom percent excess ^{15}N and 2.6 kg NO_3—N/ha, unenriched. Plot 3 was treated with N-Serve, 2 liter/ha

| | | Plot 3 | | | | Plot 4 | | | |
| | | Mar 21 | | June 23 | | Mar 21 | | June 23 | |
		$\frac{N}{\%}$	excess $\frac{^{15}N}{\%}$	$\frac{N}{\%}$	excess $\frac{^{15}N}{\%}$	$\frac{N}{\%}$	excess $\frac{^{15}N}{\%}$	$\frac{N}{\%}$	excess $\frac{^{15}N}{\%}$
Aca sho	DW	0.34	0.01	0.46	0.30	0.43	0.02		
	LS/LL	1.05	0.05						
	LS			0.66	0.31	0.70	0.10	0.75	0.28
	LL			1.51	0.16			1.43	0.46
	FR			2.26	1.35				
Amb dum	DW	0.56	0.07	0.59	0.11	0.53	0.01	0.46	0.16
	LS	0.84	0.08	1.16	0.05	1.32	0.03	0.86	0.26
	LL			2.50	-0.05			1.74	0.35
Eph fun	DW	0.75	0.02	0.70	0.10				
	LS	1.29	0.02	1.43	0.10				
Eph nev	DW					0.67	0.12	1.07	0.06
	LS					1.12	0.08	1.22	0.05
Cer lan	DW	0.54	-0.02	0.68	0.19	0.48	-0.01	0.47	0.18
	LS/LL	1.67	0.00						
	LS			0.84	0.20	1.80	0.01	0.80	0.32
	LL			1.42	0.38			1.24	0.22
	FR			1.23	0.35				
Kra par	DW	0.88	0.04	0.53	0.18	0.76	-0.07	0.68	0.21
	LS	1.17	0.10	0.95	0.12	0.85	-0.08	0.57	0.06
	LL			2.32	0.04			1.09	0.11
Lyc and	DW					0.78	-0.07	0.65	0.07
	LS					0.98	-0.06	0.89	0.08
Lar tri	DW	1.00	0.00	0.78	0.22	0.54	-0.02	0.68	0.06
	LS	1.50	0.03	1.33	0.07	1.52	-0.08	1.51	-0.02
	LL	1.78	0.03	1.65	0.04	1.91	-0.02	1.77	0.10

It should be noted that our interpretation of the acetylene reduction assay has changed. Since plant roots have been shown to produce from 0 to 100 nl·g dw^{-1}·hr^{-1} of ethylene from methionine (Abeles 1973), we now feel a larger amount of ethylene must be produced to be considered unequivocally positive. Obvious nitrogenase reactions occur frequently with lichen crust, but only sporadically with other species (Hunter et al., unpublished data). Positive reactions also vary with season as well as individual plants.

The ^{15}N experiments have an advantage in that they provide N availability averaged by the plant over the extent of its root zone. They can also be expected to provide quantitative data for residence time of N in the ecosystem, and perhaps its spread within the environment if enough ^{15}N is applied. Estimates of root zones should also be preferable to those estimates available from excavation studies.

There are some modifications to the ^{15}N plots which we feel would be valuable. The shape we chose was a rectangle around a shrub clump to provide as much centering of the shrubs as possible. However, the value of the results does not depend strongly on covering the whole root zone. It would be possible to affect more plants by treating an area with higher edge-to-area ratio, for example, 1 x 10 m or 0.5 x 10 m. Similarly, we built litter traps around the clumps intended to provide an estimate of productivity, but they have prevented sampling of annuals which would not be affected by stored N, and they interfere with cycling of the ^{15}N back to the environment. The A-value analysis does not require an accounting for ^{15}N more strict than can be reasonably provided by annual soil and plant tissue analyses. Hence, we feel any subsequent plots established would not require litter traps.

EXPECTATIONS

During early 1976 we have initiated a N balance experiment in which vials of uniformly mixed soils with various treatments are incubated in the field. We expect this experiment to obviate some of the problems of natural variability of N concentration, but still provide conditions close to those in the field.

Samples of plant tissues from N-fertilized plots and from *Ambrosia* plants harvested in 1975 are undergoing N and mineral analyses. We hope to use these data to continue study of cation-anion relationships as affected by soil N.

Samples will continue to be taken from the ^{15}N-fertilized plots. If funding can be obtained, these experiments will be continued past 1976.

Acetylene reduction assays are continuing during spring of 1976.

We consider a primary task in the latter part of 1976 to be to synthesize available data on Mohave N dynamics for a final report.

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