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SOME ECOLOGICAL ATTRIBUTES AND PLUTONIUM CONTENTS OF PERENNIAL VEGETATION IN AREA 13

UCLA 12-937
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SOME ECOLOGICAL ATTRIBUTES AND PLUTONIUM CONTENTS OF PERENNIAL VEGETATION IN AREA 13[1]

by

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ABSTRACT

This is an interim progress report of work conducted at the Nevada Test Site under the auspices of the Nevada Applied Ecology Group, Office of Effects Evaluation, USAEC Nevada Operations Office, Las Vegas, Nevada. Included are data on some ecological attributes of the vegetation within the fenced portion of the Project 57 fallout pattern in Area 13. Also included are some preliminary data on the $^{239-240}$Pu and ^{241}Am in samples of vegetation collected in conjunction with the soil sampling program.

Prominent shrub and grass species in the fallout pattern of Area 13 include Artemisia spinescens, Atriplex canescens, Atriplex confertifolia, Eurotia lanata, Grayia spinosa, Kochia americana, Lycium andersonii, and Oryzopsis hymenoides. Individual or co-dominant species distinguished local association patterns of varied size within the fenced study area. Vegetation cover estimates in sample study plots ranged from 12.8 to 28.3 percent. Shrub densities ranged from 11.2×10^3 to 17.9×10^3 plants per hectare, and the standing shrub biomass ranged from 1592 to 4285 kilograms per hectare (0.7 to 1.9 tons per acre).

Preliminary results showed rather uniform distributions of $^{239-240}$Pu and ^{241}Am among individual samples of the same plant species collected within an intensive study plot. However, there was considerable variation in the contamination levels between different species, presumably from superficial entrapment of resuspended particulate material. Concentrations in Eurotia lanata were three to five times higher than in other species sampled from the same study site. The $^{239-240}$Pu and ^{241}Am generally tended to decrease in samples of vegetation collected at increasing distances from ground zero, but there were poor correlations between vegetation and soil $^{239-240}$Pu concentrations in isopleth strata within the fenced grazing area. Results showed inconsistencies in the Pu/Am ratios for vegetation and soil. Lower ratios found in vegetation samples indicate that preferential uptake and concentration of ^{241}Am through plant roots might have occurred in the Project 57 fallout area.

INTRODUCTION

The significance of vegetation in plutonium contaminated areas of the Nevada Test Site rests primarily upon its capacity to function as the carrier of plutonium ingested by grazing animals. Two different mechanisms of incorporation are considered to be involved in this transport process. First, the contaminant may become trapped superficially on vegetation through the processes of resuspension. This is expected to be an important transport mechanism underway in fallout areas where plutonium has been dispersed into the environment, since earlier fallout studies during above-ground nuclear testing showed that superficial contamination of vegetation was the major source of radionuclides available to grazing animals (Bormann, et al., 1958; Lindberg, et al., 1959; Larson, et al., 1960; Romney, et al., 1963; Larson, et al., 1966; Rhoads, et al., 1968; Romney, et al., 1971). Secondly, the plutonium disseminated in soil may be taken up through plant roots and translocated to the above-ground vegetation. This internal incorporation mechanism, however, might be less important than superficial contamination in view of the evidence from earlier studies indicating relatively low uptake of plutonium through plant roots (Rediske, et al., 1955; Selders, et al., 1955; Wilson and Cline, 1966; Fowler, et al., 1968; Romney, et al., 1970; Buckholz, et al., 1971; and Price, 1972, 1973). The NAEG vegetation studies are expected to contribute additional information on how these two mechanisms of incorporation function in the vegetation-carrier transport of plutonium from soil to animals living in contaminated fallout areas.

Included in this progress report are data on some ecological attributes of the perennial vegetation in Area 13, and some preliminary data on $^{239-240}Pu$ and ^{241}Am in samples of vegetation collected in conjunction with the soil sampling program in Area 13.

MATERIALS AND METHODS

Non-destructive, dimensional measurements were made at eight sample study plots to estimate density, cover, and standing shrub biomass in the Project 57 fallout site in Area 13. These plots were selected arbitrarily in local shrub association patterns within the fenced area. Briefly, two 2 × 25 meter quadrats were laid out in each plot at right angles to one another in undisturbed vegetation. All perennial plants were then identified by species and measured for height and width (mean of two dimensions). Plants with canopies overlapping the quadrat boundaries were counted inside only when root crowns were within the boundary line. Calculations using these dimensional measurements were made to determine density, cover, volume, and biomass. The standing biomass estimates were derived from regression of dry weight on volume indexes developed for each shrub from the destructive sampling of plants outside the contaminated study area (Romney, et al., 1973). Species dominance in vegetation associations was determined from shrub density measurements at nine additional study plots ($100m^2$) selected arbitrarily in local association patterns within the fenced area.

Thirty seven shrubs representing three different plant species were harvested from a micro-plot study site near ground zero in Area 13. This study plot was established prior to the plutonium survey and inventory in order to investigate the heterogeneity of plutonium distribution in vegetation and soil within a localized contamination site. The plant material was clipped in 3 to 5 cm lengths into 1-gallon press-lid cans, oven-dried at 70°C, weighed and submitted to the analytical laboratories for plutonium analysis. The laboratory procedures for radiochemical analysis of these large samples of plant tissue have been described by Major, et al. (1973).

Vegetation samples were collected in conjunction with the surface soil plutonium inventory in Area 13 following an intensive field survey using a portable FIDLER instrument with 5 inch Na I crystal and PRM5 meter. Pertinent details on the selection of random, soil sampling sites within the Project 57 fallout pattern have been described by Gilbert and Eberhardt (1973). Briefly, 300 to 600 gram samples of vegetation were collected in the immediate vicinity where soil samples were taken. The shrub nearest the soil sampling site was identified, and its location was documented by distance and azimuth measurements from the sampling site. Plant material was clipped in 3 to 5 cm pieces into 1-gallon press-lid cans, oven-dried at 70°C, weighed, and submitted to the analytical laboratories for plutonium analysis. These vegetation samples were collected by the same individual to help reduce variability in sampling.

RESULTS AND DISCUSSION

Ecological Attributes of Vegetation in Area 13

Beatley (1969) recognized and described the major vegetation types and associations in the Groom Lake drainage basin as Grayia - Lycium, Grayia - Lycium - Eurotia, Atriplex - Kochia, and Atriplex - Eurotia. All are interpreted as belonging to the vegetation of the Great Basin Desert, and are associated with valley floors of "closed" drainage basins.

The Project 57 fallout pattern is located in Area 13 on the well-drained bajadas west and northwest of the Groom Lake playa. The major vegetation type at the fenced study site is Atriplex - Eurotia, but individual or co-dominant species distinguished local plant association patterns of varied size within the study area. Among those shrub and grass species which have assumed dominance in these local situations are Artemisia spinescens, Atriplex confertifolia, Eurotia lanata, Grayia spinosa, Kochia americana, and Oryzopsis hymenoides. Table 1 lists the plant species identified in sampling plots within the study area. Oryzopsis hymenoides is the only grass species generally abundant; other grasses tend to be sparsely scattered in small patches. More than 40 different species of annual and herbaceous plants are present, but their contribution to the vegetation - carrier transport of plutonium to grazing livestock may be insignificant in view of their ephemeral nature and small biomass. This might not be the case, however, for small animals living in the area which depend upon the annual plants for food. Beatley (1969) reported biomass values of 8.50, 3.51 and 92.41 kilograms per hectare for the annual plant populations in an Atriplex -Eurotia type of vegetation in nearby Yucca Flat during 1964, 1965 and 1966, respectively.

Density, cover and standing shrub biomass measurements from sample study plots are given in Table 2. The heterogeniety of perennial vegetation within the fenced grazing area is indicated in these data. Shrub densities ranged from 11.3×10^3 to 17.9×10^3 plants per hectare; cover estimates ranged from 12.8 to 28.1 percent; standing biomass ranged from 1592 to 4285 kilograms per hectare. Conservative estimates of the edible forage produced annually for livestock grazing in this area would be around 1000 kilograms per hectare. Data in Table 3 indicate the variations in the nature of species composition in local plant associations. These differences probably influence the small mammal populations, but they would not be expected to influence

TABLE 1

Plant Species Identified in Sample Plots in Area 13

SHRUBS

Artemisia spinescens "Bud sagebrush"
Atriplex canescens "Four-winged saltbush"
Atriplex confertifolia "Shadscale"
Chrysothamnus viscidiflorus "Little Rabbitbrush"
Eurotia lanata "Winter Fat"
Grayia spinosa "Spiny Hop-Sage"
Kochia americana var. vestitia "Green-Molly"
Lycium andersonii "Wolfberry"
Opuntia erinacea "Grizzly Bear cactus"
Sphaeralcea spp. "Desert Mallow"
Tetradymia axillaris "Cotton Thorn"
Tetradymia glabrata "Awn Horse Brush"

GRASSES

Bromus tectorum - annual
Hilaria jamesii
Oryzopsis hymenoides
Sitanion jubatum
(not S. hystrix)
Sporobolus contractus
Stipa speciosa

ANNUALS AND HERBACEOUS PERENNIALS

Ambrosia acanthicarpa
Amsinckia tessellata
Astragalus lentiginosus
var. fremontii
Baileya pleniradiata
Chaenactis stevioides
Chaetadelpha wheeleri - herb
Chenopodium incanum
Coldenia nuttallii
Cryptantha circumscissa
micrantha
recurvata
Cymopterus ripleyi - herb
Descurainia pinnata
Eriastrum eremicum
Eriogonum deflexum
maculatum
nidularium
Eriophyllum pringlei
Gilia campanulata
Gilia cana subsp. triceps
leptomeria
Glyptopleura marginata
Halogeton glomeratus
Ipomopis depressa
polycladon
Iva nevadensis
Langloisia schottii
Lepidium lasiocarpum
Lupinus flavoculatus
(locally abundant)
Machaeranthera leucanthemifolia
(locally abundant)
Malacothrix sonchoides
Mentzelia albicaulis (abundant)
Mirabilis pudica - herb
Nama aretioides
demissum
Oenothera avita - herb
claviformis subsp. integrior
Oxytheca perfoliata
Psathyrotes annua
Salsola paulsenii and hybrids
iberica
Sphaeralcea spp. (ambigua complex)
Stepanomeria exigua var. pentachaeta
parryi - herb

TABLE 2

Ecological Attributes of Perennial Vegetation in Sample Plots ($100m^2$) in Area 13

Plot coordinates	No. of species	Density (No./ha)	Cover (%)	Volume (m^3/ha)	Biomass (kg./ha)
936,200; 720,600	7	12.3×10^3	14.6	650	2000
935,800; 721,000	5	11.3×10^3	12.8	508	1592
937,400; 720,600	6	17.9×10^3	28.3	1193	2523
940,200; 721,000	5	16.6×10^3	26.2	848	4077
939,000; 722,600	6	11.2×10^3	27.6	1459	3167
936,200; 725,000	6	12.3×10^3	23.3	984	2278
938,200; 719,000	4	13.7×10^3	21.6	719	3253
940,200; 719,400	5	13.3×10^3	28.1	933	4285

TABLE 3

Shrub Associations Based on Plant Densities in Area 13

Species	Species composition (%) in $100m^2$ sample plots																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A. spinescens	21	26	22	24	8	7	20	21		8	9		19	25	25	14	8
A. canescens	2			10				11	10	30	18	34					
A. confertifolia	38	54	59	52	16	38	22	14		5	3		15	11	10	28	19
E. lanata	35	2	15	13	76	50	47	32	26	44	56	16	21	15	14	14	29
G. spinosa		3					4	14	23			3	30	29	37		
K. americana	3	14				3										43	43
L. andersonii									14				6	3	9		
O. hymenoides			3			2	2	6	22	12	13	40	4	11	3		1

grazing cattle. One should anticipate that preferred plant species, ie, Eurotia lanata and Oryzopsis hymenoides, will be grazed first within the fenced area, after which the cattle would turn to the less palatable species as the grazing potential is reduced.

$^{239-240}$Pu and ^{241}Am in Perennial Vegetation in Area 13.

The micro-plot study site was established in isopleth No. 4 to investigate the heterogeneities of plutonium distribution in vegetation and soil. A scaffold was erected over an 8m^2 plot from which all vegetation was removed carefully so as not to disturb the soil surface. Individual shrubs were collected and processed for radiochemical analysis. Their $^{239-240}$Pu and ^{241}Am contents, determined on an ash weight basis, are listed in Table 4. These samples were collected on 19 January, 1972, at which time the plants were dormant. However, some of the Atriplex canescens plants still retained dried, fruiting bracts, and leaf material; and the Eurotia lanata plants generally retained their characteristic, long-haired fruiting involucres. The variations in plutonium distribution among plant samples were not as great as had been anticipated. On the other hand, the higher levels of contamination in samples of Eurotia lanata came as no great surprise because the hairy, external surface of this species should trap and retain more particulate material. These findings give credence to the concept that the major source of plutonium in the vegetation-carrier transport mechanism involves resuspended materials superficially entrapped on plant foliage.

Vegetation was collected in conjunction with the soil sampling inventory from six activity strata within the fenced area defined from FIDLER surveys. The activity ranges in isopleths 1 to 6 were 0-1,000; 1,000-5,000; 5,000-10,000; 10,000-25,000; 25,000-50,000; and >50,000-100,000 counts per minute. A map showing the location and pattern of these activity strata within the fenced fallout area is shown in Figure 1. Preliminary data on the $^{239-240}$Pu and ^{241}Am in vegetation samples from these strata are plotted in Figures 2 to 4 in terms of disintegrations per minute per gram of plant ash. These units were used for the readers ease in comparing sample activity levels relative to the ranges of activity in the different isopleth strata determined from FIDLER surveys. The $^{239-240}$Pu and ^{241}Am in samples of vegetation varied considerably within each isopleth, yet the range in concentration levels progressively increased from the furthest isopleth in toward ground zero. Vegetation sampled at nine sites along a

TABLE 4

$^{239-240}Pu$ and ^{241}Am in Micro-Plot Vegetation in Area 13

Species	$^{239-240}Pu$ (nCi/gm ash)	^{241}Am (nCi/gm ash)	Species	$^{239-240}Pu$ (nCi/gm ash)	^{241}Am (nCi/gm ash)
Eurotia	6.89	.868	Oryzopsis	1.35	.158
lanata	3.06	.352	hymenoides	1.92	.242
"	2.23	.309	"	1.14	.119
"	4.41	.566	"	3.28	.377
"	4.18	.456	"	1.49	.174
"	4.35	.570	"	1.31	.154
"	3.15	.398	"	1.77	.188
"	4.81	.563			
"	6.90	.786	Atriplex	.851	.149
"	3.66	.467	canescens	.546	.052
"	5.26	.672	"	.459	.063
"	4.90	.694	"	1.64	.188
"	3.36	.417	"	.964	.121
"	3.19	.366	"	1.45	.149
"	1.36	.133	"	2.01	.179
"	2.82	.341	"	2.01	.218
"	4.55	.572	"	1.03	.138
"	2.18	.259			
"	3.12	.366			
"	2.77	.495			
"	4.26	.471			

Species	n	$^{239-240}Pu$ Mean ± S.D. (n Ci/gm ash)	^{241}Am Mean ± S.D. (n Ci/gm ash)	$^{239-240}Pu/^{241}Am$ Ratios ± S.E.*
E. lanata	21	3.88 ± 1.42	.482 ± .177	8.0 ± 0.18
O. hymenoides	7	1.75 ± .73	.202 ± .086	8.7 ± 0.20
A. canescens	9	1.22 ± .59	.140 ± .055	8.7 ± 0.57

* Calculated as indicated in Table 5.

AREA 13 — SHOWING STRATA USED IN SAMPLING FOR INVENTORY

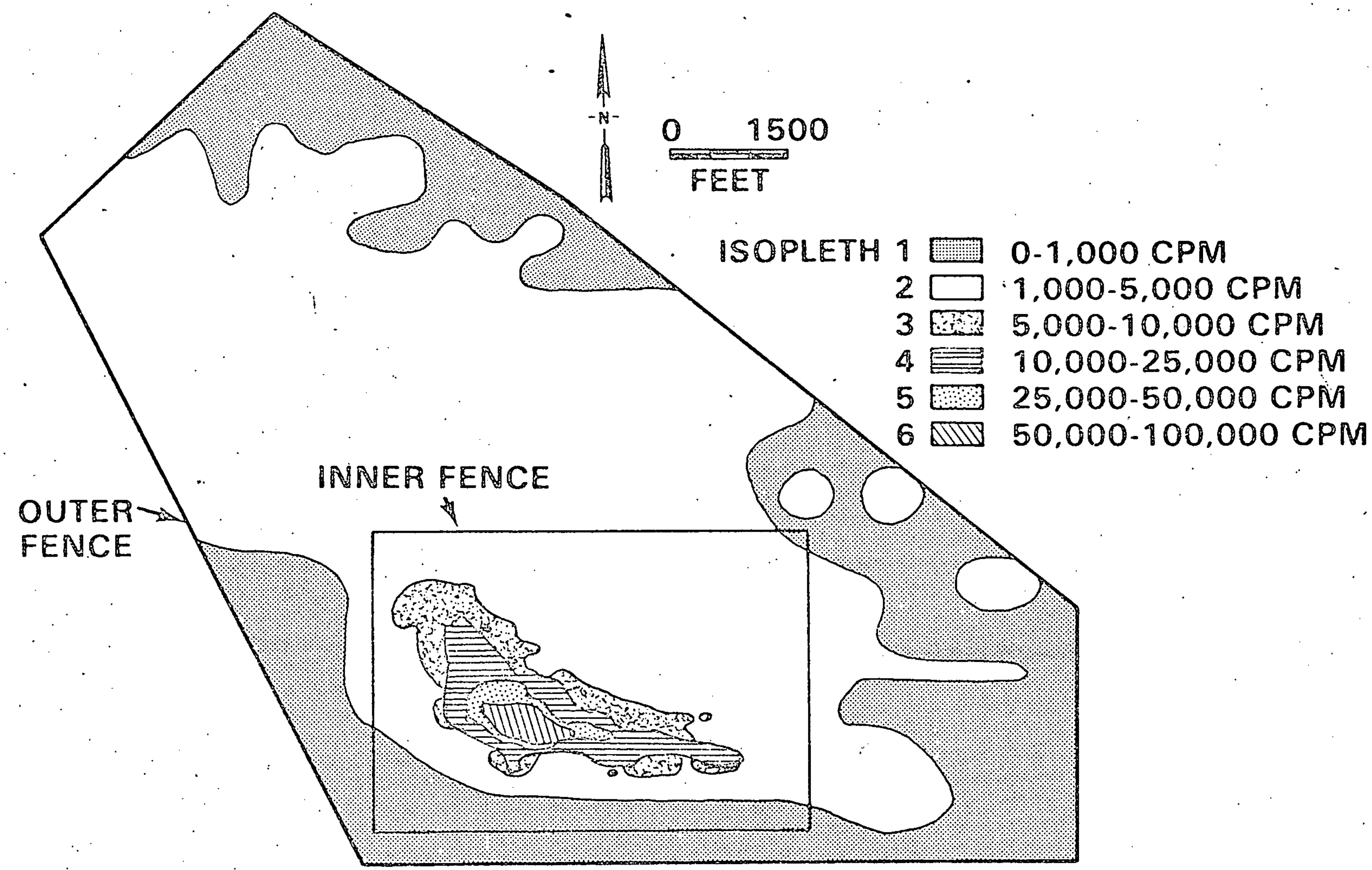
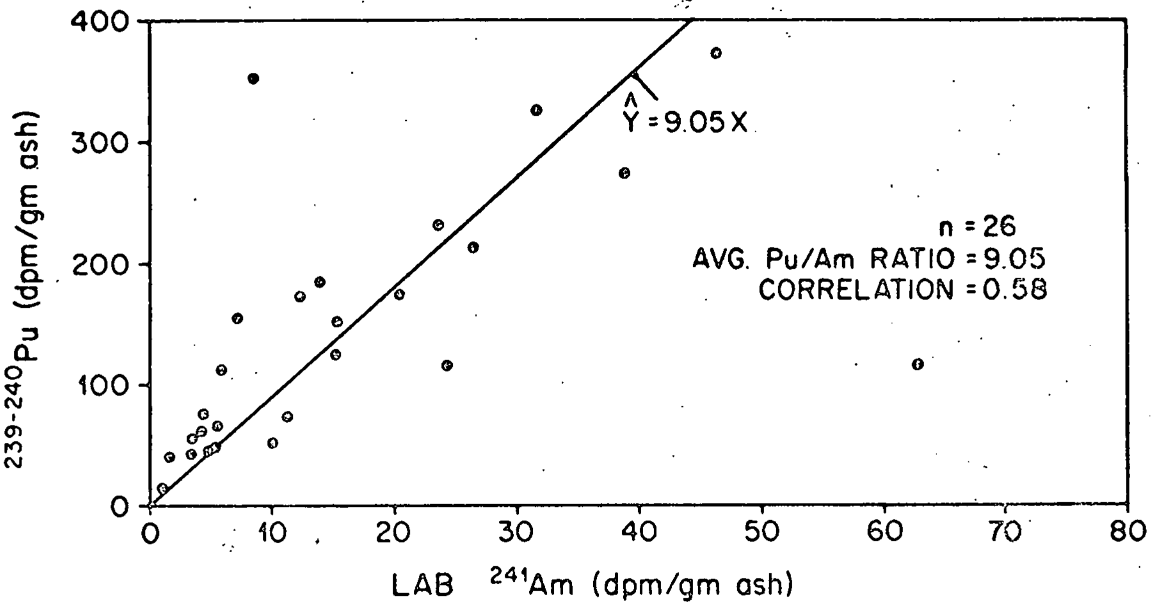


FIGURE 1

AREA 13
ISOPLETH 1 (<1000 CPM)



AREA 13
ISOPLETH 2 (1000 - 5,000 CPM)

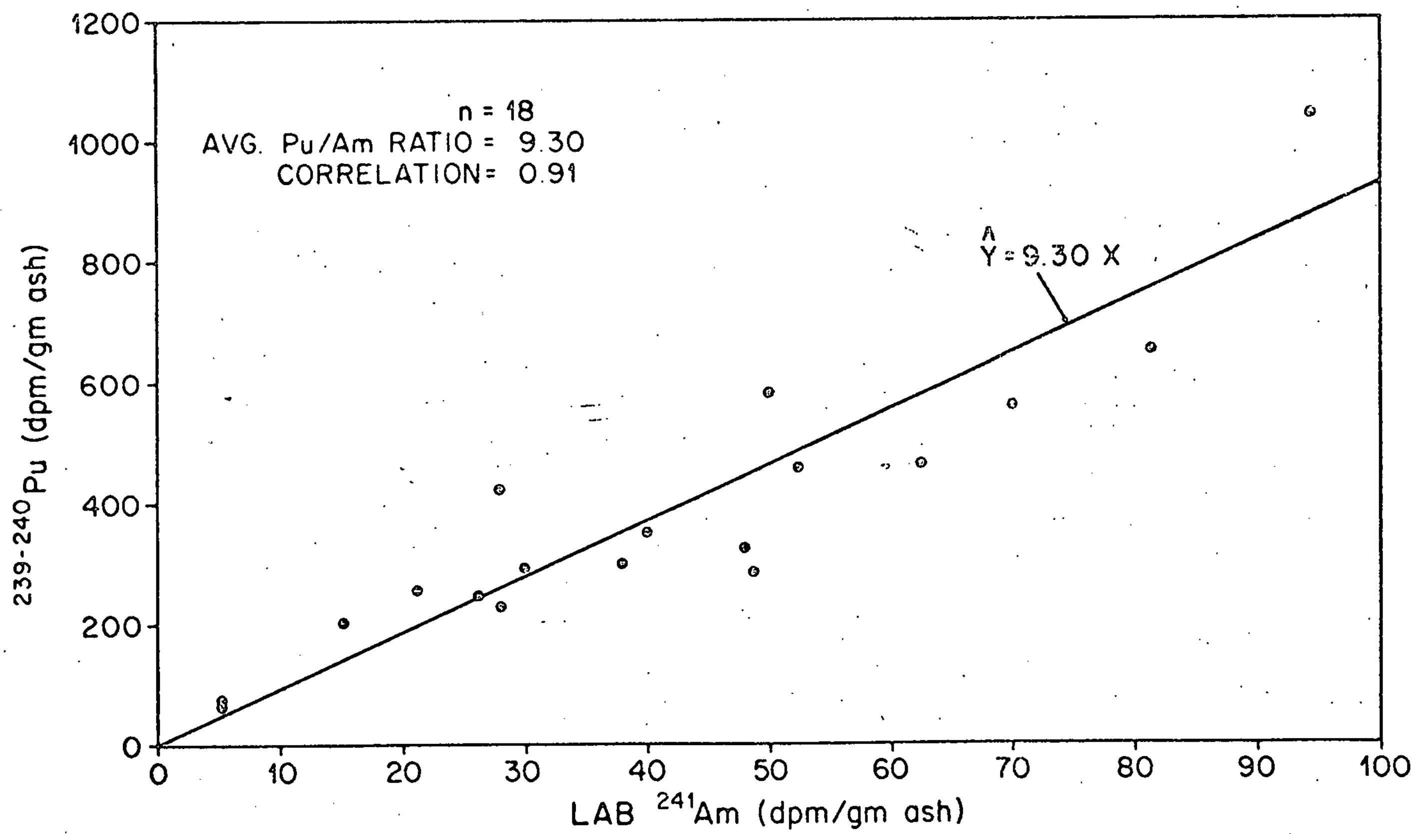
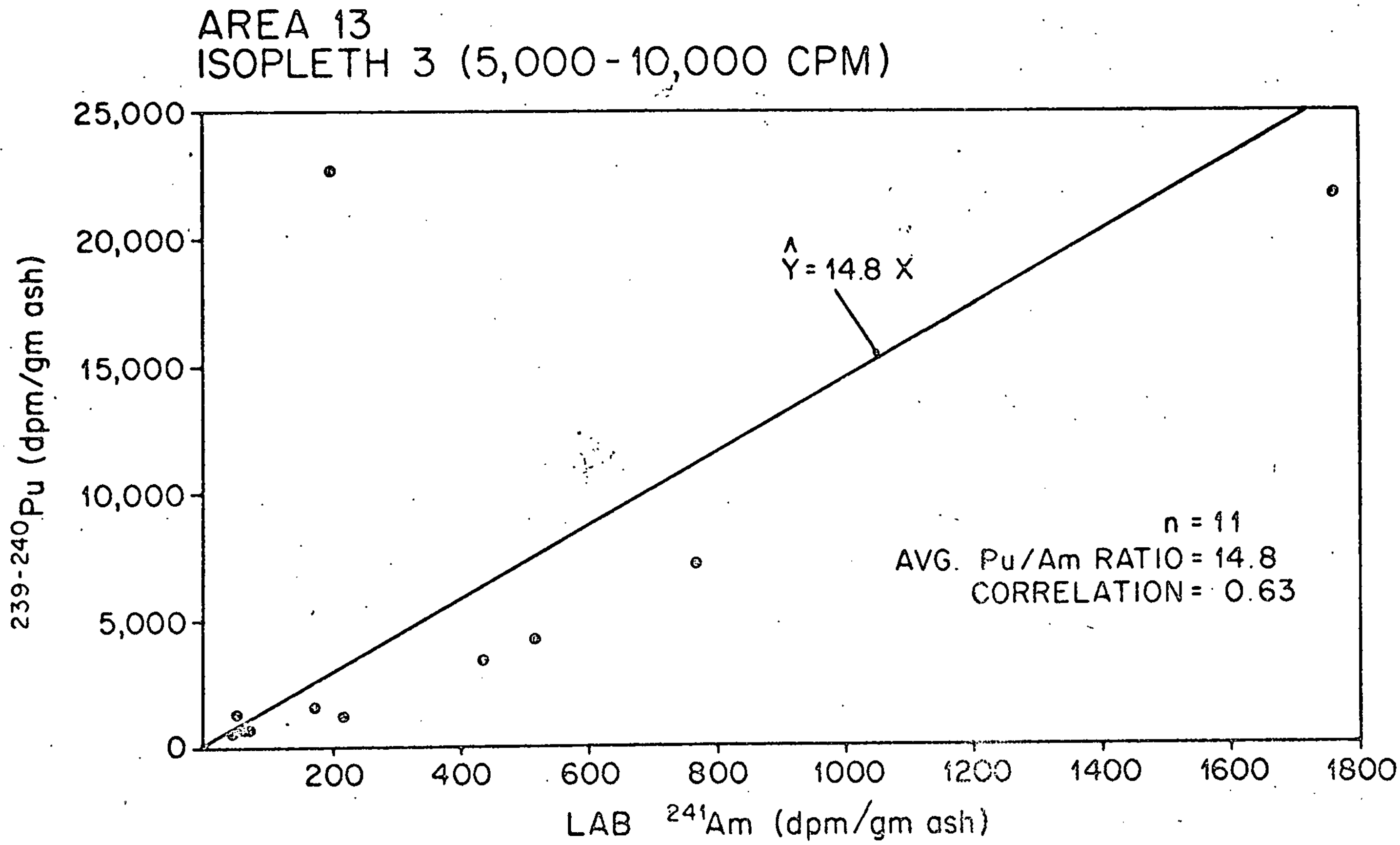


FIGURE 2


AREA 13
ISOPLETH 3 (5,000-10,000 CPM)
25,000
20,000
15,000
10,000
5,000
0
239-240Pu (dpm/gm ash)
Ŷ = 14.8 X
n = 11
AVG. Pu/Am RATIO = 14.8
CORRELATION = 0.63
200
400
600
800
1000
1200
1400
1600
1800
LAB 241Am (dpm/gm ash)

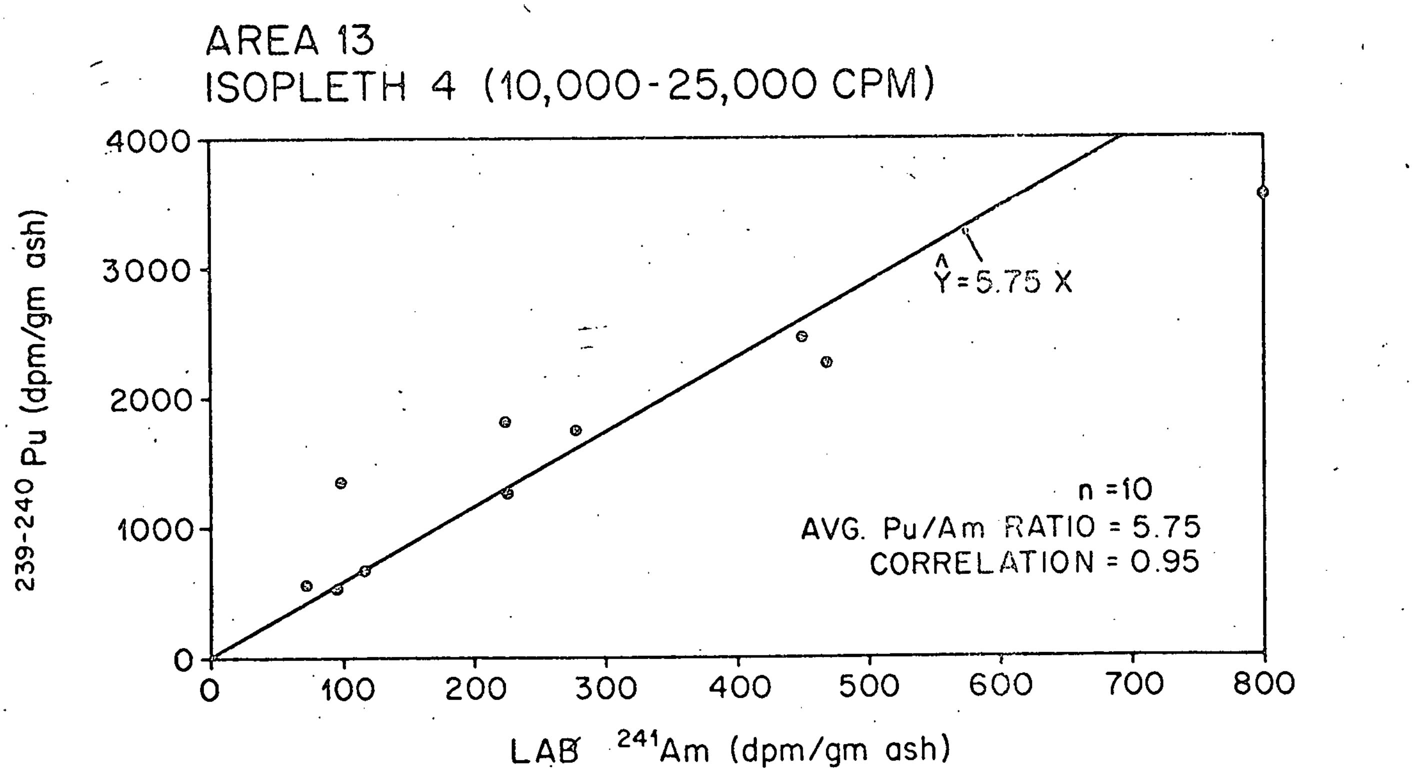
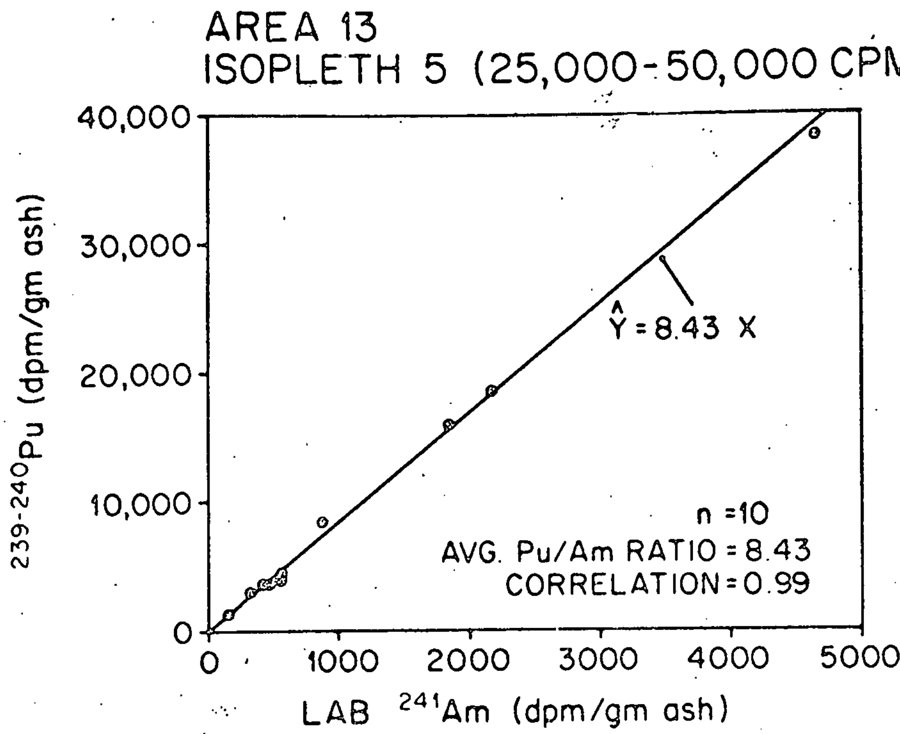

AREA 13
ISOPLETH 4 (10,000-25,000 CPM)
4000
3000
2000
1000
0
239-240 Pu (dpm/gm ash)
Ŷ = 5.75 X
n = 10
AVG. Pu/Am RATIO = 5.75
CORRELATION = 0.95
0
100
200
300
400
500
600
700
800
LAB 241Am (dpm/gm ash)

FIGURE 3


AREA 13
ISOPLETH 5 (25,000-50,000 CPM)
40,000
30,000
20,000
10,000
0
239-240Pu (dpm/gm ash)
Ŷ = 8.43 X
n = 10
AVG. Pu/Am RATIO = 8.43
CORRELATION = 0.99
0
1000
2000
3000
4000
5000
LAB 241Am (dpm/gm ash)

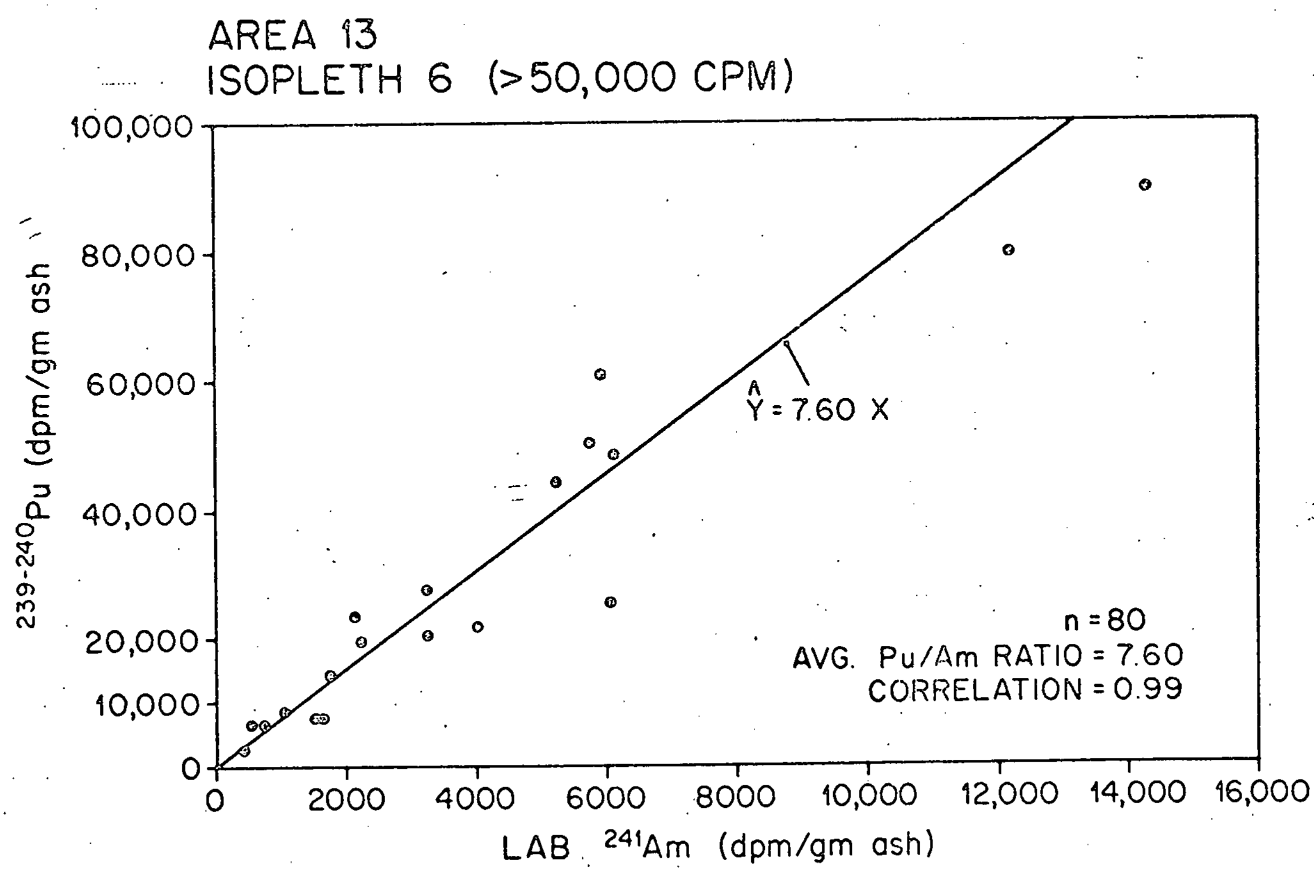

AREA 13
ISOPLETH 6 (>50,000 CPM)
100,000
80,000
60,000
40,000
20,000
10,000
0
239-240Pu (dpm/gm ash
Ŷ = 7.60 X
n = 80
AVG. Pu/Am RATIO = 7.60
CORRELATION = 0.99
0
2000
4000
6000
8000
10,000
12,000
14,000
16,000
LAB 241Am (dpm/gm ash)

FIGURE 4

two-kilometer transect extending northward from ground zero contained $^{239-240}Pu$ levels ranging from 5.43×10^3 to 12.5 d/m/gm ash, and ^{241}Am levels ranging from 7.34×10^2 to 1.62 d/m/gm ash. The correlation between the vegetation and soil $^{239-240}Pu$ concentrations indicated a good linear relationship ($r = 0.95$, F value = 72.2) along this transect.

The Pu/Am ratios in vegetation and soil from the different isopleths are given in Table 5. In general, these ratios for soil and vegetation are not very different; but no statistical tests of the data have been made, due to the incompleteness of analytical results. Ratios approaching ten should be expected in the Project 57 fallout pattern from the normal ingrowth of ^{241}Am since time zero. One very interesting point of note in these data of Table 5 is the apparent indication of an increased elevation of ^{241}Am in vegetation (lower ratios) compared to soil in five of the six isopleth strata. This raises the question of whether or not there might be greater uptake of ^{241}Am than $^{239-240}Pu$ through plant roots by vegetation in the fallout pattern. Glasshouse studies using surface soil (0-5 cm) collected at coordinate N 937, 400; E 720, 200 are underway to measure plant uptake of these two elements through root systems. In separate studies Cline (1967), Wallace, et al. (1969), Hale and Wallace (1970), Price (1972, 1973) and Wallace (1971a, 1971b, 1972) reported increased uptake of ^{241}Am relative to ^{239}Pu through plant roots.

Comparisons of data among the different isopleths (Table 6) indicate that correlations between vegetation and soil $^{239-240}Pu$ concentrations are not sufficiently near one to indicate a good linear relationship. It will be interesting to see if the use of dry plant weights to express final results on an activity per dry plant basis will improve these correlations. The Pu/Am ratios between different plant species could not contribute markedly to this lack of correlation between soil and vegetation concentrations, as can be seen from the data in Table 7. It appears, however, that differences in the capacity of plant species to superficially entrap particulate material containing $^{239-240}Pu$ could account largely for this disparity. Eurotia lanata, one of the co-dominant species of the vegetation type in the fallout pattern, is a case - in - point example indicated by the data given in Tables 4 and 8. Greater attention will be given to this apparent influence of plant type on plutonium transport in the future development of final reports on this study.

Implications of Preliminary Findings on Vegetation - Carrier Transport of Plutonium.

It is important that readers understand that $^{239-240}Pu$ and ^{241}Am results in

TABLE 5

$^{239-240}Pu/^{241}Am$ Ratios for Vegetation and Soil in Area 13

Isopleth	Vegetation (nCi/gm ash) n	R⁺	SE(R)⁺⁺	r	Soil (nCi/gm) n	R	SE(R)	r
1	26	9.05**	1.3	0.58	24	12.6**	0.9	0.98
2	18	9.30	0.53	0.91	28	14.2	3.9	0.85
3	11	14.8	6.9	0.63	15	9.4**	0.4	0.98
4	10	5.75**	0.63	0.95	20	8.8	0.2	0.99
5	10	8.43	0.18	0.99	20	8.8	0.3	0.99
6	20	7.60	0.32	0.99	46	9.4	0.3	0.95
Microplot	37	8.18	0.16	0.98	—	—	—	—
Transect	9	7.60	0.11	0.99	—	—	—	—

⁺ $R = \overline{Y}/\overline{X}$ where $\overline{Y}$ = ave. Pu concentration and $\overline{X}$ = ave. Am concentration.

⁺⁺ $SE(R) = [(\Sigma \frac{Y_i^2}{X_i} - \frac{(\Sigma Y_i)^2}{\Sigma X_i})/(n-1)\Sigma X_i]^{\frac{1}{2}}$. See Snedecor and Cochran, Statistical Methods, Iowa State University Press, 6th ed., 1967, page 168.

** Reject H_o: "constant ratio for all values of Am encountered" at $\alpha = .01$ level.

TABLE 6

$^{239-240}Pu$ Vegetation (nCi/gm ash) versus

$^{239-240}Pu$ Soil (nCi/gm) Concentration in Area 13

Isopleth	n	R⁺	SE(R)⁺⁺	r
1	24	2.0**	0.60	0.006
2	19	1.4**	0.27	0.69
3	10	5.0	1.3	0.63
4	11	0.63	0.12	0.28
5	10	2.1	0.96	0.14
6	18	3.0	0.73	0.70
Transect	9	0.93	0.13	0.95

⁺ $R = \overline{Y}/\overline{X}$ where $\overline{Y}$ = ave. $^{239-240}Pu$ concentration in vegetation and $\overline{X}$ = ave. $^{239-240}Pu$ concentration in soil at the same locations.

⁺⁺ Computed as indicated in Table 5.

** Reject H_o: "constant ratio for all values of soil Pu encountered at $\alpha = .01$ level.

TABLE 7

$^{239-240}Pu/^{241}Am$ Ratios by Plant Species in Area 13

Species	n	R+	SE(R)++	r
Atriplex canescens	12	8.9**	0.55	0.99
Atriplex confertifolia	49	6.9	0.29	0.97
Eurotia lanata	14	8.2	0.26	0.99

+ $R = \overline{Y}/\overline{X}$ where $\overline{Y}$ = average Pu concentration and $\overline{X}$ = average Am concentration.

++ Computed as indicated in Table 5.

** Reject H_o: "ratio is a constant for all values of ^{241}Am" at α = .01 level.

TABLE 8

$^{239-240}Pu$ in Vegetation (nCi/gm ash) versus

$^{239-240}Pu$ in Soil (nCi/gm) by Species in Area 13

Species	n	R+	SE(R)++	r
Atriplex canescens	12	1.0	0.28	0.87
Atriplex confertifolia	47	1.7	0.13	0.93
Eurotia lanata	14	5.1	1.07	0.90

+ $R = \overline{Y}/\overline{X}$ where $\overline{Y}$ = ave. Pu conc. in veg. and $\overline{X}$ = ave. Pu conc. in soil at the same locations.

++ Computed as indicated in Table 5.

this interim report are preliminary and subject to change after further analyses and refinement of the data. The study in progress not only awaits additional results from Area 13, but it also shall include findings from investigations in fallout patterns at GMX5, Area 11, and the Tonopah Test Range. Inasmuch as data from nearly one half of the samples collected in Area 13 are still forthcoming, it was considered premature at this time to make estimates of the potential amount of plutonium represented in the biomass of vegetation within the fenced, cattle grazing area.

Preliminary results indicated rather uniform distribution of $^{239-240}Pu$ and ^{241}Am among individual plants of the same species at a given sampling site; however, there appears to be considerable difference in the contamination levels between species presumably from superficial entrapment of resuspended particulate material. As the result, there are indications of very poor correlation between soil and vegetation $^{239-240}Pu$ concentrations in the different isopleth sampling strata within the fenced area.

Eurotia lanata, having very hairy collecting surfaces, contained notably higher concentrations of plutonium than did Atriplex canescens or the grass species, Oryzopsis hymenoides. Since Eurotia lanata is one of the most preferred forage plants within the fenced area, the transport of plutonium to cattle early in the grazing experiment might be higher than one would predict from estimates of concentration levels derived from composite vegetation samples.

The Pu/Am ratios indicate some inconsistencies in vegetation and soil samples. Slightly lower ratios found in vegetation compared to soil samples raise the question of whether or not preferential uptake and concentration of ^{241}Am in vegetation through plant roots has occurred in the Project 57 fallout area. Should this be the case, another dimension involving ^{241}Am will be added to the vegetation - carrier transport concept.

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