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in Elk That Winter on  
Los Alamos National Laboratory Lands*

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UC-908 and UC-902  
Issued: July 1994  
Revised: January 1995

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# **RADIONUCLIDE CONCENTRATIONS IN ELK THAT WINTER ON LOS ALAMOS NATIONAL LABORATORY LANDS**

by

**P. R. Fresquez, D. A. Armstrong, and J. G. Salazar**

## **ABSTRACT**

Elk spend the winter in areas at Los Alamos National Laboratory (LANL) that may contain radioactivity above natural and/or worldwide fallout levels. This study was initiated to determine the levels of  $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$ ,  $^{238}\text{Pu}$ ,  $^{239}\text{Pu}$ , and total uranium in various tissues (brain, hair, heart, jawbone, kidneys, leg bone, liver, and muscle) of adult cow elk that use LANL lands during the fall/winter months. No significant differences in radionuclide contents were detected in any of the tissue samples collected from elk on LANL lands as compared with elk collected from off-site locations. The total effective (radiation) dose equivalent a person would receive from consuming 3.2 lb of heart, 5.6 lb of liver, and 226 lb of muscle from elk that winter on LANL lands, after natural background has been subtracted, was 0.00008, 0.0001, and 0.008 mrem/yr, respectively. The highest dose was less than 0.01% of the International Commission on Radiological Protection permissible dose limit for protecting the public.

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## **I. INTRODUCTION**

Many of the activities and operations at Los Alamos National Laboratory (LANL) involve or produce liquids, solids, and gases that contain radioactive materials. Although the Laboratory makes great effort to minimize the release of radioactive materials to the environment, absolute containment and/or purification is not technically possible (USDOE 1979). Treated radioactive liquid waste effluents, for example, contain trace amounts of  $^3\text{H}$ ,  $^{90}\text{Sr}$ ,  $^{137}\text{Cs}$ ,  $^{238}\text{Pu}$ ,  $^{239}\text{Pu}$  and  $^{235}\text{U}$  (Environmental Protection Group 1993). Also, some local atmospheric releases of natural and depleted uranium occur as a result of high-explosive experiments in controlled test areas (Becker 1992).

Over 1500 elk spend the winter (October-March) on Bandelier National Monument/LANL lands (Allen 1994), with populations of elk on LANL lands peaking around the month of November (Keller and Biggs 1994). Many of these elk use LANL technical areas known to contain environmental contaminants (White 1981) and have been reported to contain significantly higher concentrations of  $^{90}\text{Sr}$  in leg bone tissue than elk collected from off-site locations (Meadows and Salazar 1982). The higher  $^{90}\text{Sr}$  levels in elk collected from Laboratory lands as compared with elk collected from background locations, however, was attributed to differences in worldwide fallout patterns.

Consumption of meat from game animals constitutes one pathway by which radionuclides can be transferred to humans (Wicker and Schultz 1982).

Thus, the objective of this study was (1) to compare radionuclide contents in elk collected from LANL lands (on-site) with radionuclide contents in elk collected from background locations (off-site), and (2) to calculate the total effective (radiation) dose equivalent (EDE) to people who consume meat from elk that use LANL lands.

## II. METHODS

Three adult female (cow) elk (*Cervus elaphus*) were harvested in October-December of 1991 and January-February of 1992 from LANL areas TA-18 (Pajarito Canyon), TA-49 (Water Canyon), and TA-5 (Mortandad Canyon) (Figure 1). Similarly, three adult cow elk were collected by the New Mexico Department of Game and Fish during this same period of time from the Lindreth, Tres Piedras (February 1993), and Chama areas. Tissue samples from each elk were collected: >200 g each of brain, hair, heart, jaw bone, kidneys, leg bone, liver, and muscle. Samples were placed into Ziplock bags and transported back to the laboratory in locked ice chests for further processing.

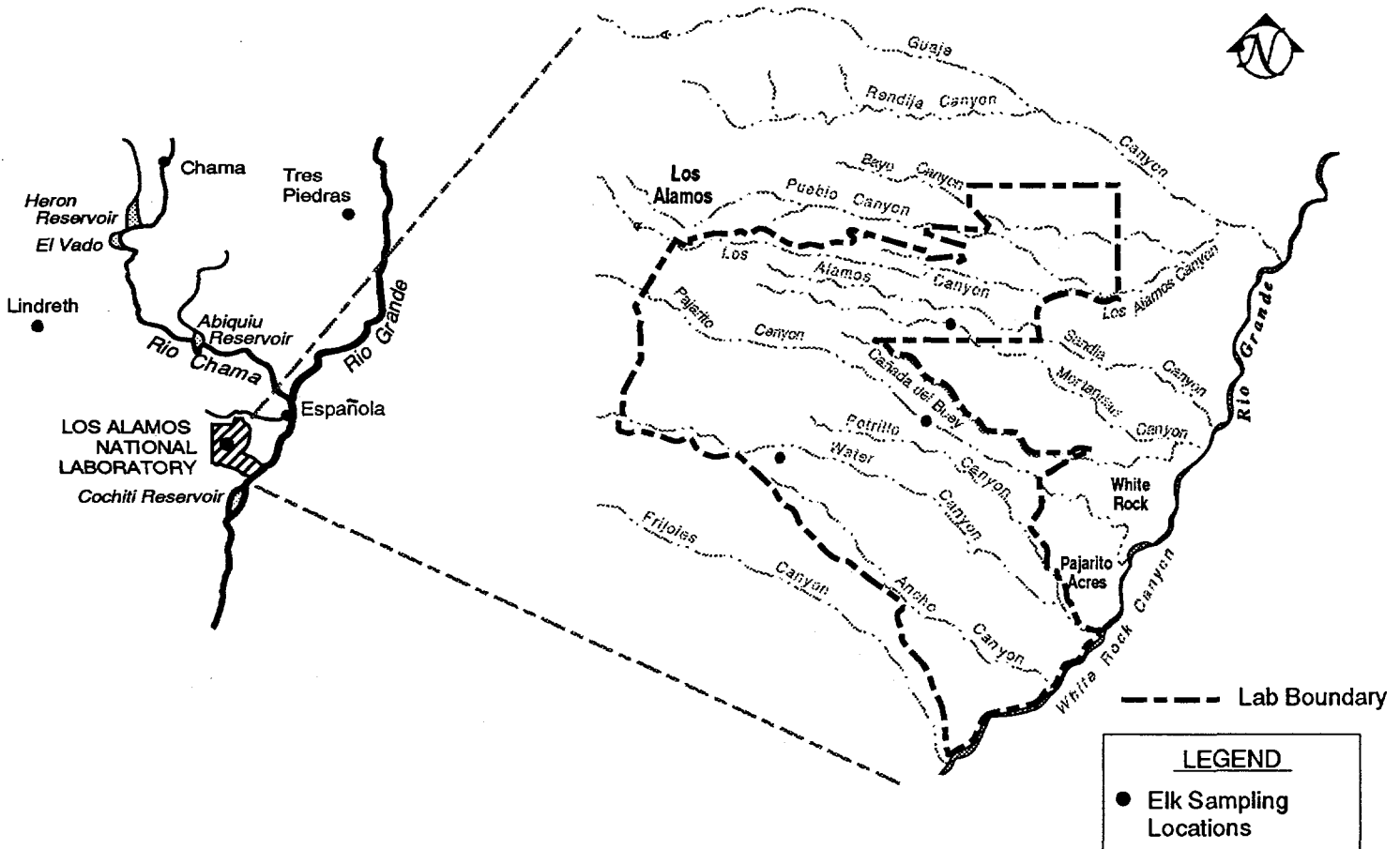


Figure 1. Locations of elk collected from LANL lands (on-site) and regional areas (off-site).

At the laboratory, approximately 200 to 1000 g of tissue material(s) were placed into tared 1-L beakers and weighed. The beaker contents were oven dried at 80°C for 120 h, weighed, and ashed at 500°C for 120 h. The sample ash was weighed, pulverized, and homogenized before it was submitted to a LANL analytical laboratory for the analysis of <sup>90</sup>Sr, <sup>137</sup>Cs, <sup>238</sup>Pu, <sup>239</sup>Pu, and total uranium. All methods of radiochemical analysis have been described previously (Salazar 1984). Results are reported on an oven dry weight basis (dry g).

Variations in the mean radionuclide content for each tissue component from elk collected from on-site and off-site areas were tested using a Student's t-test at the 0.05 probability level (Gilbert 1987). The EDE--based on a reference elk weighing 233 kg (513 lb) with 1.44 kg (3.2 lb) of heart tissue, 2.26 kg (5.6 lb) of liver tissue, and 102.4 kg (225.6 lb) of muscle tissue (Meadows and Hakonson 1982)--was calculated using the methodology outlined in International Commission on Radiological Protection (ICRP) Publication 30 (ICRP 1978) and the public dose conversion factors in Department of Energy report DOE/EH-0071 (USDOE 1984).

### III. RESULTS AND DISCUSSION

Concentrations of total uranium, <sup>137</sup>Cs, <sup>90</sup>Sr, <sup>238</sup>Pu, and <sup>239</sup>Pu detected in various tissue samples collected from on-site and off-site cow elk can be found in Table 1.

No significant differences in radionuclide contents were detected in any of the tissue samples collected from on-site and off-site elk. The concentrations of radionuclides, in general, were low, variable (i.e., the mean was smaller than two times the standard deviation), and within values (pCi/g ash) reported in a previous study (Meadows and Salazar 1982). Also, averages between on-site and off-site radionuclides varied in concentration from tissue to tissue: total uranium ranged in concentration from 1.3 ng/dry g in heart to 78 ng/dry g in hair; <sup>137</sup>Cs ranged from 0.05 pCi/dry g in heart to 0.60 pCi/dry g in kidneys; <sup>90</sup>Sr ranged from 0.0 pCi/dry g in muscle to 1.6 pCi/dry g in jawbone; <sup>238</sup>Pu ranged from 0.000002 pCi/dry g in muscle to 0.000018 pCi/dry g in leg bone; and <sup>239</sup>Pu ranged from 0.000009 pCi/dry g in muscle to 0.00043 pCi/dry g in hair. Cesium-137, a chemical analog of potassium, and <sup>90</sup>Sr, a chemical analog of calcium, deposit primarily in muscle and bone tissue, respectively (Wicker and Schultz 1982).

Sr-90 levels in leg bone of elk collected from LANL areas in 1980 were significantly higher than <sup>90</sup>Sr concentrations in leg bone of elk collected from off-site areas (Meadows and Salazar 1982). The differences in <sup>90</sup>Sr levels in leg bones in elk collected from LANL areas as compared with off-site elk was mainly attributed to differences in fallout patterns. Although no significant differences in <sup>90</sup>Sr levels were observed in tissue samples between on-site and off-site elk in this study, the jawbones and leg bones of elk contained significantly higher concentrations of <sup>90</sup>Sr than the other organ and muscle tissues. The levels of <sup>90</sup>Sr in elk bone, the critical deposition site, pose no threat to human consumers of elk meat; the transfer ratio of <sup>90</sup>Sr from elk bone to elk meat was estimated at <0.01 (Meadows and Salazar 1982). Sr-90 was not detected in muscle tissue in this study, however.

The estimated radiation dose from consuming 3.2 lb of heart, 5.6 lb of liver, and 226 lb of muscle from elk using LANL lands, after subtracting natural background, was 0.00008 ( $\pm 0.00073$ ), 0.0001 ( $\pm 0.0002$ ), and 0.008 ( $\pm 0.019$ ) mrem/yr, respectively. A calculation of the EDE from Meadows' and Salazar's

1982 muscle data shows a value of 0.009 mrem/yr--very similar to the result obtained in this study. The highest dose was <0.01% of the ICRP permissible dose limit of 100 mrem/yr from all pathways. LANL operations, therefore, do not result in significant doses to the general public from consuming meat from elk that winter on LANL lands.

**TABLE I. Radionuclide Concentrations in Various Tissues of Elk Collected from On-Site (LANL) and Off-Site (Background) Areas.**

	Total U (ng/dry g)		<sup>137</sup> Cs (10 <sup>-3</sup> pCi/dry g)		<sup>90</sup> Sr (10 <sup>-3</sup> pCi/dry g)		<sup>238</sup> Pu (10 <sup>-5</sup> pCi/dry g)		<sup>239</sup> Pu (10 <sup>-5</sup> pCi/dry g)	
	on-site/off-site	on-site/off-site	on-site/off-site	on-site/off-site	on-site/off-site	on-site/off-site	on-site/off-site	on-site/off-site	on-site/off-site	on-site/off-site
Brain	3.2 <sup>1</sup>	2.2	59.6	593.5	8.3	14.0	3.0	7.0	1.3	9.3
	3.8 <sup>2</sup>	4.5	77.6	457.4	8.0	7.0	5.2	7.0	2.3	16.2
Hair	135.1	20.2	107.3	283.9	13.0	8.7	11.0	4.3	57.7	27.7
	111.7	11.1	119.4	324.1	11.5	1.2	10.1	3.2	80.2	38.4
Heart	0.7	10.9	41.1	58.3	2.0	2.3	5.0	0.0	2.3	14.7
	1.7	19.0	40.4	4.8	3.5	2.1	6.2	0.0	2.1	25.4
Jawbone	63.5	5.6	491.8	34.5	1945.3	1361.3	0.0	20.0	19.7	0.0
	98.3	6.9	873.1	26.5	414.4	990.7	0.0	34.6	34.1	0.0
Kidneys	85.8	22.2	685.5	498.0	5.7	6.0	13.7	3.0	8.0	0.0
	134.4	1.7	629.4	229.1	6.0	0.0	7.8	4.2	6.1	0.0
Leg Bone	14.6	1.9	118.7	73.5	1215.7	1833.7	18.3	18.3	18.3	21.3
	10.4	1.8	119.7	118.9	424.2	1037.1	31.8	31.8	31.8	37.0
Liver	4.6	5.2	174.9	222.7	4.0	3.0	1.3	1.7	3.3	3.3
	6.2	8.7	158.4	186.4	4.0	2.6	2.3	2.9	3.1	3.1
Muscle	1.8	0.8	134.0	209.4	0.0	0.0	0.4	0.0	1.8	0.0
	4.5	1.3	94.1	208.4	0.0	0.0	0.9	0.0	1.8	0.0

<sup>1</sup>All means between on-site and off-site samples were not significantly different at the 0.05 level using a Student's t-test.

<sup>2</sup>Standard deviation.



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