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THE INTAKE AND DIGESTIBILITY OF RANGE PLANTS GROWN ON PLUTONIUM CONTAMINATED SOILS AS DETERMINED WITH GRAZING CATTLE

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THE INTAKE AND DIGESTIBILITY OF RANGE PLANTS GROWN ON PLUTONIUM CONTAMINATED SOILS AS DETERMINED WITH GRAZING CATTLE

by

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ABSTRACT

Area 13 is one of several areas of the Nevada Test Site contaminated with transuranics. Cattle were grazed on the area to study the botanical and chemical composition of the forage, the digestibility of range plants as selected by range cattle, and the intake of plutonium and americium by grazing cattle.

The botanical and chemical composition of the diet of cattle grazing on plutonium-contaminated range was determined. The major portion of the diet was browse plants which were high in fiber and ash but low in energy. Daily feed intake of the grazing animals was also determined so that the amount of nuclides ingested daily could be ascertained. Cattle generally consumed over 2 kilograms per 100 kilograms body weight of dry matter daily which resulted in a daily intake of 3,600 to 6,600 picocuries of plutonium-238, 85,000 to 400,000 picocuries of plutonium-239, and 11,000 to 31,000 picocuries of americium-241. The soil ingested by range cattle constituted the principal source of ingested plutonium and americium. This is not unexpected as plutonium oxide is one of the least soluble substances known and the range studied is one of very limited rainfall. As expected, the forage from an "inner" compound was contaminated to a greater extent than the range plants from an "outer" compound.

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INTRODUCTION

Area 13 is one of several areas on the Nevada Test Site contaminated with plutonium and americium. The contamination of Area 13 resulted from Project 57 which consisted of one safety test in 1957 (Dunaway and White 1974). This area was isolated by fencing (400 hectares). Within this area, the most heavily contaminated area was further fenced to form an inner compound (100 hectares). These isolated areas have been restricted from all vehicular use or grazing by domestic animals since contamination. This area has been extensively studied and reports have been published of the plutonium and americium in the soil, plants and small mammals of the area (Dunaway and White, 1974; White and Dunaway, 1975, 1976, 1978; White, Dunaway and Wireman, 1977). Area 13 soil survey and contamination maps have been published by Leavitt in 1974 and 1978 by Gilbert Eberhardt in 1974.

With the slow decay of plutonium and related nuclides, and since this area was fenced, an opportunity was provided to graze the area with experimental livestock and measure the intake and digestibility of desert range forage by these animals and also to measure the intake of residual plutonium and other contaminants by grazing livestock.

The isotopes selected for study were plutonium-238, plutonium-239 and americium-241. All are alpha-particle emitting nuclides with half-lives between 86 and 24,000 years. Americium-241 arose from beta-decay of plutonium-241 which has a half-life of 13 years. Based on isotope equilibrium calculations, one would expect the maxiumum americium-241 levels to occur approximately 65 years after the initial plutonium contamination.

Plutonium and americium can enter grazing cattle either by inhalation of dust or by ingestion. An insignificant portion may also enter through cuts and other abrasions in the skin. Ingestion would include both the nuclides contained within the grazed plants and with any soil adhering to the plants and consumed at the same time. Soil data indicate that the greatest concentration of plutonium in Area 13 is contained in the coarse silt fraction (20- to 53-micron diameter) of the soil and in a somewhat larger particle-size fraction of blown sand in the area (Tamura 1974). This soil plutonium is present as plutonium dioxide (PuO_2). Plutonium dioxide is one of the least soluble compounds known, and americium oxide is only somewhat more soluble. Plutonium and americium exhibit appreciable solubility in artificial rumen fluids (Barth and Mullen 1974; Barth 1978) indicating that it can be absorbed by ruminants. Plutonium and americium have been reported in tissues of cattle grazing Area 13 (Smith 1974, 1979; Smith, Barth, and Patzer 1976).

The first part of this report deals with methodology. The second part reports on the dry matter intake, botanical and chemical composition of the grazed forage, and the dry matter digestibility of range plants at various seasons of the year on a qualitative as well as quantitative basis as selected by grazing cattle. The third part deals with the qualitative and quantitative intake of plutonium and americium by grazing range cattle.

METHODOLOGY

Four rumen-fistulated cattle were used to sample native forage grown on plutonium-contaminated range from July 1973 to January 1975 according to the procedure described by Lesperance et al. (1960a, 1960b). This procedure involves complete removal of the contents of the rumen and reticulum of cattle adapted to grazing the experimental area, allowing the animals to graze for 15 minutes to 2 hours (depending on forage density), removal of the grazed forage from the rumen and reticulum, then replacing the original rumen contents within the animal. A rumen solid and a rumen liquid sample were collected separately. The rumen liquid sample consisted almost entirely of saliva. If the next sampling period were soon, the animal was allowed to graze the experimental range until again utilized for sampling. If the interval before the next sampling were extended, the animal was kept elsewhere until 1 to 2 weeks prior to sampling and then returned to the experimental pasture. The dates of sample collections from 16 fistulated steers were:

Period I - June 28 to July 2, 1974
Period II - October 1 to October 5, 1974
Period III - January 17 to January 21, 1975

Rumen samples were also collected from resident cattle of the study area that were sacrificed on the following dates:

Nos. 2, 8, 12 and 3 - September 25, 1973
Nos. 1, 4 and 6 - July 9, 1974
Nos. 5, 13 and 15 - January 29, 1975

Forage and fecal samples were taken three times during the sampling period, according to the procedure outlined by Conner et al. (1963) for digestion and feed intake studies utilizing fecal grab samples. These procedures were as follows: Fistula samples for forage evaluation were obtained, as described earlier, one day prior to beginning of fecal sample collections and the second and fourth day of fecal collection. A group of fistulated cattle was used as forage samplers, and a second group of cattle was used for the digestion studies. Starting one week prior to the initiation of fecal collections, 5 grams of powdered chromic oxide, hand-packaged in filter paper, was administered morning and evening to the animals on the digestion trials. The chromic oxide, an external indicator, is used to measure fecal excretion, and was analyzed according to the procedure of Bolin et al. (1952) as modified by Connor et al. (1963). Fecal grab samples were obtained twice daily for 6 consecutive days from the same animals for the intake and digestibility studies.

Internal indicators, i.e., indigestible, measurable components of the diet, are used with grazing animals to determine the digestibility of the diet. Lignin has been used extensively for this purpose. The lignin content of forage samples collected by fistulated cattle are consistently higher than the lignin content of forage consumed (Lesperance et al. 1974). A regression equation has been developed from the composition of forage samples fed to rumen fistulated cattle and forage samples collected though fistulas as described earlier which permits a correction for this change (Connor et al. 1963).

Samples for botanical composition were collected by the Environmental Monitoring Systems Laboratory-Las Vegas (EMSL-LV) and summarized in this report. Other analyses were completed according to Association of Official Analytical Chemists (AOAC 1975) methods.

Individual range plants were collected from both the inner and outer compound while the digestion and intake studies were underway. These samples were limited to the current years growth of each plant.

The fresh plant samples and rumen contents were dried to remove surface moisture and split into two subsamples of equal size. One subsample ("as received") was subjected to no further treatment. The other subsample was washed with petroleum ether (40-70°C boiling range) until essentially no further adhering material could be removed (Dye 1962). The solvent was filtered and residual solvent was evaporated from both the plant material ("washed") and the removed soil ("soil"). The "as received" and "washed" subsamples were dried at 70°C in a mechanical convection oven to less than 10 percent moisture content, ground in a Wiley mill, and mixed thoroughly. Total moisture was determined on these samples by standard procedure 7.008 (AOAC 1975). Samples of the "as received" and "washed" plant material and the entire "soil" fraction were ashed for 16 hours at 550°C. The entire ash from the "washed" samples was forwarded to EMSL-LV for radioassay. The major portion of the ash from the "soil" fraction was also sent for radioassay. The sample number key is given in Appendix Table 1. Details on the sample weights are given in Appendix Table 2.

As an indicator of soil remaining on the washed plant material, titanium was determined on the "as received" and the "washed" samples (Mitchell 1960). Titanium is present in soils in reasonably large concentrations and is present in quite small concentrations in plants. The soil concentration is about 10,000 times that of plants. Thus the amount of titanium in a sample of plant material is indicative of the amount of soil contamination of the sample. In these studies, a comparison of the titanium contained in plant samples as received by the laboratory ("as received" samples) and that after the washing procedure outlined above ("washed" samples) indicated the efficiency of the washing processes. A correction for the plutonium and americium remaining in the soil contaminating the washed samples was made. A colorimetric analytical procedure was used (Yoe and Armstrong 1947; Clark 1968). Some studies of the titanium analytical procedures were made. Samples and standards were prepared by wet digestion and fusion with sodium carbonate. Since identical results were obtained, the simpler wet digestion procedure was used. Studies were also made of optimum development time and the standard curve stability.

Five samples of the "rumen liquid" were analyzed for titanium and gross alpha radioactivity. Very small amounts of titanium (19 ± 16 micrograms per collection) and no detectable alpha radioactivity were found. This confirmed our procedure of not assaying the "rumen liquid" samples. Transuranic elements are reported in rumen liquid (Smith, Barth, and Patzer 1976). It should be pointed out that the "rumen liquid" sample analyzed here is that liquid accumulated during the time the fistulated animals were sampling the range. Since the normal rumen contents were removed prior to this sampling, this "rumen liquid" consisted largely of saliva. This is markedly different from normal, in vivo, rumen liquid in that it would (a) have a much lower microorganism content, and (b) it would not have been in prolonged contact with the ingested feed and especially with remasticated rumen contents. For these reasons its content of compounds likely to complex metals, such as tricarboxylic acid cycle intermediates, would be quite low. It is not surprising that the "rumen liquid" analyzed in these studies would not contain transuranic elements whereas the rumen liquid from normally functional ruminants would.

Data Calculation: The radioactivity per unit weight (dry basis) was first calculated. The radioactivity "in" and "on" the samples was calculated using the titanium analysis to correct for soil remaining after washing the samples. The radioactivity "in" the sample was that measured in the washed sample less the correction for unremoved soil (Mitchell 1960). This unremoved radioactivity was calculated by three methods:

(a) By the ratio of the titanium in the "as received" sample to that in the "washed" sample. This used no average values and three data points per calculation.

(b) By using an average value for the titanium in the soil (24,000 micrograms per gram ash) and two data points per calculation.

(c) By using an average ratio of radioactivity to titanium for each nuclide and only one data point per calculation.

The results of all three calcuations were tabulated. Method "a" was considered to be more reliable since it used only data and no average values, however agreement between two calculated values was required. The value reported was selected as follows: If there was agreement between method "a" and one of the other methods ("b" or "c"), the results from methods "a" were used. If there was agreement between methods "b" and "c", but the results were markedly different from those with method "a", the results from method "b" were used. In approximately two-thirds of the samples the value from calculation method "a" was reported. The radioactivity "on" the sample was the sum of that measured in the soil removed by washing and the soil still remaining on the plant. An example of this calculation is given as Appendix Table 3.

Other calculations, including statistical analysis of data, were by standard methods. All calculations were made by digital computers.

Error: The over-all analytical error for the various procedures is given in Table 1. In all cases, the standard deviation of analysis was estimated from presumably blind duplicate sample analyses (Youden 1951). In the case of the plutonium and americium assay, duplicates were derived both from the same original sample prior to ashing and from the same ashed sample. These standard deviations were of the same order of magnitude.

BOTANICAL AND CHEMICAL COMPOSITION AND INTAKE OF RANGE FORAGE

The botanical composition of range forage selected by fistulated steers grazing on Area 13 of the Nevada Test Site is given in Table 2 and illustrated in Figure 1. Details are given in Appendix Table 4. The plant cover in Area 13 is predominantly browse. When grass is available, cattle select grass as the main component of their diet. As grass disappeared from the environment, a higher proportion of browse was then consumed. Forbs, nongrass annuals, did not consitute a major portion of the animal's diet at any time, although they have in other studies (Smith et al. 1968) on different areas of the Nevada Test Site at times. Since this portion of Area 13 had been restricted from grazing by domestic livestock for some period of time, more grass was available at the beginning of the grazing period than later. Since animals were restricted to a relatively small area of desert range, the variation in grass and forb consumption was not as great as noticed in other studies of desert range areas (Connor et al. 1963; Smith et al. 1968; Bohman and Lesperance 1967). Some examples of grass intake by range cattle are illustrated by location: NTS, 22 to 100 percent (Smith et al. 1968); Delamar Valley, Lincoln Co., Nevada, 0 to 85 percent, Elko Co., Nevada, 60 to 80 percent (Connor et al. 1963). In the current study, the grass present in the diet varied from 0 to 64 percent depending on the month sampled.

The chemical composition of forage selected by fistulated steers grazing on Area 13 on the Nevada Test Site is given in Table 3. Details are given in Appendix Table 5. The ash content of range forage (11.9 to 14.9 percent) is consistently higher than harvested hays (7 to 10 percent). This reflects not only mineral incorporated into plant tissues but also soil materials that adhere to the surface of the plant. This has been noticed in other studies on Nevada ranges which reported 11 to 22 percent ash (Connor et al. 1963; Smith et al. 1968). The protein content of the diet did not vary as much as expected considering the variation in the plant species ingested. Animals graze very selectively (Bohman and Lesperance 1967) and thus the chemical composition of the diet shows much less variation than the botanical composition. The total protein content of the diet generally increases when the plant is rapidly growing (May 1974) and is lowest on desert ranges when the plants are dry and mature (September 1973; October 1974). Except when plant growth is modified by non-seasonal rains, these trends in composition are usually seasonal.

The composition of selected hand-sampled plants harvested during the intake and digestion trials is shown in Table 4. Grass species were fairly mature when harvested hence their low protein and high fiber content. Browse was consistently higher in lignin as compared with annual species. Forbs and grasses were heavily utilized at sampling and the residual material was short and heavily contaminated with soil material and consequently has a high mineral content.

The digestibility and intake of range forage are shown in Table 5. In this current study, it ranged from 34.0 to 44.4 percent. The digestibility is low but is comparable to other studies where greater feed selection was possible. In other similar range studies in Southern Nevada, Connor et al. (1963) found that the dry matter digestibility ranged from 39.7 to 42.7 percent. Smith et al. (1968) at the NTS found that dry matter digestibility was 43.6 to 62.5 percent. Browse is far less digestible than grass and during the time that the digestion trials occurred, cattle were consuming browse almost exclusively. The digestibility of Northern Nevada range varied during the summer from 47 to 61 percent on predominantly grass type range. The feed intake was higher than expected for poor quality range, but quite normal for grazing animals on pasture. Animals probably attempted to compensate for the low nutritive value of the forage by greater consumption.

PLUTONIUM AND AMERICIUM INTAKE OF GRAZING CATTLE

Plant Radioactivity: Table 6 summarizes the data on the radioactivity of range plants collected from the study area. Sample and analysis numbers are given in Appendix Table 1 and detailed data are presented in Appendix Table 2. Samples were taken from two levels of contamination, the "inner" compound being more severely contaminated than the "outer" area. Plant samples from the "inner" area averaged about thirty times more radioactivity than samples from the "outer" area. No time trends were apparent, but none would be expected because of the long half-life of the nuclides studied. Table 6 also gives the partitioning of the radioactivity between that as external contamination on the plant and that contained within the plant. For the purposes of Table 6, negative calculated values of radioactivity within the plant were reported as zero. The mean and standard deviation for each nuclide in plants, considering both positive and negative calculated values were:

Plutonium-238	-0.08 ± 0.54 pCi/g (dry basis)
Plutonium-239	31 ± 12
Americium-241	3 ± 3

Except for plutonium-239 the average radioactivity contained within the range plants was insignificantly different from zero. This was also reflected in similar data from rumen contents. Since the plant uptake of plutonium isotopes would depend on the chemical properties of plutonium rather than on the isotope, one cannot draw conclusions from the above table about the uptake of plutonium by desert plants.

Table 6 also compares the measurement of total radioactivity in the "as received" sample ("measured") with that calculated by the sum of the radioactivity "in" and "on" the sample. The agreement is generally quite good and a paired t-test indicates no significant difference between the two methods of ascertaining the total radioactivity of the "as received" sample.

Rumen Contents: The concentration of radioactivity in the rumen contents of the test animals is summarized in Table 7 and the total ingested radionuclides in Table 8. As was the case with the plant samples, essentially all of the plutonium and americium ingested by the experimental animals was ingested as surface contamination and as soil rather than being contained within the plant matter. A somewhat larger proportion of the americium was found within the ingested plant material. Again, if the calculated negative values are included; the mean value for the radioactivity contained within the plant material is not significantly different from zero.

Ingested Radioactivity: The measured radioactivity ingested is given in Table 8 as the radioactivity in the total rumen content. The fistula samples (Animals 707, 729, 761 and 774) were the sum of collections on three consecutive days. The other samples were the rumen contents collected from sacrificed animals. Table 9 gives the estimated radioactivity ingested based on the plant analyses (Table 6) and the botanical composition of the rumen ingesta (Table 2). The two methods of estimating the radioactivity ingested were compared using a paired t-test. Considering all data, there were no statistically significant differences between methods although the intake calculated from feed composition tended to be higher than that directly measured. Table 10 gives the average daily intake of the three nuclides by cattle. This was based on the daily forage intake (Table 5) and on the measured radioactivity per unit weight of the rumen contents of the rumen-fistulated animals (Table 8).

DISCUSSION

The cattle in this study were grazing Area 13 of the Nevada Test Site. This is a rather poor, very dry desert range. Grass disappeared from the diet as grass became unavailable due to continued grazing. Dry matter digestibility was rather low but the animals compensated by increasing dry matter intake.

The transuranics consumed by the cattle were largely consumed as soil associated with their diet. This was reflected both by studies of the plants consumed and by studies of the rumen contents. The diet was high in ash reflecting surface contamination of the plants with soil. Soil had been noted in the digestive tract of animals grazing this area and it was estimated that cattle grazing this range consumed 0.25 to 0.5 kg of soil per day (Smith 1979).

Plants grown under irrigated, greenhouse conditions on soils from Area 13 take up the transuranics (Au et al. 1977). These studies were with non-native species under irrigated conditions. The native species on this range are rather deep rooted, drawing water and nutrients from considerable depth (Robertson, Blincoe and Torell 1972). Transuranic contamination is largely confined to the upper portion of the soils in Area 13 (Gilbert and Eberhardt 1974). It is thus not surprising that this study found only minimal concentrations of the transuranics within the desert flora consumed by grazing cattle.

The quantities of plutonium and americium ingested by grazing cattle were determined both from measurements on the ingesta and from measurements on the range plants. The two methods gave substantial agreement. How much of the ingested radioactivity was assimilated by the cattle was not addressed by this study. Plutonium and americium are reported in the tissues from cattle grazing Area 13 (Smith 1979). Plutonium and americium are also reported to be very poorly absorbed from the gastrointestinal tract even when ingested in a soluble form (Stanley, Bretthauer and Sutton 1975 and Sutton et al. 1978). Since the insoluble oxides in glass-like particles were ingested by grazing cattle (Tamura 1974) one would anticipate minimal assimilation of the ingested transuranics.

SUMMARY

The botanical and chemical composition of the diet of cattle grazing on plutonium-contaminated range was determined. The major portion of the diet was browse plants which were high in fiber and ash but low in energy. Daily feed intake of the grazing animals was also determined so that the amount of nuclides ingested daily could be ascertained. Cattle generally consumed over 2 kg/100 kg body weight of dry matter daily which resulted in a daily intake of 3.6×10^3 to 6.6×10^3 pCi ^{238}Pu, 8.5×10^4 to 4×10^5 pCi ^{239}Pu, and 1.1×10^4 to 3.1×10^4 pCi ^{241}Am. The soil ingested by range cattle constituted the principal and possibly only source of ingested plutonium and americium. This is not unexpected as plutonium oxide is one of the least soluble substances known and the range studied is one of very limited rainfall. As expected, the forage from the "inner" compound was contaminated to a greater extent than the range plants from the "outer" compound.

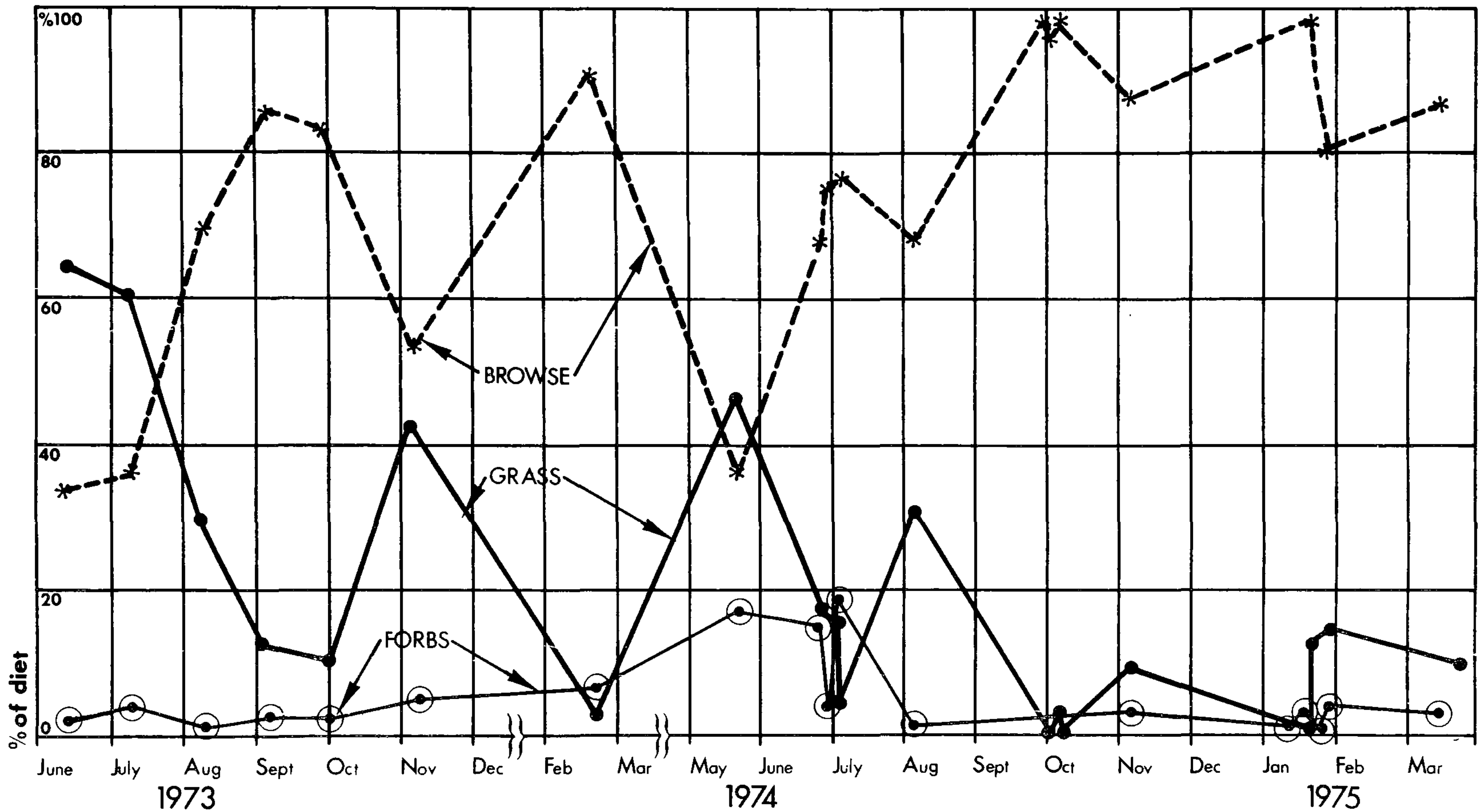

Figure 1. Botanical composition of diet of grazing range cattle.

TABLE 1. ANALYTICAL ERROR

Statistic	Pu-238	Pu-239	Am-241	Moisture	Titanium
Chemical analyses:					
n				20	20
Standard deviation of % composition				±0.42	±0.0079
Standard deviation of % error				±8.0	±7.0
Radiochemical analyses*:					
n	7	7	7		
Standard deviation of pCi/g ash	±2.1	±74	±35		
Standard deviation of % error	±57	±54	±45		
Overall**:					
n	15	15	14		
Standard deviation of pCi/g ash	±2.7	±88	±14		
Standard deviation of % error	±35	±30	±40		

* All steps subsequent to forwarding the ash to EMSL-LV for radiochemical analysis
** Includes all analytical errors
n Number of duplicate-pairs used for statistical analysis

TABLE 2. BOTANICAL COMPOSITION OF RANGE FORAGE SELECTED BY RUMEN-FISTULATED STEERS GRAZING ON AREA 13 OF THE NEVADA TEST SITE*

Plant Species	Percent of Total Forage at Various Sampling Dates																				
	6/12/73	7/19/73	8/8/73	9/5/73	10/1/73	11/6/73	2/20/74	5/21/74	6/28/74	6/30/74	7/2/74	8/7/74	10/1/74	10/3/74	10/5/74	11/5/74	1/17/75	1/19/75	1/21/75	1/29/75	3/12/75
Grasses:																					
Hilaria jamesii	4	28	10					T	1	2	1										
Oryzopsis hymenoides	60	32	19	12	13	41	1	6	8	2	3	29	T	2	T	9	1	1	8	11	8
Sitanion jubatum	T**	T	T			2		40	7	6	T	2						1	4		
Stipa speciosa								1	1	5										3	1
Sporobolus spp.				T	1		1			T											
unidentified				T	1		1	1		1								T	1	1	2
Total	64	60	29	12	15	43	3	47	17	16	4	31	0	2	0	9	1	2	13	15	11
Forbs:																					
Salsola paulsenii	T	4	T	T		2	4		12	1	16	T	1	1	2	2		1	1	3	2
Sphaeralcea ambigua	T	T	T				1	2			T										
Eriogonum spp.		T	T		1		T	1	T	4	T	T	1	1		1		1	T	1	T
Chaenactis spp.	T			T		T		5		2											
Chenopodium spp.				T		1	T	2		1											
Malacothrix spp.								4													
Ambrosia acanthicarpa								T													
Phlox spp.								T													
Gilia spp.																					
unidentified	2		1	2	1	1	1	3	1	1	3	1				T	1	T	1		1
Total	2	4	1	2	2	5	6	17	15	9	19	1	2	2	2	3	1	2	2	4	3
Browse (shrubs):																					
Eurotia lanata	26	21	14	31	20	45	82	26	34	26	49	54	33	21	23	50	12	3	36	31	40
Atriplex canescens	8	15	55	55	62	5	3	2	4	9	6	4	2	2	4	T		1	7	12	
Atriplex confertifolia		T	T	T	1		2	1	T	32	5	2	58	63	68	38	86	92	42	30	42
Lycium andersonii																				1	
Suadea spp.							4	4	28	5	14	8	5	10	3						
unidentified						2		3	2	3	3							T		7	4
Total	34	36	69	86	83	53	91	36	68	75	77	68	98	96	98	88	98	96	85	81	86

* These data were collected by EMSL-LV.
** T indicates trace amount - lower than 1 percent.

TABLE 3. THE CHEMICAL COMPOSITION OF FORAGE SELECTED BY RUMEN FISTULATED STEERS (in percent)

Date	Ash	Organic Matter	Protein		Acid Detergent Fiber		Lignin	
	Dry Basis	Dry Basis	Dry Basis	Ash Free	Dry Basis	Ash Free	Dry Basis	Ash Free
07-10-73	13.99	86.01	8.85	10.29	40.18	46.72	9.19	10.68
08-08-73	14.91	85.09	7.86	9.24	40.76	47.90	9.29	10.92
09-05-73	15.44	84.56	6.20	7.33	41.72	49.34	9.15	10.82
10-01-73	13.65	86.35	7.44	8.62	40.57	46.98	12.91	14.95
11-06-73	12.72	87.28	7.91	9.06	40.30	46.17	12.01	13.76
02-20-74	11.92	88.08	7.60	8.63	41.30	46.89	14.56	16.53
05-24-74	14.86	85.14	11.21	13.17	37.27	43.77	9.96	11.41
06-28 to 07-02-74	13.02	86.98	8.83	10.15	37.95	43.63	10.46	12.03
08-07-74	12.76	87.27	8.64	9.90	39.80	45.61	13.11	15.02
10-01 to 10-05-74	11.54	88.46	6.92	7.82	42.37	47.90	13.87	15.68
01-17 to 01-21-74	14.33	85.67	7.72	9.01	43.90	51.24	15.35	17.92

TABLE 4. COMPOSITION OF SELECTED HAND-SAMPLED PLANTS DURING INTAKE AND DIGESTION TRIAL, (DRY BASIS) AREA 13

Date and Location	Species	Percent of Dry Matter Protein	Acid Detergent Fiber	Lignin	Ash
07-02-74 Outer Compound	Russian thistle (Salsola paulsenii)	9.74	19.47	3.01	23.76
	Galleta grass (Hilaria jamesii)	10.41	42.13	4.10	24.21
	Indian rice grass (Oryzopsis hymenoides)	5.28	39.61	4.84	12.79
	Four-wing saltbush (Atriplex canescens)	7.13	29.04	11.22	19.95
	White sage (Eurotia lanata)	8.15	38.25	12.64	6.81
Inner Compound	Four-wing saltbush	6.86	27.26	11.09	20.84
	White sage	7.35	34.61	9.07	9.73
10-08-74 Outer Compound	Russian thistle	6.97	51.76	2.85	56.39
	Grass spp.	5.48	53.96	6.68	29.94
	White sage	8.70	41.68	14.49	10.30
Inner Compound	Russian thistle	7.34	32.69	3.04	34.11
	Grass spp.	3.29	61.19	5.08	43.73
	Four-wing saltbush	8.66	30.36	12.42	16.47
	White sage	7.15	40.15	15.45	7.30
01-20-75 Outer Compound	Grass spp.	7.92	45.19	5.73	19.62
	Bud sage (Artemesia spinescens)	7.84	47.83	15.91	14.87
	Four-wing saltbush	8.47	32.66	13.30	12.68

(continued)

TABLE 4. (Continued)

Date and Location	Species	Percent of Dry Matter: Protein	Acid Detergent Fiber	Lignin	Ash
	White sage	7.77	42.29	17.46	5.80
Inner Compound	Grass spp.	5.39	50.14	6.37	22.23
	Bud sage	8.05	48.04	15.25	16.96
	Four-wing saltbush	8.65	31.93	13.27	13.13
	White sage	7.74	42.30	16.91	6.35

TABLE 5. DIGESTIBILITY AND INTAKE OF RANGE FORAGE

Measurement	Periods: I	II	III
Dry matter digestibility, %[a]	40.1	34.0	44.4
Dry matter intake, kg daily[b]	7.32	9.00	8.23
Cattle weight, kg	311	337	334
Intake, % of body weight	2.35	2.67	2.46

[a]Dry matter (D.M.) digestibility =

$$100\left(\frac{\%\ \text{lignin feed}}{\%\ \text{lignin feces}}\right)\left(\frac{\%\ \text{D.M. in feces}}{\%\ \text{D.M. in feed}}\right)$$

where % lignin in feed is corrected for sample processing according to the following equation (Conner et al. 1963)

$$\text{corrected lignin value} = 3.63 + 0.405\ (\text{lignin in samples})$$

$$\text{Fecal dry matter output, g} = \frac{\text{amount of } Cr_2O_3 \text{ fed}}{\%\ Cr_2O_3 \text{ in fecal grab sample}}$$

$$^{b}\text{Dry matter intake} = \frac{100\ \text{fecal weight, dry basis}}{\%\ \text{dry matter indigestibility}}$$

TABLE 6. RADIOACTIVITY OF HAND-SELECTED RANGE PLANTS‡

Nuclide	Period	Sample No.	Area*	Species	pCi/g (d.b.)† ON	IN	Sum	TOTAL Measured
^{238}Pu	I	01	0	Russian thistle	0.14	0.06	0.20	0.20
		02	0	Galleta grass	0.32	0	0.32	0.27
		03	0	Indian rice grass	0.11	0.09	0.20	0.20
		04	0	Four-wing saltbush	0.38	0	0.38	0.20
		05	0	White sage	0.19	0	0.19	0.16
		06	I	Indian rice grass	(T)			
		07	I	Galleta grass	15.	12.	27.	27.
		08	I	Russian thistle	6.5	39.	46.	46.
		09	I	White sage	2.2	3.6	5.8	5.8
		10	I	Four-wing saltbush	1.0	0	1.0	0.94
	II	01	0	White sage	0.15	0.15	0.30	0.30
		02	0	Russian thistle	0.31	0.10	0.41	0.41
		03	0	White sage	0.22	0	0.22	0.082
		04	0	Four-wing saltbush	0.046	0.11	0.16	0.16
		05	0	Grass	0.35	0	0.35	0.48
		06	I	Undetermined	1.1	3.4	4.5	4.5
		07	I	White sage	1.8	0	1.8	2.4
		08	I	Four-wing saltbush	0.31	0	0.31	0.28
		09	I	Russian thistle	4.4	0	4.4	4.2
		10	I	Grass	2.9	0.30	3.2	3.3
	III	01	0	Bud sage	0.17	0.80	0.97	0.98
		02	0	Four-wing saltbush	0.17	0.02	0.19	0.18
		03	0	White sage	0.014	0.25	0.26	0.26
		04	0	Grass	0.31	0.02	0.33	0.34
		05	I	Bud sage	2.0	4.5	6.5	6.6
		06	I	White sage	0.52	0.95	1.00	1.00
		07	I	Four-wing saltbush	0.41	0.17	0.58	0.58
		08	I	Grass	5.5	1.6	7.1	7.1
^{239}Pu	I	01	0	Russian thistle	4.5	0	4.5	3.8
		02	0	Galleta grass	4.1	5.5	9.6	9.6
		03	0	Indian rice grass	1.1	1.6	2.7	2.7
		04	0	Four-wing saltbush	5.4	0	5.4	7.1
		05	0	White sage	2.7	3.1	5.8	5.8

(continued)

TABLE 6. (Continued)

Nuclide	Period	Sample No.	Area*	Species	pCi/g (d.b.)† ON	IN	Sum	TOTAL Measured
		06	I	Indian rice grass	(T)			
		07	I	Galleta grass	530.	430.	960.	960.
		08	I	Russian thistle	260.	140.	400.	400.
		09	I	White sage	44.	200.	240.	250.
		10	I	Four-wing saltbush	20.	9.2	2.9	30.
	II	01	0	White sage	8.2	0	8.2	7.2
		02	0	Russian thistle	0.74	2.4	3.1	3.2
		03	0	White sage	3.5	0	3.5	1.7
		04	0	Four-wing saltbush	0.17	1.2	1.5	1.5
		05	0	Grass	11.	0	11.	12.
		06	I	Undetermined	20.	52.	72.	73.
		07	I	White sage	110.	0	110.	89.
		08	I	Four-wing saltbush	7.3	4.5	12.	12.
		09	I	Russian thistle	120.	0	120.	120.
		10	I	Grass	96.	17.	110.	110.
	III	01	0	Bud sage	7.3	20.	27.	27.
		02	0	Four-wing saltbush	5.2	0	5.2	4.8
		03	0	White sage	0.64	5.7	6.3	6.3
		04	0	Grass	3.8	3.3	7.1	7.1
		05	I	Bud sage	78.	190.	270.	270.
		06	I	White sage	2.2	38.	40.	40.
		07	I	Four-wing saltbush	9.7	5.9	16.	16.
		08	I	Grass	220.	59.	280.	280.
^{241}Am	I	01	0	Russian thistle	0.75	0	0.75	0.64
		02	0	Galleta grass	1.7	0.61	2.3	2.3
		03	0	Indian rice grass	0.75	0	1.75	0.59
		04	0	Four-wing saltbush	2.4	0	2.4	1.4
		05	0	White sage	1.1	0.14	1.2	1.3
		06	I	Indian rice grass	(T)			
		07	I	Galleta grass	68.	79.	32.	33.
		08	I	Russian thistle	27.	5.4	27.	25.
		09	I	White sage	27.	0	3.5	3.5
		10	I	Four-wing saltbush	1.7	1.8	2.3	1.5

(continued)

TABLE 6. (Continued)

Nuclide	Period	Sample No.	Area*	Species	pCi/g (d.b.)†			
					ON	IN	TOTAL Sum	TOTAL Measured
	II	01	0	White sage	2.3	0	0.83	0.83
		02	0	Russian thistle	0.10	0.73	0.92	0.55
		03	0	White sage	0.92	0	1.4	1.4
		04	0	Four-wing saltbush	1.2	0.19	1.6	1.7
		05	0	Grass	1.6	0		
		06	I	Undetermined	1.4	14.	15.	15.
		07	I	White sage	18.	0	18.	15.
		08	I	Four-wing saltbush	1.4	1.1	2.5	2.5
		09	I	Russian thistle	12.	1.7	14.	14.
		10	I	Grass	6.5	4.8	11.	11.
	III	01	0	Bud sage	0.65	3.4	4.1	4.1
		02	0	Four wing saltbush	0.39	0.25	0.64	0.64
		03	0	White sage	0.12	0.90	1.0	1.0
		04	0	Grass	0.58	0.63	1.2	1.2
		05	I	Bud sage	11.	7.3	18.	18.
		06	I	White sage	0.52	9.4	10.	10.
		07	I	Four-wing saltbush	12.	0	12.	8.
		08	I	Grass	15.	10.	25.	26.

Notes:

T - Data Missing - Sample lost

* - "0" = Outer area; "I" = Inner area

† - Picocurie per gram dry basis

‡ All data expressed to two significant figures

TABLE 7. RADIOACTIVITY OF RANGE FORAGE SAMPLED BY RUMEN FISTULATED CATTLE

Nuclide	Period	Animal No.	(pCi/g (d.b.) ON	IN	Total
^{238}Pu	I	707	0.62	0	0.62
		729	0.33	0	0.33
		761	0.99	0	0.99
		774	1.52	0	1.52
	II	707	0.66	0	0.66
		729	0.60	0	0.60
		761	1.10	0	1.10
		774	0.51	0.07	0.58
	III	707	0.38	0	0.38
		729	0.43	0	0.43
		761	0.43	0	0.43
		744	0.49	0	0.49
	-	-	-	-	-
	I	1	1.22	0	1.22
		4	.91	0	.91
		6	2.32	0	2.32
	III	5	0.16	0.008	0.17
		13	1.53	0	1.53
		15	0.027	0.117	0.14
	'73	2	1.77	0	1.77
		3	1.85	0	1.85
		8	0.073	0.095	0.17
		12	2.73	2.59	5.32
^{239}Pu	I	707	49.	0	49.
		729	74.	0	74.
		761	40.	0	40.
		774	54.	0	54.
	II	707	13.	0	13.
		729	20.	0	20.
		761	63.	0	63.
		774	21.	1.6	23.

(continued)

TABLE 7. (Continued)

Nuclide	Period	Animal No.	(pCi/g (d.b.) ON	IN	Total
	III	707	11.	1.0	12.
		729	6.9	1.4	8.3
		761	9.9	0	9.9
		774	10.	0	10.
	-	-	-	-	-
	I	1	31.	0	31.
		4	2.4	6.2	8.6
		6	76.	0	76.
	III	5	6.2	0	6.2
		13	68.	0	68.
		15	2.8	4.3	7.1
	'73	2	55.	0	55.
		3	29.	0	29.
		8	2.1	3.4	5.5
		12	5.8	17.	23.
^{241}Am	I	707	2.2	0	2.2
		729	4.3	0	4.3
		761	2.7	0	2.7
		774	7.6	0	7.6
	II	707	2.0	0	2.0
		729	1.8	0	1.8
		761	1.4	2.8	4.2
		774	0.92	1.1	2.0
	III	707	0.89	0.44	1.3
		729	0.17	0.34	0.51
		761	2.1	0.35	2.5
		774	0.57	0.27	0.84
	-	-	-	-	-
	I	1	4.8	0	4.8
		4	2.5	0	2.5
		6	10.0	0	10.0

(continued)

TABLE 7. (Continued)

Nuclide	Period	Animal No.	(pCi/g (d.b.) ON	IN	Total
	III	5	0.40	0.18	0.58
		13	3.8	0	3.83
		15	1.2	0.68	1.9
	'73	2	8.5	1.6	10.
		3	1.9	0	1.9
		8	0.21	.46	0.67
		12	0.67	1.0	1.7

ON - Radioactivity on particles adhered to the plant
IN - Radioactivity of plant materials

TABLE 8. MEASURED RADIOACTIVITY INGESTED

Period	Animal No.	pCi/Sampling ^{238}Pu	^{239}Pu	^{241}Am
I	707	850	39000	2400
	729	4100	17000	4500
	761	3400	120000	7000
	774	7300	220000	19000
	1	59	2400	82
	4	88	2800	200
	6	57	910	90
II	707	550	16000	820
	729	1000	41000	3500
	761	8400	33000	8200
	774	1200	51000	7600
III	707	410	17000	160
	729	630	18000	410
	761	470	16000	1500
	774	400	9400	860
III	5	120	1600	230
	13	30	1800	290
	15	45	1900	240
'73	2	240	8300	270
	3	160	3200	370
	8	64	2400	160
	12	130	1500	200

TABLE 9. CALCULATED RADIOACTIVITY INGESTED

Period	Animal No.	pCi/Sampling		
		^{238}Pu	^{239}Pu	^{241}Am
I	707	640	20000	4100
	729	3200	10000	21000
	761	1600	35000	7900
	774	50000	1500000	180000
	1	83	2200	510
	4	65	2000	300
	6	84	2400	530
II	707	550	19000	5100
	729	1700	29000	10000
	761	4800	180000	31000
	774	375	7900	2200
III	707	550	15000	2300
	729	720	19000	2900
	761	850	16000	2200
	774	631	17000	2500
	5	200	4800	760
	13	140	3600	550
	15	150	3400	580

TABLE 10. AVERAGE MEASURED DAILY INTAKE OF RADIOACTIVITY

Nuclide	Period	Area*	pCi/day
^{238}Pu	I	I	11 100
		0	4 700
	II	I	9 900
		0	5 500
	III	All	3 600
^{239}Pu	I	I	400 000
		0	400 000
	II	I	570 000
		0	170 000
	III	All	85 000
^{241}Am	I	I	56 000
		0	22 000
	II	I	42 000
		0	16 000
	III	All	11 000

* I = one animal in the inner area
0 = average of three animals in the outer area
All = average of all animals (distribution of animals between inner and outer areas unknown for period III)

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APPENDIX

APPENDIX TABLE 1. SAMPLE AND ANALYSES NUMBERS

Sample Numbering

UNR Numbers:
391-x-yyy-zzz

391 = Project 391
x = Sampling Period
- 1 = June-July 1974
- 2 = Sept. 1974
- 3 = Jan. 1975
- 4 = Any other

yyy = Sample Identity Number
- One or two digit numbers are plant samples.
- Three digit numbers are rumen contents.
- Bos or Bc followed by one or two digit numbers are rumen contents.

zzz = Type of Sample
- Plant Samples:
  - AR = As Received
  - W = Washed plant material.
  - S = Soil removed by washing plant material
- Rumen Samples:
  - RS = Rumen solids
  - RL = Rumen liquid
  - AR, W & S as above

Analysis Numbers:
wxyz

w = Sampling period
- 1 = June-July 1974
- 2 = Sept. 1974
- 3 = Jan. 1975
- 4 = Any other

x = Sampling type
- 1 = Plant, As received (Category not used for samples to NERC-LV)
- 2 = Plant, washed
- 3 = Plant, Soil removed by washing
- 4 = Rumen Solids, As received
- 5 = Rumen Solids, Washed
- 6 = Rumen Solids, Soil removed by ashing
- 7 = Rumen Solids, Fraction of questionable indentity

(continued)

APPENDIX TABLE 1. (Continued)

yz = Sample Identity Number
  Plant Samples: Serial number of sample
    0z if serial number below 10
    yz if serial number 10-19
    2z if duplicate of sample number below 10
    3z if duplicate of sample number 10-19
  Rumen Solids:
    Three digit sample numbers use first and last digit number with 0 as needed
    6z for duplicates of samples 7z.

Examples:
  391-3-707-RSAR
    Project: 391. Period: 3. Animal: 707. Sample: Rumen Solids, As Received.
  3477 (Same as 391-3-707-RSAR).
  3467 (Duplicate of 3477).

APPENDIX TABLE 2. SAMPLE ANALYSIS DATA (All data dry basis)

Lab No.	Analysis No.	Sample Weights,g					Water %	Ti µg/g Dry wt	pCi/sample			pCi/g Ash		
		A*	Dry Ashed	Total	Ash NERC	UNR			^{238}Pu	^{239}Pu	^{241}Am	^{238}Pu	^{239}Pu	^{241}Am
PLANT SAMPLES - HAND COLLECTED														
391-1-1 AR		252.					6.07	110						
391-1-1 W	1201	152.	103.95	25.75	25.75		5.33	140	12.2	126.	21.8	.474	4.89	.847
391-1-1 S	1301			4.775	3.715	1.			8.69	279.	46.6	2.34	75.1	12.5
391-1-2 AR		186.					3.91	660						
391-1-2 W	1202	106.	35.37	5.63	5.63		3.97	200	6.84	296.	64.4	1.21	52.6	11.4
391-1-2 S	1302			6.255	4.28	2.			5.14	66.7	27.1	1.20	15.6	6.33
391-1-3 AR		140.					3.60	200						
391-1-3 W	1203	120.	47.61	4.37	4.37		5.17	100	7.34	107.	15.3	1.67	24.5	3.50
391-1-3 S	1303			1.07	.585	.5			<4.60	23.4	15.9	<7.80	40.0	27.2
391-1-4 AR		400.					5.11	200						
391-1-4 W	1204	300.	51.27	12.14	12.14		4.90	80	5.99	116.	26.7	0.493	13.7	2.20
391-1-4 WB	1224			12.47	12.47				2.89	182.	49.1	0.232	14.6	3.94
391-1-4 S	1304			6.185	4.095				20.6	815.	128.	5.03	165.	31.2
391-1-5 AR		300.					6.11	140						
391-1-5 W	1205	200.	52.58	4.20			3.86	150	30.08	220.	34.5	0.733	53.4	8.21
391-1-5 S	1305			.485	.260				9.82	141.	58.6	37.8	542.	225.
391-1-6 AR		160.												
391-1-6 W		182.												
391-1-6 S	1306			1.07	.52	.5			11.8	468.	87.2	22.7	900.	168.
391-1-7 AR		142												
391-1-7 W	1207	82.	8.59	2.76	2.16		4.13	770	125.	4640.	784.	57.9	2148.	303.
391-1-7 S	1307			6.88	4.89	2.			635.	22200.	2860.	130.	4540.	585.
391-1-8 AR		280.												
391-1-8 W	1208	180.	33.89	11.26	11.26		4.78	450	145.	5950.	312.	115.	528.	27.7
391-1-8 S	1308			19.80	8.17				415.	16500.	2150.	50.8	2020.	263.
391-1-8 S	1328				8.41				370.	14900.	640.	44.0	1772.	133.
391-1-9 AR		205					3.69	270						
391-1-9 W	1209	115	45.15	4.50			4.50	26	202.	8890.	982.	44.9	1976.	218.
391-1-9 S	1309			.525	.305				70.3	2560.	156.	230.	8393.	511.
391-1-10 AR		220					4.88	130						
391-1-10 W	1210	100	69.56	12.44	12.44		5.63	100	32.6	1370.	182.	2.62	110.	14.6
391-1-10 S	1310			.535	.270	.2			21.1	431.	36.1	78.2	1596.	134.
391-2-1 AR		216					3.60	400						
391-2-1 W	2201	116	45.96	4.25	4.25		5.56	340	9.80	150.	19.2	2.31	35.3	4.52
391-2-1 S	2301			2.15	1.16	1.			4.15	228.	64.4	3.58	197.	55.5
391-2-2 AR		142					2.74	110						
391-2-2 W	2202	72	19.59	8.46	8.46	-	4.00	1120,1070	2.49	46.8	14.0	0.294	5.53	1.65
391-2-2 S	2302			19.685	8.77				<1.20	6.04	2.88	<0.14	0.689	0.328

(continued)

APPENDIX TABLE 2. (Continued)

Lab No.	Analysis No.	Sample Weights, g: A*	Dry Ashed	Total	Ash NERC	UNR	Water %	Ti µg/g Dry wt	pCi/sample: ^{238}Pu	^{239}Pu	^{241}Am	pCi/g Ash: ^{238}Pu	^{239}Pu	^{241}Am
391-2-2 S	2322				8.22				15.8	34.1	<3.26	1.92	4.15	<.397
											<2.80			<.341
391-2-3 AR		90					5.45	300						
391-2-3 W	2203	45	16.00	2.02	2.02		4.63	130	<.50	9.97	4.21	<.248	4.85	2.08
391-2-3 S	2303			.695	.365	.3			<2.92	23.9	6.22	<8.00	65.5	17.0
391-2-4 AR		256												
391-2-4 W	2204	156	51.35	8.00	8.00		3.64	160	4.29	90.1	16.3	.536	11.3	2.04
391-2-4 WA	2224			5.755	5.755			160	4.91	30.3	7.03	.853	5.25	1.22
391-2-4 S	2304			4.24	3.24	1.			4.95	18.1	13.2	1.53	5.59	40.7
391-2-5 AR		240.					2.38	1130						
391-2-5 W	2205	140.	49.78	7.53	7.53		4.47	340,430	8.37	94.6	10.8	1.11	12.6	1.43
391-2-5 S	2305			20.29	9.43	2.			23.6	869.	155.	2.50	92.2	16.5
391-2-5 S	2325				8.155				12.6	324.	21.6	1.55	39.7	2.65
391-2-6 AR		38.					4.84	109,210						
391-2-6 W	2206	23.	2.10	.38	.38				7.84	105.	27.8	20.6	276.	73.2
391-2-6 S	2306			.465	.240				6.40	232.	15.4	26.7	967.	64.2
391-2-7 AR		406.					3.68	130,150						
391-2-7 W	2207	306.	62.20	3.06	.		4.84	180	37.1	1610.	400.	12.1	526.	131.
391-2-7 WB	2227			3.72				140	48.6	1820.	225.	13.1	489.	60.5
391-2-7 S	2307			5.245	3.28	2.			316.	11500.	1840.	96.3	3506	561.
391-2-8 AR		215.					4.59	120,190						
391-2-8 W	2203	115.	47.24	9.07	9.07		3.91	60,110	8.93	442.	93.7	.985	48.7	10.3
391-2-8 S	2308			1.715	.88	.9			4.91	114.	21.8	5.58	130.	24.8
391-2-9 AR		48.					4.46	470,500						
391-2-9 W	2209	33.	7.96	1.94	1.94	-	5.31	250	1.33	69.4	21.5	.686	35.8	11.1
			96.14	28.41	28.41				1.11	4960.	660	3.91	175.	23.2
391-2-9 S	2309			2.95	1.945	1.			82.9	2300.	232	42.6	1183.	119.
391-2-10 AR		308.					2.15	1390,1700						
391-2-10 W	2210	208.	47.15	6.37	6.37		4.22	400,490,450	34.6	1450.	261.	5.43	228	41.0
391-2-10 S	2310			75.21	35.46	2.			297.	9620.	594.	8.38	271.	16.8
391-2-10 S	2330				35.60	2.			180.	5920.	457.	5.06	166.	12.8
391-3-1 AR		225					3.76	400						
391-3-1 W	3201	125	34.45	4.215	4.215		4.22	520,750	28.7	756.	121.	6.81	179.	28.7
391-3-1 S	3301			2.655	1.63	1.			7.79	332.	29.4	4.78	204.	18.0
391-3-2 AR		247.					3.78	860						
391-3-2 W	3202	147.	57.42	6.29	6.29		4.30	100	4.00	97.7		.636	15.5	
									4.86	106..	14.6	.773	16.9	2.32
391-3-2 S	3302			.380	.215				8.02	238.	29.6	37.3	1107.	138.
391-3-3 AR		370					4.45	130						
391-3-3 W	3203	270	41.64	2.19	2.19		4.85	170	7.93	314.	44.8	3.62	143	20.5
391-3-3 WA	3223		41.26	2.23	2.23				12.6	161.	30.8	5.65	72.2	13.8
391-3-3 S	3303			.745	.400	.35			<2.20	50.0	9.19	<5.50	125.	23.0
391-3-4 AR		260					3.36	1580						
391-3-4 W	3204	160	50.88	6.36	6.36		3.71	230	9.37	177.	33.6	1.47	27.8	5.28

(continued)

APPENDIX TABLE 2. (Continued)

Lab No.	Analysis No.	A*	Sample Weights, g: Dry Ashed	Total	Ash NERC	UNR	Water %	Ti µg/g Dry wt	pCi/sample: ^{238}Pu	^{239}Pu	^{241}Am	pCi/g Ash: ^{238}Pu	^{239}Pu	^{241}Am
391-3-4 S	3304			4.86	3.83	1.0			17.7	423.	64.4	4.26	110.	16.8
391-3-5 AR		270					3.63	730						
391-3-5 W	3205	170	72.78	7.27	7.27		4.30	650	390.	16080.	910.	53.7	2212.	125.
391-3-5 S	3305			4.25	3.24	1.			120.	4600.	640.	37.0	1419.	198.
391-3-6 AR		328					4.21	180						
391-3-6 W	3206	228	40.65	2.90	2.90		4.04	130	52.7	2020.	378.	25.2	967.	181.
391-3-6 WA	3206		40.31	2.01	2.01				22.3	1020.	366.	11.1	507.	182.
391-3-6 S	3306			.53	.32	.21			<5.75	121.	29.0	<18.0	378	90.6
391-3-7 AR		270					3.49	90						
391-3-7 W	3207	170	50.32	5.52	5.52		3.66	80	18.8	535.	106.	3.41	96.9	19.2
391-3-7 WA	3227		31.54	3.525	3.525				10.1	468.	86.	2.82	133.	24.4
391-3-7 S	3307			.300	.155	.15			16.2	386.	40.0	105.	2490.	258.
391-3-8 AR		165					3.57	760						
391-3-8 W	3208	100	26.62	3.05	3.05		4.25	300	55.9	2140.	305.	18.3	720.	100.
391-3-8 S	3308			9.19	7.17	2.			366.	15000.	1030.	51.0	2092.	144.
							RUMEN CONTENTS							
391-1-Bos 1 ASAR	1401	2350	127.81	9.715			4.70	190	20.2	802.	27.9	2.08	82.6	2.87
391-1-Bos 1 RSW	1501		127.91	9.15			7.06	310	26.6	600.	112.	2.91	65.5	12.2
391-1-Bos 1 RSS	1601		101.17	2.24	1.24	1.			4.21	263	46.4	3.40	212	37.4
	1701		113.19	1.16	.655	0.5			7.43	93.2	15.4	11.3	142	23.5
391-1-Bos 4 RSAR	1404	1998	132.54	9.43			6.80	170	36.4	1170	82.0	3.86	124.0	8.70
391-1-Bos 4 RSW	1504		131.53	8.705			7.49	180	23.7	854.	166.	2.72	98.1	19.1
391-1-Bos 4 RSS	-		-	-			-	-	-	-	-	-	-	-
391-1-Bos 6 RSAR	1406	2590	72.74	5.94			6.59	180	9.95	160.	15.8	1.68	26.9	2.66
391-1-Bos 6 RSW	1506		81.37	6.27			7.01	180	19.6	560.	72.1	3.13	89.3	11.5
391-1-Bos 6 RSS	1606		16.88	1.93	1.00	.9			26.3	870.	115.	26.3	870.	115.
391-3-Bos 5 RSAR	3405	3440	130.66	9.23			5.64	110	28.8	373.	55.4	3.12	40.4	6.00
391-3-Bos 5 RSW	3505		129.03	8.13			7.17	110	6.71	280.	54.1	.825	34.4	6.65
391-3-Bos 5 RSS	3605		26.06	2.53	1.525				<1.93	79.7	5.50	<1.27	52.3	3.59
391-4-Bos 2 RSAR	4402	3000	35.58	3.40			3.17	120	17.5	617.	20.1	5.15	181.	5.91
391-4-Bos 2 RSW	4502		41.98	3.42			5.31	120,190	32.8	1320.	252.	9.59	386.	73.7
391-4-Bos 2 RSS	4602			2.71	1.74	1.			28.8	941.	65.3	16.6	541.	37.5
391-4-Bos 3 RSAR	4403	2550	59.40	7.10			3.59		23.0	473.	54.5	3.24	66.6	7.68
391-4-Bos 3 RSW	4503		47.19	5.06			4.96	210	3.72	240.	65.3	.735	47.6	12.9
391-4-Bos 3 RSS	4603			2.406	1.400	1.			14.0	179.	21.8	10.0	128.	15.6
391-4-Bos 8 RSAR	4408	2300	129.20	13.38			4.61	240,200	22.7	838.	57.5	1.70	62.6	4.30
391-4-Bos 8 RSW	4508		137.71	12.46			5.68	150	15.4	486.	74.3	1.24	39.00	5.89
391-4-Bos 8 RSS	4608			3.715	2.68	1.			<0.86	12.1	3.82	<0.32	4.51	1.43
391-4-Bos 12 RSAR	4412	2100	5.91	.665			3.49	200,320	2.35	26.1	3.54	3.53	39.2	5.32
391-4-Bos 12 RSW	4512		7.41	.74	.44	.3	5.72	180,170	1.33	83.8	5.54	3.02	190.	12.6
391-4-Bos 12 RSS	4612			.900	.540	.4			7.57	19.7	2.25	14.0	36.5	4.17
391-2-Bc 15 RSAR	2415	2370	102.86	8.15	8.15		5.98	220	12.2	528.	64.0	1.50	64.8	7.85

(continued)

APPENDIX TABLE 2. (Continued)

Lab No.		Analysis No.	A*	Sample Weights, g: Dry Ashed	Total	Ash NERC	UNR	Water %	Ti µg/g Dry wt	pCi/samples: ^{238}Pu	^{239}Pu	^{241}Am	pCi/g Ash: ^{238}Pu	^{239}Pu	^{241}Am
391-2-Bc	15 RSW	2515		128.74	8.87	8.87		5.77	150	16.4	748.	157.	1.85	84.3	17.7
391-2-Bc	15 RSS	2615			3.21	2.21	1.			<0.70	70.7	23.6	<0.32	32.0	10.7
391-2-Bc	13 RSAR	4533	2380.		9.22	9.22	.3			11.8	694.	116.	1.28	75.3	12.6
391-3-Bc	13 RSW	3513		152.51	9.09	9.09		6.60	60	15.6	447.	67.0	1.72	49.2	7.37
391-3-Bc	13 RSS	3613			.715	.450				9.41	418.	23.5	20.9	929.	52.2
PLANT SAMPLES - ANIMALS COLLECTED															
391-1-707	RSAR	1477	7000.	131.51	18.125	18.125		4.29	250	99.5	4590.	285.	0.52	253.	15.7
391-1-707	RSW	1577		123.20	16.19	16.19		4.68		26.1	1130.	142.	1.61	69.8	8.77
391-1-707	RSS	1677			11.86	9.615	2.			34.1	1550	50.0	3.51	160.1	5.14
						7.615									
391-1-729	RSARA	1469	37300.	122.54	13.70	13.70		4.73	260	83.8	3410	91.4	6.12	248.9	6.67
391-1-729	RSW	1579		133.49	19.47	19.47		4.94							
391-1-729	RSS	1679			7.655 .	5.66	2			38.2	1530	169.	6.75	270.	29.9
391-1-761	RSAR	1471	37800.	125.17	18.365	18.365		4.37	480	69.8	2470	145.	3.80	135.	7.89
391-1-761	RSW	1571		131.32	15.84	15.84		4.90	370	20.7	789.	15.7	1.31	50.4	9.91
391-1-761	RSS	1671			18.70	16.69	2.			66.7	2840.	235.	4.00	170.	14.1
391-1-774	RSAR	1474	41600.	61.17	9.025	7.025		4.27	330	66.7	2060.	172.	7.39	295.	19.0
391-1-774	RSW	1574		49.24	7.015	7.015		4.87	300	17.1	673.	129.	2.44	95.9	18.4
391-1-774	RSS	1674			4.645	3.635	1.			19.0	650.	126.	5.23	179.	34.7
391-2-707	RSAR	2477	8480.	131.48	14.23	14.23		3.10	250	53.5	1470.	79.6	3.76	103.	5.59
391-2-707	RSARA	2467		128.75	13.90	13.90				45.0	1670	175.	3.26	120.	12.6
												154			11.1
391-2-707	RSW	2577		122.14	11.00	11.00		1.73	350	31.4	986.	136.	2.85	89.6	12.4
391-2-707	RSWA	2567		124.96	13.92	13.92		5.80	160	29.5	720.	139.	2.2	57.7	9.99
391-2-707	RSWA	2569			11.04	11.04				29.9	532.	105.	2.71	48.2	9.51
391-2-729	RSAR	2479	16600.	128.01	14.21	14.21		2.51	280	50.2	1980.	169.	3.53	139.	11.9
391-2-729	RSW	2579		124.27	11.07	11.07		2.91	190	7.93	464.	139.	.716	41.9	12.6
391-2-729	RSS	2679			5.99	4.00	2.			12.8	418.	50.0	3.20	105.	12.5
391-2-761	RSAR	2471	17500		12.60	12.60		7.27	380	223.	8540.	223.	17.7	678.	17.7
391-2-761	RSAR	2771		132.98	16.12	16.12		1.80	310	160.	7010.	349.	9.93	435.	21.7
391-2-761	RSARA	2461		113.51	11.00	11.00				202.	8650	198.0	18.8	782	18.0
391-2-761	RSW	2571		136.93	14.07	14.07		4.95	360	734	2820	458.	5.22	200.	32.6
391-2-761	RSS	2671			4.85	3.85	1.			26.1	910.	27.2	6.78	236	7.06
												27.5			7.14
391-2-774	RSAR	2474	11100.	110.75	26.30	26.30		3.81	330,300	74.0	3180	476.	100.3	121.	18.1
391-2-774	RSW	2574		128.40	12.48			5.26	210	29.0	830.	171.	2.32	66.5	13.7
391-2-774	RSWA	2564		133.83	13.22					27.6	996.	198.	2.09	75.3	15.0
391-2-774	RSS	2674			41.085	19.23	2.			35.5	1210.	78.7	1.85	62.9	18.09
391-2-774	RSS	2664				19.77				33.6	1650.	80.8	1.70	83.5	4.09
391-3-707	RSAR	3477	7840	137.36	20.32			4.58	380	44.7	1870	17.5	2.20	92.0	0.861
391-3-707	RSARA	3467		133.87	20.04					32.5	889.	42.0	1.62	44.6	2.10
391-3-707	RSW	3577		134.90	15.52			5.18	210	18.6	676.	97.3	1.20	43.6	6.27
391-3-707	RSS	3677			35.09	15.59	2.			32.2	972	56.6	2.07	59.5	3.63

(continued)

APPENDIX TABLE 2. (Continued)

Lab No.		Analysis No.	Sample Weights, g: A*	Sample Weights, g: Dry Ashed	Sample Weights, g: Total	Sample Weights, g: Ash NERC	Sample Weights, g: Ash UNR	Water %	Ti µg/g Dry wt	pCi/sample: ^{238}Pu	pCi/sample: ^{239}Pu	pCi/sample: ^{241}Am	pCi/g Ash: ^{238}Pu	pCi/g Ash: ^{239}Pu	pCi/g Ash: ^{241}Am
391-3-707	RSS	3667				15.57	2.4			26.5	620	59.0	1.70	39.8	3.79
391-3-729	RSAR	3479	11100.	155.66	21.74			3.57	270	55.4	1560	35.6	2.55	71.8	1.64
391-3-729	RSW	3579		152.39	16.25			4.93	140	9.10	455.	58.1	0.560	27.4	3.58
391-3-729	RSS	3679			38.47	36.34	2.			67.8	790	28.2	1.87	21.7	0.776
391-3-761	RSAR	3471	13800.	157.28	19.92			4.49	360	32.2	1120	106.	1.67	56.2	5.32
391-3-761	RSW	3571		161.31	14.50			4.87	240	24.2	1120.	216.	1.67	77.2	14.9
391-3-761	RSWA	3561		155.58	15.38					34.4	1300.	256.	2.24	84.5	16.6
391-3-761	RSS	3671			33.11					83.6	3210.	308.	2.52	96.9	9.30
391-3-774	RSAR	3474	9770	131.42	22.13			4.56	370	33.7	788.	71.9	1.52	35.6	3.25
391-3-774	RSARA	3464		164.80	28.10					66.7	2290.	171.	2.37	81.5	6.09
391-3-774	RSW	3574		144.59	18.17			4.92	280	11.8	404.	81.1	.649	22.2	4.46
391-3-774	RSWA	3564		136.31	18.52					16.1	312.	63.1	.869	16.8	3.41
391-3-774	RSS	3674			48.30	22.36	2.			54.8	935.	51.0	2.45	41.8	2.28
391-3-774	RSS	3664				21.95				18.1	322.	33.4	.824	14.7	1.52
391-2-707	A-RL								26.0						
391-2-729	Bc-RL								36.0						

* Weight "A"
"AR" Samples: Total collected
"W" Samples: Weight washed

APPENDIX TABLE 3. SAMPLE CALCULATION OF ^{238}Pu "IN" AND "ON" A PLANT SAMPLE

Data:

Sample Number: 391-1-2. (Plant sample number 2, period 1).

	As Received	Washed	Soil
Weight Sample, g	186		
Weight Washed, g		106	
Weight Ashed, g		35.37	
Ash Weight Total, g		5.63	6.255
Ash Weight to EMSL-LV, g		5.63	4.28
Water, %	3.91	3.97	
Titanium, mcg/g (db)	660.	200.	
^{238}Pu, pCi/sample		6.84	5.14

Radioactivity per gram ash:

$RA/g\ ash]_W = 6.84/5.63 = 1.21$ gCi/g

$RA/g\ ash]_S = 5.14/4.28 = 1.20$ pCi/g

Calculation of radioactivity per unit weight of plant (dry basis):

Z = Proportion of ash (db) in plant material:

$$= \frac{\text{Ash Weight}}{\text{Wgt. Ashed } (1 - \%\ \text{water}/100)}$$

$$Z_W = \frac{5.64}{35.37\ (1 - 3.91/100)} = 0.1657 \quad (16.57\%\ \text{ash})$$

$$Z_S = \frac{6.25}{106\ (1 - 3.97/100)} = 0.0614$$

$$RA/g\ \text{plant (db)} = (RA/g\ \text{Ash})Z$$

$$RA/g\ \text{plant (db)}]_W = 1.21 \times 0.1657 = 0.2005\ \text{pCi/g plant (db)}.$$

$$RA/g\ \text{plant (db)}]_S = 1.20 \times 0.0614 = 0.0737\ \text{pCi/g plant (db)}.$$

$$RA/g\ \text{plant (db)}]_{AR} = RA/g\ \text{plant (db)}]_W + RA/g\ \text{plant (db)}]_S$$

$$= 0.2005 + 0.0737 = 0.2742\ \text{pCi/g plant (db)}.$$

(continued)

Calculation of radioactivity in and on plant:

a. Method of titanium ratio:

$$C = \frac{Ti/g\ plant\ (db)]_{AR}}{Ti/g\ plant\ (db)]_W}\ (RA/g\ soil\ ash)$$

$$= \frac{660}{200}\ 0.0737 = 0.2432$$

RA in plant = RA/g plant (db)$]_W$ - C = 0.2005 - 0.2432
= 0.0427 pCi/g plant (db)

RA on plant = RA/g plant (db)$]_S$ + C = 0.0737 + 0.2432
= 0.3169 pCi/g plant (db)

(N.B. for this sample washing was rather inefficient for removal of the contaminating soil.).

RA in AR sample = RA in plant + RA on plant = 0.3169 - 0.0427 = 0.2742

b. Method using average titanium composition of ash (2400 mcg/g ash) as calculated from this project:

$$C = \frac{Ti]_W}{2400}\ (RA/g\ soil\ ash)$$

$$= \frac{200}{2400}\ (0.0737) = 0.00614$$

RA in plant = RA/g plant (db)$]_W$ - C = 0.2005 - 0.00614
= 0.1944 pCi/g plant (db).

RA on plant = RA/g plant (db)$]_S$ + C = 0.0737 + 0.00614
= 0.0798 pCi/g plant (db).

c. Method using average value of the ratio of soil radioactivity to soil titanium (0.0014) as calculated from this project:

$$C = 0.0014 \times Ti]_W$$

$$= 0.0014 \times 200 = 0.280$$

RA in plant = RA/g plant (db)$]_W$ - C = 0.2005 - 0.280
= -0.0795 pCi/g plant (db).

RA on plant = RA/g plant (db)$]_S$ + C = 0.0747 + 0.28
= 0.3737 pCi/g plant (db).

(continued)

APPENDIX TABLE 3. (Continued)

Selection of reported value:

RA in plant = -0.0426 (Method a and c agree. Results of Method a reported.).

RA on plant = 0.317 (Method a and c agree. Results of Method a reported.).

*Abbreviations:

RA = Radioactivity
db = Dry Basis

Subscripts

AR = As Received Sample
W = Washed Sample
S = Soil Washed from Sample

APPENDIX TABLE 4. BOTANICAL COMPOSITION OF FORAGE SELECTED BY RUMEN-FISTULATED STEERS GRAZING ON AREA 13 OF THE NEVADA TEST SITE (Percent of Total Forage)

Date Sampled	Plant Species / Steer No.	Grasses: *Hilaria jamesii*	*Oryzopsis hymenoides*	*Sitanion jubatum*	*Stipa speciosa*	*Sporobolus* spp.	Unidentified Grasses	Forbs: *Salsola paulsenii*	*Sphaeralcea ambigua*	*Eriogonum* spp.	*Chaenactis* spp.	*Chenopodium* spp.	*Malacothrix* spp.	*Ambrosia acanthicarpa*	*Phlox* spp.	*Gilia* spp.	Unidentified Forbs	Shrubs: *Eurotia lanata*	*Atriplex canescens*	*Atriplex confertifolia*	*Lycium andersonii*	*Grayia spinosa*	*Suadea* spp.	Unidentified Shrubs
06-12-73	707	Not used																						
	729	Not Used																						
	761	8	32	1					T								2	44	13					
	774		88					1	T		1							8	2					
07-19-73	707	17	41		T			2	T								1	24	15					
	729	49	42							T							T	5	3					
	761	1	12	1				14									2	29	41					
	774	43	31														T	26	1					
08-08-73	707	11	29						1								1	5	53					
	729	11	19							T							2	27	41					
	761	9	13	T				1										15	62					
	774	7	16														1	10	65	1				
09-05-73	707		16														1	29	54					
	729		19					1			T	1						38	42	T				
	761		8			1											2	43	46					
	774		6				2											15	76	1				
10-01-73	707		10	4														19	65	2				
	729	Sample lost																						
	761		14	2		1				T							2	23	58					
	774		16			2											2	18	62					
11-06-73	707		32	5				4									3	49	7					
	729		36					1				2						54	7					T
	761		79					2			3							13						
	774		16	4								2						65	7					6

(continued)

APPENDIX TABLE 4. (Continued)

Date Sampled	Steer No.	Hilaria jamesii	Oryzopsis hymenoides	Sitanion jubatum	Stipa speciosa	Sporobolus spp.	Unidentified Grasses	Salsola paulsenii	Sphaeralcea ambigua	Eriogonum spp.	Chaenactis spp.	Chenopodium spp.	Malacothrix spp.	Ambrosia acanthicarpa	Phlox spp.	Gilia spp.	Unidentified Forbs	Eurotia lanata	Atriplex canescens	Atriplex confertifolia	Lycium andersonii	Grayia spinosa	Suadea spp.	Unidentified Shrubs
		Grasses						Forbs										Shrubs						
02-20-74	707		2			3	1	10				1					1	76		T		8		
	729						1	3	1	T								85		2		6		
	761							2	T									83	9	2	4			
	774						2			1								85	3	3	6			
05-21-74	707	1	2	70								8	6	2	T		T	6	4	T		1		
	729		3	42				T			12		3				4	26	5	T		3		2
	761		6	26	3				6	1	5		3					38				12		
	774		13	23			3		T	2	5	1	6				7	33		2		1		4
06-28-74	707	4	28	15	2			32									3	5	3			6		2
	729			3	1			6									1	63	3			21		2
	761		2	4	1			10									4	36	6	1		30		6
	774		3	6				T		T							1	32	1			55		2
06-30-74	707	3		7	4		3	4	T	4							2	33	9	19		8		4
	729	5	5	8	8					11	3	5					2	6	14	29				4
	761	T	2	3	5			1		1					T	T		46	6	34		2		
	774		2	6	3	1				1	3						1	18	6	44		12		3
07-02-74	707		2	5				14		2							4	39	4	14		10		6
	729			3	1			16	1								4	57	6	T		9		3
	761			1				16	T	T							2	61	4	4		11		1
	774		3	2				16		T							2	39	9	1		25		3
08-07-74	707		39					1		T								43	12	4		1		
	729		23	8						T								68				1		
	761		29	T						T								39	6	4		22		
	774		26	2				T		T								66				6		

(continued)

APPENDIX TABLE 4. (Continued)

Date Sampled	Steer No.	Grasses: Hilaria jamesii	Oryzopsis hymenoides	Sitanion jubatum	Stipa speciosa	Sporobolus spp.	Unidentified Grasses	Forbs: Salsola paulsenii	Sphaeralcea ambigua	Eriogonum spp.	Chaenactis spp.	Chenopodium spp.	Malacothrix spp.	Ambrosia acanthicarpa	Phlox spp.	Gilia spp.	Unidentified Forbs	Shrubs: Eurotia lanata	Atriplex canescens	Atriplex confertifolia	Lycium andersonii	Grayia spinosa	Suaeda spp.	Unidentified Shrubs
10-01-74	707							3										19	9	69				
	729		1							1								46		40				12
	761									T								38		62				
	774							1		4								29		59				7
10-03-74	707		8							1								23	3	65				
	729							3		1								24	7	49				16
	761																	19		55				26
	774		1	T						T								19		80				
10-05-74	707		1							T								7		92				
	729		T															21		77				2
	761							T		T								56		44				
	774							6		T								9	14	59				12
11-05-74	707		19		2			6		1							T	33		38				
	729		5							1								59		35				
	761		10					T		1							T	62		27				
	774							2		T							T	46	1	51				
01-17-75	707									T										100				
	729		3				T	T		T								14		83				
	761						1			1							2	18		79				
	774						T			T							T	16		84				
01-19-75	707		3	1				1		T							1	2		86				
	729			1						T										99				
	761																T	10	4	86				
	774									T							2			98				

(continued)

APPENDIX TABLE 4. (Continued)

Date Sampled	Steer No.	Grasses: Hilaria jamesii	Grasses: Oryzopsis hymenoides	Grasses: Sitanion jubatum	Grasses: Stipa speciosa	Grasses: Sporobolus spp.	Grasses: Unidentified Grasses	Forbs: Salsola paulsenii	Forbs: Sphaeralcea ambigua	Forbs: Eriogonum spp.	Forbs: Chaenactis spp.	Forbs: Chenopodium spp.	Forbs: Malacothrix spp.	Forbs: Ambrosia acanthicarpa	Forbs: Phlox spp.	Forbs: Gilia spp.	Forbs: Unidentified Forbs	Shrubs: Eurotia lanata	Shrubs: Atriplex canescens	Shrubs: Atriplex confertifolia	Shrubs: Lycium andersonii	Shrubs: Grayia spinosa	Shrubs: Suadea spp.	Shrubs: Unidentified Shrubs
01-21-75	707			6						T								T	7	79				
	729		19	6						1							3	34	9	28				
	761		4				T										T	61	4	28				
	774		8	2				1		T		T						48	9	48				
10-29-75	5		17		8			2		T								36	15	16				
	15		11		2			4									1	24	9	34				
	13		6															34	13	40				
	13						2	2		1												2		
03-12-75	707						4	3		T							1	39	1	52				
	729		27	T	4			1									6	52						
	761						2	1		T							4	32		61				
	771		4				3	2		1							6	38		46				

T = Trace

APPENDIX TABLE 5. CHEMICAL COMPOSITION OF RANGE FORAGE SAMPLED BY FISTULATED CATTLE

Date	Animal Number	Dry Matter	Percent by Weight Dry Basis Protein	ADF	Lignin	Ash
7/10/73	707	97.12	7.90	40.75	8.04	13.67
7/10/73	729	97.40	9.62	40.00	8.13	13.40
7/10/73	761	95.64	8.41	41.37	11.57	13.68
7/10/73	774	95.43	9.48	38.58	9.01	15.40
			Σ 35.41	160.70	36.75	55.95
			X̄ 8.85	41.18	9.19	13.99
8/8/73	707	94.76	8.32	38.50	8.66	13.43
8/8/73	729	98.44	6.65	43.65	10.09	12.76
8/8/73	761	95.77	7.93	42.65	9.05	18.74
8/8/73	774	96.60	8.56	38.23	9.37	14.70
			Σ 31.46	163.03	37.17	59.63
			X̄ 7.86	40.76	9.29	14.91
9/5/73	707	96.00	5.71	43.64	8.31	25.98
9/5/73	729	95.55	5.17	44.91	10.37	8.44
9/5/73	761	95.49	6.41	41.40	8.82	12.25
9/5/73	774	96.04	6.97	36.93	9.11	15.10
			Σ 24.80	166.88	36.61	61.77
			X̄ 6.20	41.72	9.15	15.44
10/1/73	707	95.40	7.99	39.27	12.31	12.24
10/1/73	729	98.40	7.05	43.83	15.35	11.59
10/1/73	761	95.75	7.28	40.57	12.23	16.14
10/1/73	774	95.83	7.46	38.62	11.76	14.62
			Σ 29.78	162.29	51.65	54.59
			X̄ 7.44	40.57	12.91	13.65
11/6/73	707	94.75	8.36	40.71	13.01	10.97
11/6/73	729	98.32	7.22	41.22	12.00	11.17
11/6/73	761	95.03	8.64	38.42	11.13	14.98
11/6/73	774	96.75	7.43	40.83	11.91	13.76
			Σ 31.65	161.18	48.05	50.88
			X̄ 7.91	40.30	12.01	12.72
2/20/74	707	97.97	7.10	42.40	14.01	12.53
2/20/74	729	97.45	7.87	39.59	12.42	11.77
2/20/74	761	95.91	7.88	41.45	16.17	10.95
2/20/74	774	95.34	7.54	41.78	15.62	12.44
			Σ 30.39	165.22	58.22	47.69
			X̄ 7.60	41.30	14.56	11.92

(continued)

APPENDIX TABLE 5. (Continued)

Date	Animal Number	Percent by Weight: Dry Matter	Dry Basis: Protein	ADF	Lignin	Ash
5/21/74	707	96.14	11.89	35.60	9.80	12.18
5/21/74	729	97.74	11.12	36.61	9.90	13.74
5/21/74	761	96.05	9.82	40.96	11.22	19.41
5/21/74	774	95.22	12.02	34.92	9.63	14.14
			Σ 44.84	149.09	39.83	59.46
			X̄ 11.21	37.27	9.96	14.86
8/7/74	707	95.45	9.95	39.02	11.85	14.06
8/7/74	761	94.97	8.19	40.70	14.07	11.71
8/7/74	774	96.09	7.77	39.68	13.41	12.50
			Σ 25.91	119.4	39.33	38.27
			X̄ 8.64	39.8	13.11	12.76
No date	761	95.03	11.61	35.60	6.40	14.77
No date	774	95.74	10.33	39.74	6.99	16.36
Goat #2 10/25/73		96.32	6.03	40.54	13.27	12.21
No # No Date		96.44	7.66	36.90	8.73	13.74

Σ = summation or total

X̄ = average

ADF = acid detergent fiber

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