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THE RADIONUCLIDE CONCENTRATIONS AND BOTANICAL COMPOSITION OF THE DIET OF CATTLE GRAZING THE AREA 18 RANGE OF THE NEVADA TEST SITE, 1966-1970

by
D. D. Smith, K. W. Brown, R. A. Brechbill*,
K. R. Giles and A. L. Lesperance†
Radiological Research Program
Western Environmental Research Laboratory

ENVIRONMENTAL PROTECTION AGENCY

Published May 1972

*U. S. Atomic Energy Commission
Nevada Operations Office
Las Vegas, Nevada 89114

†University of Nevada
Max C. Fleischmann College
of Agriculture
Reno, Nevada 89507

This study performed under a Memorandum of
Understanding (No. SF 54 373)
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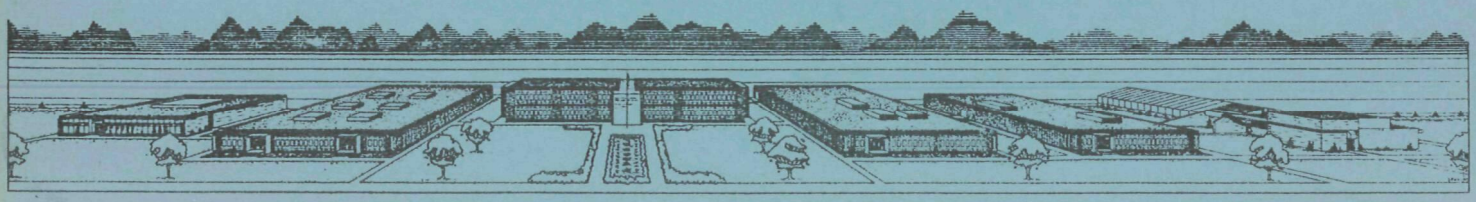
U. S. ATOMIC ENERGY COMMISSION



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ABSTRACT

The radionuclide content and botanical composition of the diet of the beef animals grazing on the Area 18 range of the Nevada Test Site was determined by analyzing rumen samples collected from fistulated steers.

The radionuclide concentrations were generally low with periodic increases in individual isotope levels which could be traced to a specific contaminating event.

Grass exceeded 80% of the diet of 23 out of 43 monthly samples. Squirrel tail grass, *Sitanion hystrix* and Indian rice grass, *Orhyzopsis hymenoides*, were the major components of this portion of the diet. The major browse plants ingested were Gambel's Oak, *Quercus gambelii*, and desert bitter brush, *Purshia glandulosa*. Russian thistle, *Salsola kali*, and desert buckwheat, *Eriogonum* spp. were the main contributors to the forb portion of the diet. At times during the summer months Russian thistle constituted over 30% of the total diet.

ACKNOWLEDGMENT

The authors wish to express their appreciation to Mr. John T. Titus for his aid in maintaining the fistulated steers over the four-year period of this study. Without his assistance the project could not have been completed.

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INTRODUCTION

The Atomic Energy Commission and the Western Environmental Research Laboratory of the Environmental Protection Agency have maintained a herd of beef cattle on the Nevada Test Site (NTS) since 1957. Various research has been conducted concerning the uptake of radioactive material by these grazing animals[1,2]. However, no information is available concerning the actual composition of a grazing animal's diet in Area 18, NTS. In an adjacent area (Delamar Valley) a detailed study[3] was conducted to determine, among other things, the botanical and chemical composition of the diet of the grazing animal. In that study little relationship was found to exist between the botanical composition of the animal's diet and that found on the range. Data of this nature for the NTS would allow a more accurate prediction of the plant species the grazing animal would eat and, thus, lead to a better understanding of its nutritional intake while on this range.

During 1966 a four-year cooperative study with the University of Nevada, Reno, was initiated. The objectives of this study were to:

1. determine the botanical composition of the grazing animal's diet on the NTS,
2. determine the nutritional and radionuclide composition of the same diet, and
3. relate changes in the composition of the diet to season, and relate changes in the radionuclide composition of the diet to nuclear testing and to document yearly variations.

A suitable site for these studies was Area 18 of the NTS which had been used for atmospheric nuclear testing. Three detonation sites were within the normal grazing pattern of Area 18. These sites were: Little Feller II, detonated July 7, 1962; Johnny Boy, detonated July 11, 1962; and Little Feller I, detonated July 17, 1962. Prior to 1962, numerous atmospheric

tests were conducted adjacent to the grazing area, primarily on the southern and western edges. The grazing area was also in the fallout pattern of Project Buggy, A Plowshare cratering experiment detonated March 12, 1968, and is frequently in the effluent pattern of the nuclear reactors tested at the Nuclear Rocket Development Station. This area has a much higher probability of contamination than off-site ranges. The total area encompasses approximately 13,630 acres and ranges from 4,800 feet to 6,200 feet in elevation. There are five plant communities which have a total vegetative composition of 15.9% grass, 79.7% browse, and 4.4% forbs[5]. Plant communities are mapped in Figure 1.

This report presents the data collected on the botanical and radionuclide composition of the animal's diet. A summary of the nutritional results will be published as a separate report. A report on the intake and digestibility of range forages was published previously[4]. Also published are range and soil surveys of the Area 18 grazing area[5,6].

Note: At the time this study was performed this Laboratory was named Southwestern Radiological Health Laboratory and was part of Public Health Service, Department of Health, Education and Welfare.

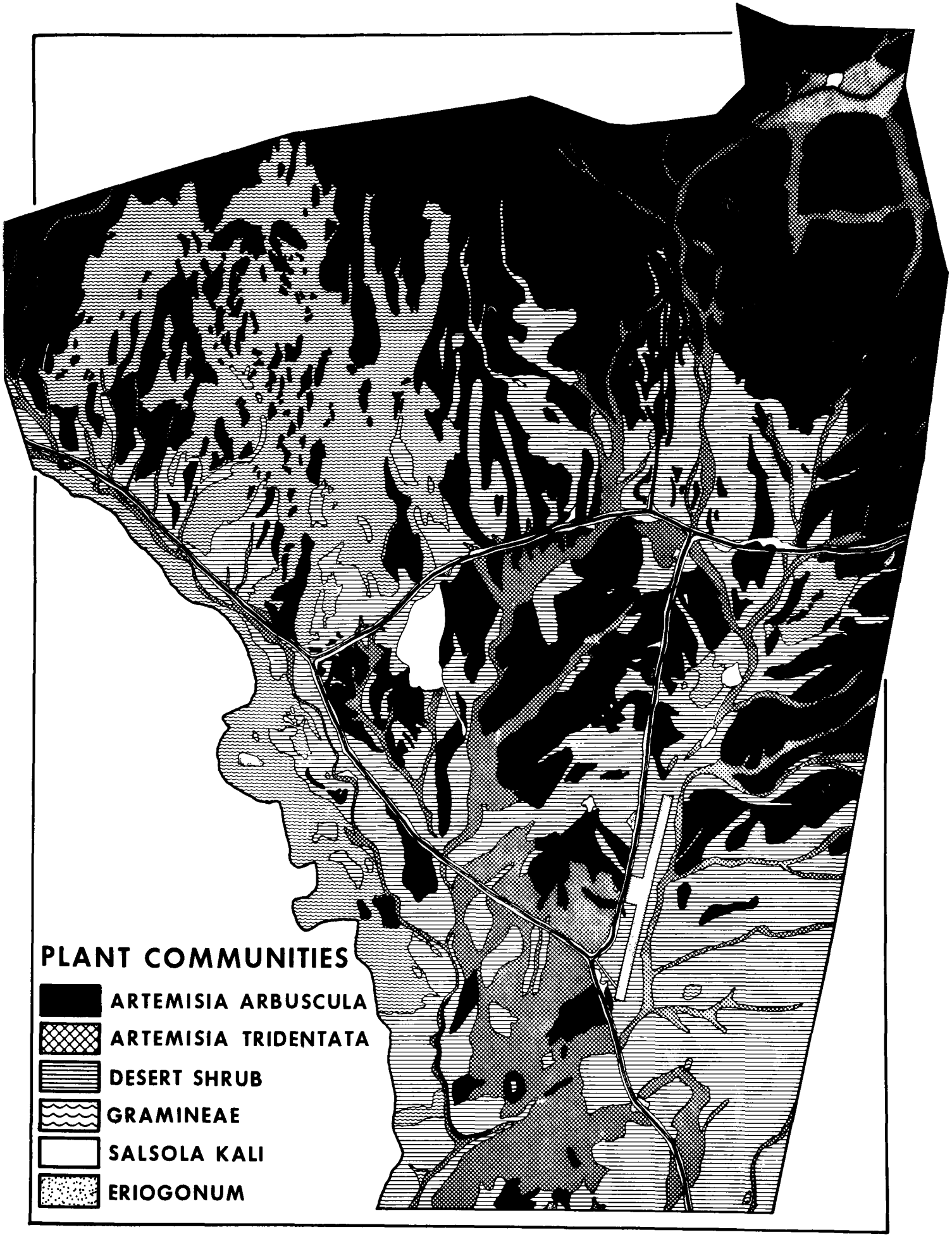

Figure 1. Area 18, Nevada Test Site, Plant Communities

PROCEDURES

Five mature Hereford fistulated steers were obtained from the University of Nevada, Reno. These animals had a permanent fistula into the rumen. A cannula with a readily removable plug keeps the fistula patent.

The forage samples were collected by a four-step rumen evacuation technique[7]:

1. the hand removal of rumen and reticulum contents via the fistula, washing of the rumen walls with water, and removal of wash water,
2. release of animals to graze for a sufficient period of time for obtaining adequate samples,
3. the removal of grazed forage samples from the rumen,
4. the return of original ingesta to the rumen.

From three to five fistulated steers were placed on the Area 18 range each month from February 1966 through March 1970. Prior to placement on the range, the rumen contents were removed. They were then transported about 60 km to the Area 18 range (grazing area of the NTS beef herd)[8] where they were allowed to graze for 6 to 10 hours. The animals were then returned to the Well 3 corrals in Area 6 and forage samples collected by the rumen evacuation method outlined above.

Following collection, all samples were placed in polyethylene bags and protected from heat and sunlight until they were placed in a freezer. They were kept frozen until analysis.

Individual samples were utilized for botanical analysis and composite samples were utilized for the radionuclide analyses which were performed at the Western Environmental Research Laboratory. Duplicate composite samples were sent to the University of Nevada, Reno, for nutritional analysis.

Quantitative analysis of the rumen content was made for various gamma-emitting radionuclides and stable potassium. Periodically the rumen

contents were ashed and analyzed for ^{239}Pu. The radionuclides which were included in the analyses were chosen because of their half-life, their ease of analysis, and their possible metabolic importance. The minimum detectable activity (MDA) used in this report is based on laboratory findings or on calculations (Appendix I). Analytical procedures used in this study are described elsewhere[9]. No inferences are drawn from the radionuclide concentrations in the ruminant ingesta or in tissues as these have been included in other reports[1,2].

The botanical analysis was accomplished by examining a random aliquot of the rumen sample with a binocular microscope. The sample was washed through a fine mesh screen preparatory to examination. After the species in the sample were identified, a visual estimate of the percentage of each species was made and recorded[10]. No effort was made to determine the radionuclide content of individual species. The browse species were identified according to McMinn[11], forbs according to Abrams[12], and grasses according to Hitchcock[13].

RESULTS AND DISCUSSION

This study was initiated in February of 1966 and concluded in March of 1970. Data presented are tabulated on an annual basis. Discussion of radionuclide data precedes discussion of botanical data in each case. Radionuclide results are reported in pCi/g wet weight.

1966

The radionuclide results are tabulated in Table 1. All samples were below the minimum detectable activity (MDA) for ^{54}Mn and ^{140}Ba.

Appendix II lists all announced events which released radioactivity detected off-site during the study period. The low levels of ^{65}Zn, ^{106}Ru, and ^{144}Ce reported in May and June of 1966 may have come from Pin Stripe (April 25, 1966), and/or Double Play (June 15, 1966) and/or from an atmospheric non-U.S. test conducted on May 9, 1966.

As seen in Figure 2, grasses made up over 90% of the diet during the second quarter of the year. Samples from the February and May collections were not analyzed for botanical content. The results of the other collections are tabulated in Table 2.

In July, August, and September of 1966, grass in the diet was less than 70% due to the inclusion of comparatively large amounts of forbs: Russian thistle, *Salsola kali*, in July and August and Russian thistle plus desert buckwheat, *Eriogonum* spp., in September. The percentage of grass increased again in October and decreased in November and December when desert bitterbrush, *Purshia glandulosa*, made up 21.5% and 40% of the diet, respectively.

1967

The radionuclide results from 1967 are tabulated in Table 3. The short-lived isotopes ^{131}I and ^{140}Ba were observed in January and February. The January levels may have been released by the non-U.S. nuclear test of December 27, 1966 and/or by the Nash Event on January 19, which released

Table 1. Radionuclide Composition of Rumen Contents Collected - 1966

Date Collected	Area Collected and Remarks	K g/g	^{65}Zn pCi/g	^{95}Zr pCi/g	^{106}Ru pCi/g	^{131}I pCi/g	^{137}Cs pCi/g	^{144}Ce pCi/g	^{239}Pu pCi/g
24 Feb 66	5 miles SW Well 8, Area 18. Composite 4 samples.	0.002 ±.0001	<1.0	<0.1	1 ±1	<0.1	<0.1	<1.0	NA
24 Mar 66	5 miles SW Well 8, Area 18. Composite 4 samples.	0.001 ±.0001	<1.0	<0.1	<1.0	<0.1	0.2 ±0.1	<1.0	NA
21 Apr 66	5 miles SW Well 8, Area 18. Composite 3 samples.	0.001 ±.0001	<1.0	<0.1	<1.0	<0.1	<0.1	<1.0	NA
29 May 66	Jct. of Airport and Buckboard Mesa Roads. Composite 4 samples.	0.002 ±.0001	3.5 ±1.0	<0.1	1.5 ±1.0	<0.1	<0.1	2.3 ±1.0	NA
23 Jun 66	2 miles N of Jct. of Pahute Mesa Road and Airport Road. Composite 3 samples.	0.002 ±.0001	3.4 ±1.0	<0.1	1.7 ±1.0	<0.1	<0.1	2.7 ±1.0	NA
21 Jul 66	2 miles N of Jct. of Pahute Mesa Road and Airport Road. Composite 3 samples.	0.002 ±.0001	<1.0	<0.1	<1.0	<0.1	<0.1	<1.0	NA
25 Aug 66	2 miles N of Jct. of Pahute Mesa Road and Airport Road. Composite 4 samples.	0.002 ±.0001	<1.0	0.5 ±0.1	<1.0	<0.1	<0.1	<1.0	NA

Table 1. Radionuclide Composition of Rumen Contents Collected - 1966 cont'd

Date Collected	Area Collected and Remarks	K g/g	^{65}Zn pCi/g	^{95}Zr pCi/g	^{106}Ru pCi/g	^{131}I pCi/g	^{137}Cs pCi/g	^{144}Ce pCi/g	^{239}Pu pCi/g
22 Sep 66	1/2 mile N of runway. Composite 4 samples.	0.001 ±.0001	<1.0	0.1 ±0.1	<1.0	<0.1	<0.1	<1.0	0.01
19 Oct 66	1/2 mile N of runway. Composite 4 samples.	0.001 ±.0001	<1.0	0.2 ±0.1	<1.0	<0.1	<0.1	<1.0	0.01
23 Nov 66	North end of Area 18 airport. Composite 3 samples.	0.002 ±.0001	<1.0	0.5 ±0.1	<1.0	<0.1	<0.1	<1.0	0.003
22 Dec 66	North end of Area 18 airport. Composite 3 samples.	0.002 ±.0001	<1.0	0.7 ±0.1	<1.0	<0.1	0.3 ±0.1	<1.0	0.07

N.A. = Not analyzed.

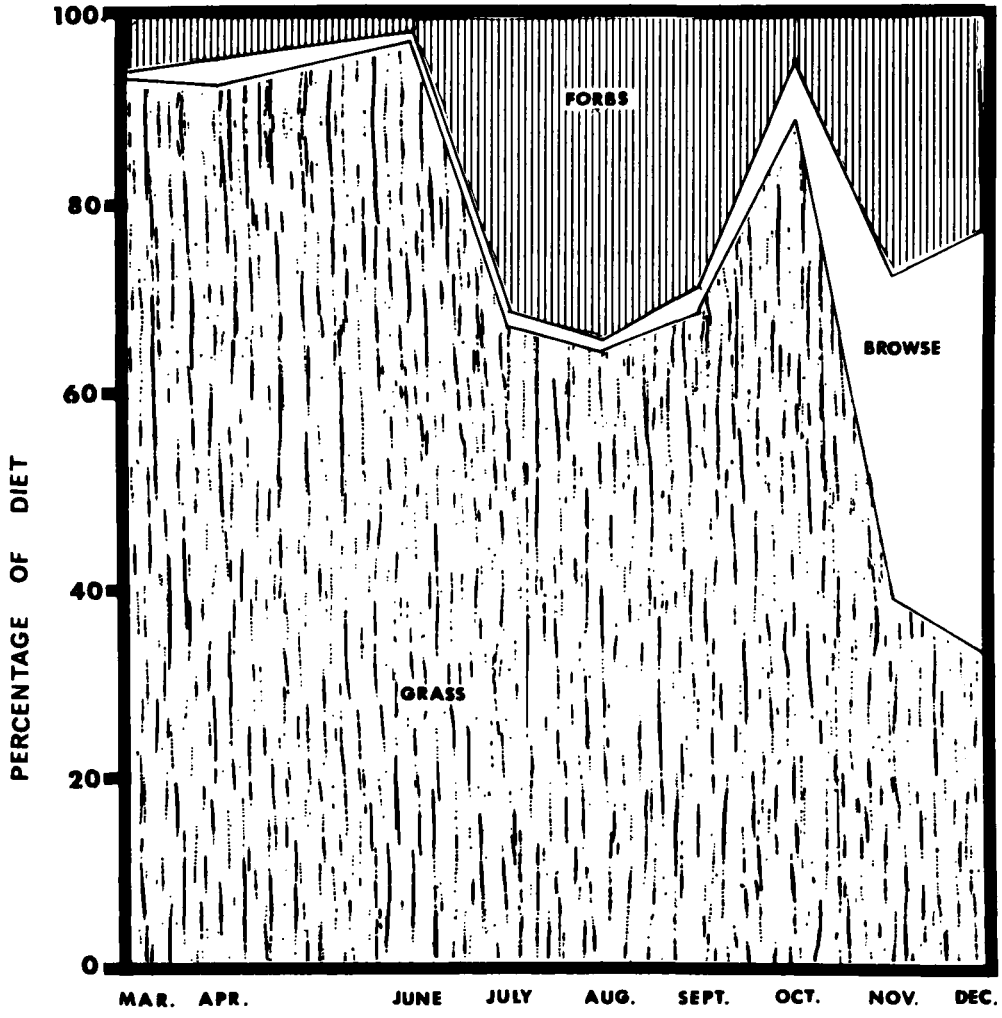

Figure 2. Graphic Representation of the Food Habits of Fistulated Steers on Area 18, Nevada Test Site, 1966 (No Food Habit Analysis in May)

Table 2. Botanical Composition by Percent of Forage Selected by Fistulated Steers Grazing in Area 18 of the Nevada Test Site - 1966

Plant Species	March	April	June	July	August	September	October	November	December
Orhyzopsis hymenoides	39.5	2.0	21.3	25.0	18.5	57.0	46.5	7.5	26.5
Sitanion hystrix	50.8	45.7	41.6	26.7	45.5	9.7	13.8	11.5	4.5
Bromus tectorum	1.5	22.0	8.6	1.0		1.7	0.2		
Stipa speciosa							24.5		
Elymus cinereus	1.2	9.0	0.5	12.0	0.5		0.8	14.0	1.0
Hilaria jamesii	0.2	14.0	25.3	2.3			0.8		0.5
Other							2.2	6.0	
Total grass	93.2	92.7	97.3	67.0	64.5	68.4	88.8	39.0	32.5
Purshia glandulosa									
Grayia spinosa				0.3	0.5	2.3	2.2	21.5	40.0
Quercus gambelii								8.5	
Ephedra nevadensis									
Ephedra viridis									
Other	0.5	2.7	0.4			0.3	3.8	3.0	4.5
Total browse	0.5	2.7	0.4	0.3	0.5	2.6	6.0	33.0	44.5
Salsola kali				32.7	29.0	11.7	1.2	24.0	1.5
Eriogonum spp.	6.3	0.3	2.3		5.8	17.3	3.5	4.0	20.0
Other		4.3			0.2		0.5		1.5
Total forbs	6.3	4.6	2.3	32.7	35.0	29.0	5.2	28.0	23.0

Table 3. Radionuclide Composition of Rumen Contents Collected - 1967

Date Collected	Area Collected and Remarks	K g/g	^{54}Mn pCi/g	^{65}Zn pCi/g	^{95}Zr pCi/g	^{106}Ru pCi/g	^{131}I pCi/g	^{137}Cs pCi/g	^{140}Ba pCi/g	^{144}Ce pCi/g
25 Jan 67	Well 8 canyon. Composite 4 samples.	0.001 ±.0001	<0.1	<1.0	0.9 ±0.1	3.6 ±1.0	0.8 ±0.1	<0.1	<1.0	6.6 ±1.0
28 Feb 67	Well 8 canyon. Composite 4 samples	0.001 ±.0001	<0.1	<1.0	2.6 ±0.2	3.7 ±1.0	1.0 ±0.1	<0.1	0.5 ±0.1	60 ±6.0
24 Mar 67	Well 8 canyon. Composite 4 samples.	0.003 ±.0001	<0.1	<10	<0.1	<1.0	<0.1	<0.1	<0.1	1.3 ±1.0
20 Apr 67	Well 8 canyon. Composite 4 samples.	0.001 ±.0001	0.1 ±0.1	<1.0	0.6 ±0.1	<1.0	<0.1	0.2 ±0.1	<0.1	1.6 ±1.0
26 May 67	Well 8 canyon. Composite 4 samples.	0.001 ±.0001	<0.1	<1.0	<0.1	<1.0	<0.1	<0.1	<0.1	<1.0
11 Jun 67	Well 8 canyon. Composite 5 samples.	0.001 ±.0001	<0.1	<1.0	<0.1	<1.0	<0.1	0.4 ±0.1	<0.1	<1.0
No samples collected in July										
2 Aug 67	Well 8 canyon. Composite 4 samples.	0.002 ±.0001	<0.1	<1.0	<0.1	<1.0	<0.1	<0.1	<0.1	<1.0
28 Sep 67	Well 8 canyon. Composite 4 samples.	0.001 ±.0005	<0.1	<1.0	0.2 ±0.04	<1.0	<0.1	0.2 ±0.05	<0.1	<1.0
27 Oct 67	Well 8 canyon. Composite 4 samples.	0.001 ±.0005	<0.1	0.1 ±0.07	0.5 ±0.05	<1.0	<0.1	0.2 ±0.05	<0.1	<1.0
30 Nov 67	Well 8 canyon. Composite 4 samples.	0.001 ±.0007	<0.1	<1.0	0.2 ±0.05	<1.0	<0.1	<0.1	<0.1	<0.1
27 Dec 67	Well 8 canyon. Composite 4 samples.	0.001 ±.0005	<0.1	<1.0	<0.1	<1.0	<0.1	<0.1	<0.1	<1.0

minimal levels of activity (see Appendix II). The February levels probably resulted from effluent from the Phoebus 1B tests of February 10 and 23 (see Appendix III). Only the January sample was analyzed for ^{239}Pu.

In 1967, grass exceeded 80% of the diet from January through July (Figure 3). In August, Russian thistle was 77% of the grazed forage (Table 4). During September and November grass again constituted the greatest part of the diet. However, in December grass levels decreased with the inclusion of over 60% browse.

1968

Samples were not collected in January. The fallout pattern of Project Buggy I (March 12, 1968), a Plowshare cratering experiment, fell across the Area 18 range. Samples of March and April revealed the presence of ^{95}Zr, ^{131}I, ^{137}Cs, ^{140}Ba, and ^{144}Ce (see Table 5) which probably came from this experiment. The ^{95}Zr levels persisted for most of the year. The December collection following contamination by Project Schooner (December 8, 1968), a Plowshare cratering experiment, also showed the same isotopes.

In 1968 grass exceeded 80% of the diet for six of the ten months sampled (Figure 4). During February and September browse constituted slightly more than 30% of the diet. Comparatively large amounts of Russian thistle were found in August and October, 32% and 48%, respectively (Table 6).

1969 and 1970

Table 7 lists the isotopes found in samples collected during 1969 and January and February of 1970. No samples were collected in February of 1969. All samples were below the MDA for ^{54}Mn and ^{131}I. Samples collected during the first quarter had detectable levels of ^{106}Ru, ^{137}Cs, and ^{144}Ce. Zirconium-95 and ^{106}Ru were detected periodically the rest of the year. Appendix II lists the events reported to have released activity during the period of this report.

During 1969 and 1970, grass exceeded 80% of the diet from January through May (Figure 5). In June, July, August, and October, Russian thistle constituted 21.1%, 52.3%, 87.6%, and 23% of the diet, respectively. During

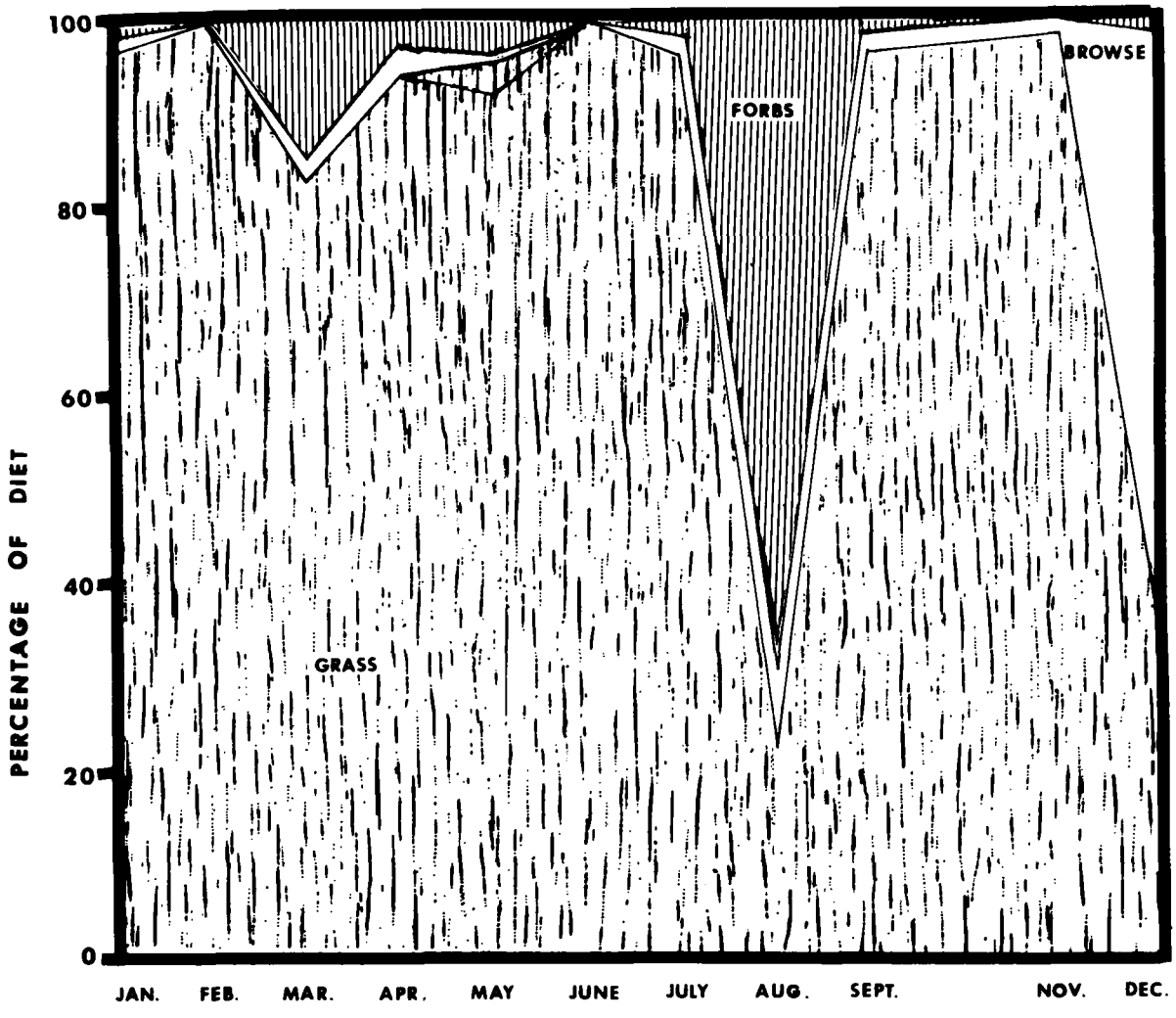

Figure 3. Graphic Representation of the Food Habits of Fistulated Steers on Area 18, Nevada Test Site, 1967 (No Food Habit Analysis in October)

Table 4. Botanical Composition by Percent of Forage Selected by Fistulated Steers Grazing in Area 18 of the Nevada Test Site - 1967

Plant Species	January	February	March	April	May	June	July	August	September	November	December
Orhyzopsis hymenoides	15.8	12.0			9.0	5.8		9.1	20.8	53.0	11.2
Sitanion hystrix	63.2	30.5	1.2	5.5	2.3	35.5	20.8	6.2	15.8	39.5	6.8
Bromus tectorum				1.2	79.5	48.9	34.8	1.5	0.5		
Stipa speciosa						0.9					
Elymus cinereus	19.3	57.5	78.0	87.5	5.0	2.5	1.2	1.8	6.5		9.8
Hilaria jamesii	0.1		4.3			5.6	37.0	3.2	53.0	7.0	
Other						0.8	2.7		1.2		
Total grass	98.4	100.0	83.5	94.2	95.8	100.0	96.5	21.8	97.8	99.5	37.8
Purshia glandulosa	0.6							0.3	1.5	0.2	12.2
Grayia spinosa											
Quercus gambelii			0.8	2.2	0.2		2.2				44.2
Ephedra nevadensis	0.2		0.2					0.1			4.8
Ephedra viridis											
Other			0.2	1.3			0.3			0.3	
Total browse	0.8		1.2	3.5	0.2		2.5	0.4	1.5	0.5	61.2
Salsola kali							1.0	77.8	0.5		0.2
Eriogonum spp.	0.8		15.3	2.0	0.5				0.2		0.8
Other				0.3	3.5						
Total forbs	0.8		15.3	2.3	4.0		1.0	77.8	0.7		1.0

Table 5. Botanical Composition of Rumen Contents Collected - 1968

Date Collected	Area Collected and Remarks	K g/g	^{54}Mn pCi/g	^{95}Zr pCi/g	^{106}Ru pCi/g	^{131}I pCi/g	^{137}Cs pCi/g	^{140}Ba pCi/g	^{144}Ce pCi/g	^{239}Pu pCi/g
January samples not collected										
21 Feb 68	Well 8 canyon. Composite 4 samples.	0.002 ±.0008	<0.1	0.2 ±0.06	<1.0	<0.1	<0.1	<0.1	<1.0	NA
28 Mar 68	Well 8 canyon. Composite 4 samples.	0.002 ±.0008	<0.1	0.3 ±0.05	<1.0	0.3 ±0.05	0.2 ±0.05	0.2 ±0.02	1.7 ±0.4	NA
17 Apr 68	North end of Cat Canyon. Composite 4 samples.	0.005 ±.0007	<0.1	0.2 ±0.05	<1.0	0.4 ±0.07	0.2 ±0.05	0.2 ±0.03	2.3 ±0.4	NA
23 May 68	North end of Cat Canyon. Composite 4 samples.	0.002 ±.001	<0.1	0.4 ±0.07	<1.0	<0.1	<0.1	<0.1	<1.0	0.02
3 Jul 68	Well 8 canyon. Composite 4 samples.		<0.1	0.2 ±0.06	<1.0	<0.1	<0.1	<0.1	<1.0	NA
25 Jul 68	Sample was lost.									
21 Aug 68	Well 8 canyon. Composite 4 samples.	0.003 ±.0006	<0.1	0.1 ±0.05	<1.0	<0.1	<0.1	<0.1	<1.0	NA
26 Sep 68	Well 8 canyon. Composite 3 samples.	0.001 ±.0006	<0.1	<0.1	<1.0	<0.1	<0.1	<0.1	<1.0	NA
27 Oct 68	Well 8 canyon. Composite 4 samples.	0.002 ±.001	<0.1	0.3 ±0.1	1.8 ±1.1	<0.1	<0.1	<0.1	<1.0	NA
27 Nov 68	Well 8 canyon. Composite 3 samples		<0.1	<0.1	<1.0	<0.1	<0.1	<0.1	<1.0	NA
26 Dec 68	Well 8 canyon. Composite 3 samples.		2.0 ±0.6	<0.1	2.2 ±1.5	3.0 ±0.1	1.3 ±1.1	1.9 ±0.6	<1.0	NA

N.A. = Not analyzed.

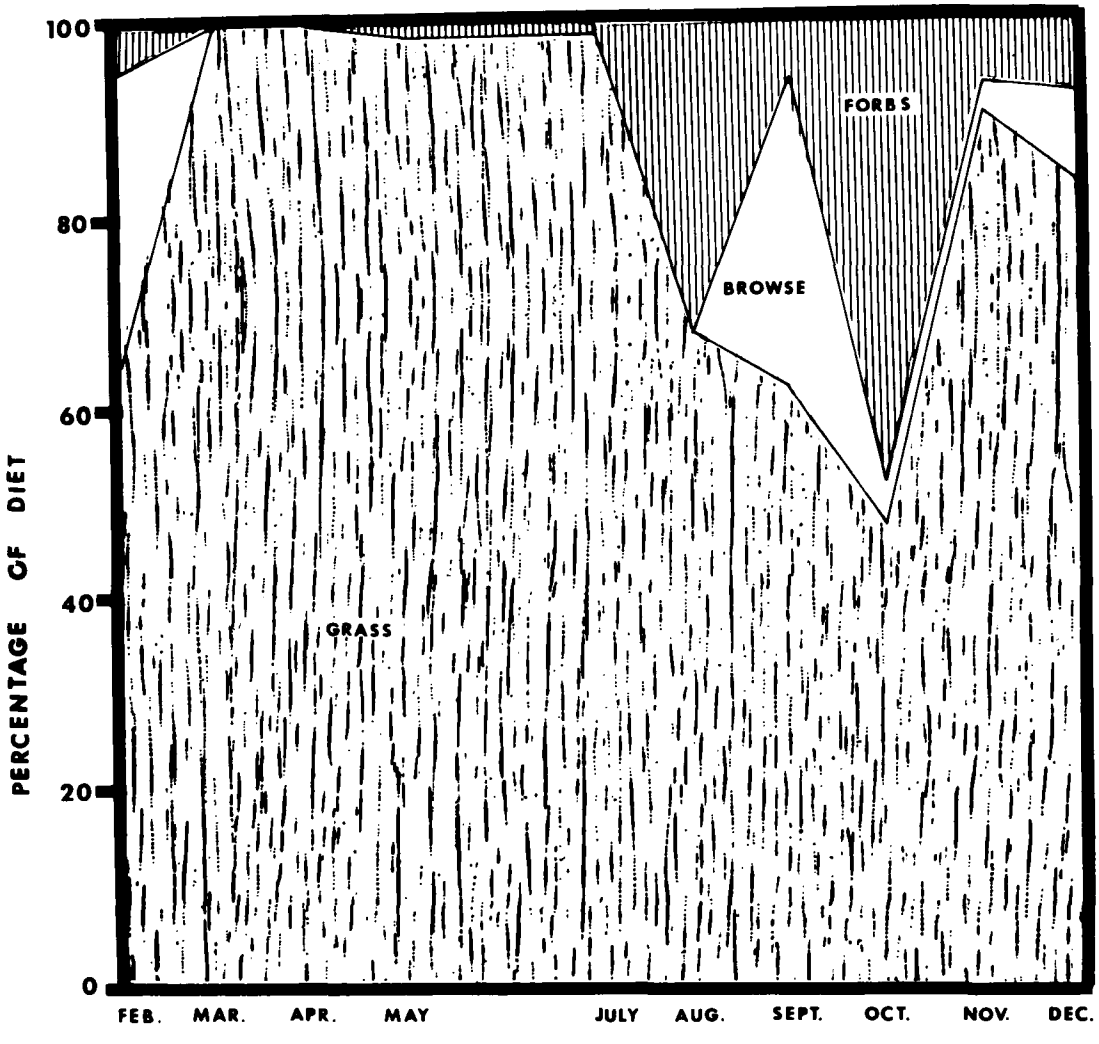

Figure 4. Graphic Representation of the Food Habits of Fistulated Steers on Area 18, Nevada Test Site, 1968 (No Food Habit Analysis in June)

Table 6. Botanical Composition by Percent of Forage Selected by Fistulated Steers Grazing in Area 18 of the Nevada Test Site - 1968

Plant Species	February	March	April	May	July	August	September	October	November	December
Orhyzopsis hymenoides	1.3	3.0	2.3	35.0	2.2	1.0			51.0	3.0
Sitanion hystrix	36.1	96.0	5.1	9.7	56.3	46.0	5.3	6.0	5.7	69.0
Bromus tectorum	0.3		85.7	5.7	0.3				2.7	
Stipa speciosa			0.2	44.7	9.2		2.1	33.0	2.0	4.6
Elymus cinereus	26.3	1.0					16.6	9.0	25.0	7.0
Hilaria jamesii				4.3	31.8	21.0	38.3		6.3	0.3
Other			6.7							
Total grass	64.0	100.0	100.0	99.4	99.8	68.0	62.3	48.0	92.7	83.9
Purshia glandulosa	26.1								0.7	0.6
Grayia spinosa										
Quercus gambelii							32.1			
Ephedra nevadensis	4.6				0.2			4.0		7.7
Ephedra viridis										
Other										
Total browse	30.7				0.2		32.1	4.0	0.7	8.3
Salsola kali						32.0	5.6	48.0		
Eriogonum spp.	5.3								6.6	7.8
Other				0.6						
Total forbs	5.3			0.6		32.0	5.6	48.0	6.6	7.8

Table 7. Radionuclide Composition of Rumen Contents Collected - 1969

Date Collected	Area Collected and Remarks	K g/g	^{95}Zr pCi/g	^{106}Ru pCi/g	^{137}Cs pCi/g	^{140}Ba pCi/g	^{144}Ce pCi/g	^{181}W pCi/g	^{239}Pu pCi/g
23 Jan 69	Well 8 canyon Composite 3 samples.	0.004 ±.0007	<0.1	<1.0	0.2 ±0.01	0.2 ±0.05	3.7 ±0.5	NA	NA
6 Mar 69	2 miles south of Pahute airport. Composite 3 samples.	0.001 ±.0006	0.2 ±0.05	1.7 ±0.5	<0.1	0.1 ±0.05	2.0 ±0.4	NA	NA
27 Mar 69	2 miles south of Pahute airport. Composite 2 samples	0.004 ±.0005	<0.1	1.5 ±0.3	0.2 ±0.03	<0.1	1.1 ±0.3	NA	NA
24 Apr 69	Well 8 canyon. Composite 3 samples.		<0.1	<1.0	<0.1	<0.1	<1.0	NA	NA
28 May 69	Well 8 canyon. Composite 3 samples.	0.002 ±.0006	0.2 ±0.05	1.3 ±0.5	<0.1	<0.1	<1.0	NA	NA
25 Jun 69	Well 8 canyon. Composite 3 samples.	0.003 ±.001	0.5 ±0.08	2.0 ±0.8	<0.1	<0.1	<1.0	NA	NA
31 Jul 69	Well 8 canyon. Composite 3 samples.	0.003 ±.0008	0.3 ±0.06	<1.0	<0.1	<0.1	<1.0	NA	NA
18 Aug 69	Well 8 canyon. Composite 3 samples.	0.002 ±.001	0.2 ±0.07	<1.0	<0.1	<0.1	<1.0	NA	2.1 ±0.4
25 Sep 69	Well 8 canyon. Composite 3 samples.	0.002 ±.0007	<0.1	<1.0	<0.1	<0.1	<1.0	NA	NA
23 Oct 69	Well 8 canyon. Composite 3 samples.	0.004 ±.0006	0.1 ±0.04	<1.0	<0.1	<0.1	<1.0	NA	1.3 ±0.3
26 Nov 69	Well 8 canyon. Composite 3 samples.	0.002 ±.0005	<0.1	<1.0	<0.1	<0.1	<1.0	NA	22 ±2

Table 7. Radionuclide Composition of Rumen Contents Collected - 1969 cont'd

Date Collected	Area Collected and Remarks	K g/g	^{95}Zr pCi/g	^{106}Ru pCi/g	^{137}Cs pCi/g	^{140}Ba pCi/g	^{144}Ce pCi/g	^{181}W pCi/g	^{239}Pu pCi/g
10 Dec 69	Well 8 canyon. Composite 2 samples.	0.002 ±.0005	<0.1	<1.0	<0.1	<0.1	<1.0	NA	NA
	Radionuclide Composition of Rumen Contents Collected - 1970								
22 Jan 70	Well 8 canyon. Composite 2 samples.	0.003	<0.1	<1.0	<0.1	<0.1	<1.0	NA	NA
1 Mar 70	2 miles south of Buckboard Mesa.	0.001	<0.1	<1.0	<0.1	<0.1	<1.0	0.5	NA

N.A. = Not analyzed.

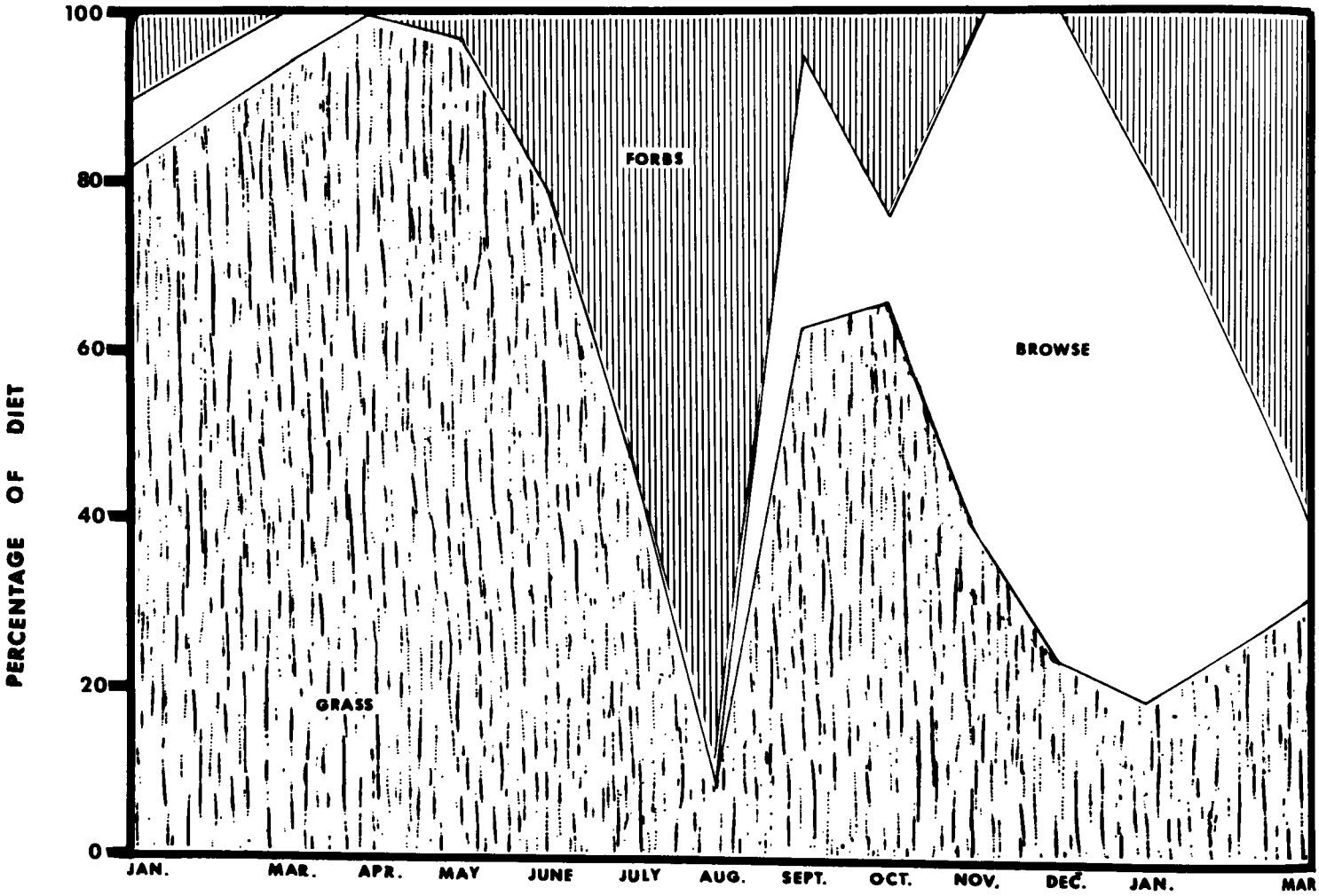

Figure 5. Graphic Representation of the Food Habits of Fistulated Steers on Area 18, Nevada Test Site, 1969-1970 (No Food Habit Analysis in February)

September, November, and December the grass was less than 70%. This is due to the inclusion of Gambel's oak in September and December, and mountain joint fir, *Ephedra viridis*, and desert bitterbrush in November (Table 8). In January of 1970, browse constituted over 60% and forbs 19% of the diet. The two dominant species included Mormon tea, *Ephedra nevadensis*, and Russian thistle. During February, Russian thistle constituted over 60% of the diet.

Table 8. Botanical Composition by Percent of Forage Selected by Fistulated Steers Grazing in Area 18 of the Nevada Test Site - 1969 and 1970

Plant Species	January	March	April	May	June	July	August	September	October	November	December	January	March
Orhyzopsis hymenoides	4.3	9.1	0.4	0.3	0.3					30.0	13.5	5.3	15.7
Sitanion hystrix	66.3	23.8	0.3	0.3	28.7	1.4		5.3	1.0	10.0	9.0	12.3	9.3
Bromus tectorum				41.6	12.3	0.2							
Stiva speciosa	4.6	61.1		13.7	6.0	0.7		2.0	0.6				
Elymus cinereus	5.3		99.3	40.4	24.0	27.8	8.0	16.6	62.5	0.5	1.0	0.7	5.3
Hilaria jamesii					7.3	17.6	1.0	38.3	1.3			1.1	1.0
Other													
Total grass	80.5	94.0	100.0	96.3	78.6	47.7	9.0	62.2	65.4	40.5	23.5	19.4	31.3
Purshia glandulosa	3.0	5.8								20.5	2.5	1.7	8.1
Grayia spinosa													
Quercus gambelii							3.1	32.2	11.6		74.0	13.3	
Ephedra nevadensis	6.3	0.2										46.6	
Ephedra viridis										38.0			
Other													0.3
Total browse	9.3	6.0					3.1	32.2	11.6	58.5	76.5	61.6	8.4
Salsola kali				3.7	21.1	52.3	87.6	5.6	23.0			19.0	60.3
Eriogonum spp.	10.2												
Other					0.3		0.3			1.0			
Total forbs	10.2			3.7	21.4	52.3	87.9	5.6	23.0	1.0		19.0	60.3

SUMMARY

As observed from tables in this report, the radionuclide concentrations of the rumen samples both from world-wide fallout and from NTS events were either below the MDA or are of very low magnitude. Twice yearly six beef animals are selected from the herd that grazes this area the year round and are sacrificed; selected tissues are analyzed for radionuclide content and are examined for macro- and micro-pathology[1,2]. No pathology has been found that can be attributed to radiation.

Detectable levels of ^{95}Zr, ^{106}Ru, ^{140}Ba, and ^{144}Ce were usually found in samples collected during the late spring and early summer. Levels of ^{106}Ru and ^{95}Zr persisted into the fall. Samples collected following a contaminating event usually showed ^{131}I and ^{140}Ba.

The November 26, 1969, value for ^{239}Pu of 22 pCi/g is questionable but could be the result of ingestion of a single particle by the grazing animal.

Generally, the major portion of the diet was grass, which exceeded 80% in 23 of the 43 monthly samples (Figures 1 to 4). Appendix IV lists all species of plants found in rumen samples during the period of this report.

Squirrel tail grass, *Sitanion hystrix*, and Indian rice grass, *Oryzopsis hymenoides*, either singly or in combination, were the two grasses which made up the major portion of the grasses ingested. Galleta grass, *Hilaria jamesii*, the dominant grass in Area 18, appeared in large amounts in June 1966 (25.3%); July 1967 (37%); July, August, and September 1968 (31.8%, 21%, and 38.3%, respectively) and in September 1969 (38.3%).

Desert bitterbrush, *Purshia glandulosa*, and Gambel's oak, *Quercus gambelii*, were the principal browse species during most months. The greatest period of browse ingestion occurred during the months of November and December.

Russian thistle, *Salsola kali*, and desert buckwheat, *Eriogonum* spp., were the only forbs to exceed 2% of the total diet during any month. Desert buckwheat was found in small amounts rather consistently over the monthly periods while Russian thistle occurred mainly in the summer, especially during the month of August, when it made up 30 to 70% of the diet.

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APPENDIX I. Minimum Detectable Activities by Gamma Spectroscopy of Selected Radionuclides

Radionuclide	pCi total sample 40-min. count Planchet	400 ml	3.5 liter	10-min. count Planchet
^{144}Ce	250	400	350	500
^{140}Ba	25	40	35	50
^{137}Cs	25	40	35	50
^{131}I	25	40	35	50
^{106}Ru	250	400	350	500
^{95}Zr	25	40	35	50
^{65}Zn	250	400	350	500
^{54}Mn	25	40	35	50
K*	0.3	0.4	0.4	0.5

*grams of potassium

The minimum detectable activities (MDA's) are expressed in terms of total activity per sample for the standard geometries and counting times used at this laboratory. These values are applicable to ideal conditions and simple complexes of nuclides. Complex spectra or spectra showing fresh fallout contamination can raise the MDA's considerably.

The values are based on a combination of a number of technical experiments and operational experience. The MDA is defined by means of experimentation as that activity which produces a ±100% deviation at the 95% confidence level On the basis of experience the MDA is defined as that activity which can be positively identified on a net spectrum plot.

APPENDIX II. Nuclear Events that Released Radioactivity into the Atmosphere which was Detected Off NTS - February 1966 February 1970

Date	Event	Location	Remarks
03/05/66	Red Hot	Tunnel-NTS	Minor levels of radioactivity detected off-site.
04/25/66	Pin Stripe	NTS	Minor levels of radioactivity detected off-site.
05/09/66			Non-U.S. atmospheric. Lower end of intermediate range.
06/15/66	Double Play	Tunnel-NTS	Minor levels of radioactivity detected off-site.
09/12/66	Derringer	NTS	Minor levels of radioactivity detected off-site.
10/27/66			Non-U.S. atmospheric test. Low-low/intermediate.
12/27/66			Non-U.S. atmospheric test of a few hundred kt.
01/19/67	Nash	NTS	20-200 kilotons. Minor levels of radioactivity detected off-site.
06/29/67	Umber	NTS	Minor levels of radioactivity detected off-site.
08/31/67	Door Mist	Tunnel-NTS	Minor levels of radioactivity detected off-site.
12/24/67			Non-U.S. atmospheric test of low power.
01/18/68	Hupmobile	NTS	Minor levels of radioactivity detected off-site.
01/26/68	Cabriolet	Pahute Mesa, NTS	Plowshare cratering experiment.
03/12/68	Buggy I	Area 30, NTS	Plowshare. Row charge cratering experiment with 5 simultaneous detonations.
12/08/68	Schooner	Pahute Mesa, NTS	Plowshare. Low intermediate cratering experiment.
12/27/68			Non-U.S. atmospheric test. About 3 megatons.
10/29/69	Pod	NTS	Minor levels of radioactivity detected off-site.

APPENDIX III. Tests at the Nuclear Rocket Development Station which Released Radioactivity Detectable off the Nevada Test Site[14]

Reactor/Engine	Experimental Plan	Date
NRX-A4/EST	IIB	02/03/66
	III	03/03/66
	IV	03/16/66
	IVA	03/25/66
NRX-A5	III	06/08/66
	IV	06/23/66
Phoebus 1B	III	02/10/67
	IV	02/23/67
NRX-A6	IIIA	12/15/67
Phoebus 2A	III	06/08/68
	IV	06/26/68
	V	07/18/68
Pewee 1	III	12/04/68
XE Prime	VC	06/11/69
	IXA	08/28/69

APPENDIX IV. Botanical and Common Names of Range Plants Found in Fistulated Steer Rumen Samples 1966-1970

Botanical Name	Common Name
Grasses	
Bromus tectorum	cheat grass
Bromus rubens	red brome grass
Elymus cinereus	basin wild rye
Hilaria jamesii	galleta grass
Poa spp.	blue grass
Orhyzopsis hymenoides	Indian rice grass
Sitanion hystrix	squirrel tail grass
Stipa speciosa	desert needle grass
Forbs	
Abronia spp.	verbena
Amsinckia spp.	fiddleneck
Astragalus spp.	locoweed
Chenopodium fremontii	Fremont's goosefoot
Chenopodium spp.	goosefoot
Descurainia pinnata	tansy mustard
Eriogonum spp.	desert buckwheat
Eriogonum umbellatum	sulphur-flowered eriogonum
Erodium cicutarium	desert heron's bill
Euphorbia spp.	spurge
Linum perenne	flax
Phlox spp.	phlox
Physaria spp.	bladder pod
Salsola kali	Russian thistle
Sphaeralcea grossulariaefolia	desert mallow
Browse	
Artemisia arbuscula	black sagebrush
Artemisia tridentata	big sagebrush
Atriplex canescens	four-winged saltbush
Ephedra nevadensis	Mormon tea
Ephedra viridis	mountain joint-fir
Eurotia lanata	winter fat
Grayia spinosa	spiny hop-sage
Juniperus osteosperma	juniper
Purshia glandulosa	desert bitterbrush
Quercus gambelii	Gambel's oak

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