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Radionuclide Concentrations in Deer and Elk from Los Alamos National Laboratory: 1991–1998

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by

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ABSTRACT

Mule deer (*Odocoileus hemionus*) and Rocky Mountain elk (*Cervus elaphus*) forage in many areas at Los Alamos National Laboratory (LANL) that may contain radioactivity above natural and/or worldwide fallout levels. This paper summarizes radionuclide concentrations (^{3}H, ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239,240}Pu, ^{241}Am, and ^{tot}U) in muscle and bone tissue of deer and elk collected from LANL lands from 1991 through 1998. Also, the committed effective dose equivalent (CEDE) and the risk of excess cancer fatalities (RECF) to people who ingest muscle and bone from deer and elk collected from LANL lands were estimated. Most radionuclide concentrations in muscle and bone from individual deer and elk collected from LANL lands were either at less than detectable quantities (where the analytical result was smaller than two counting uncertainties) and/or within upper (95%) level background (BG) concentrations. As a group, most radionuclides in muscle and bone of deer and elk from LANL lands were not significantly higher ($p<0.10$) than in similar tissues from deer and elk collected from BG locations. Also, elk that had been radio collared and tracked for two years and spent an average time of 50% on LANL lands were not significantly different in most radionuclides from road kill elk that have been collected as part of the environmental surveillance program. Overall, the upper (95%) level net CEDEs (the CEDE plus two sigma for each radioisotope minus background) at the most conservative ingestion rate (51 lbs of muscle and 13 lbs of bone) were as follows: deer muscle = 0.220, deer bone = 3.762, elk muscle = 0.117, and elk bone = 1.67 mrem/y. All CEDEs were far below the International Commission on Radiological Protection guideline of 100 mrem/y, and the highest muscle plus bone CEDE (4.0 mrem/y) corresponded to a RECF of 2E-06 which is far below the Environmental Protection Agency upper level guideline of 1E-04.

I. INTRODUCTION

Mule deer (*Odocoileus hemionus*) and Rocky Mountain elk (*Cervus elaphus nelsoni*) are common inhabitants of the Bandelier National Monument (BNM) and Los Alamos National Laboratory (LANL) area (Guthrie and Large 1980, Biggs et al. 1997, Hinojosa 1997). Although mule deer populations in the area exhibited high populations in the 1950s to 1960s (Eberhardt and White 1979), recent aerial surveys by BNM biologists suggest that mule deer numbers may be in a declining mode (Allen 1996). The populations of elk in the BNM/LANL area, on the other hand, have been significantly increasing in numbers over the years (Allen 1996); this increase has been attributed to the the La Mesa Fire in 1977 which created over 15,000 acres of grassy winter range (White and Lissoway 1980). Conley et al. (1979) estimated that less than 100 elk wintered on BNM in 1977-78; presently, populations of elk range from 1500 to 2000 animals (Allen 1996) with numbers peaking on BNM/LANL lands around the month of November (Keller and Biggs 1994).

In the past and with the onset of spring, most of these elk typically migrated west of BNM/LANL to the Valle Grande's Baca Ranch—a privately owned 95,000-acre high-elevation forest/meadow—where they calved and spent the majority of their summer time (White 1981). More recent studies, however, show that a large number of elk and some deer are now inhabiting BNM and especially LANL areas on a year-round basis (Biggs et al. 1996a)—the number of resident animals at LANL are about 100 to 200 elk and about 50 to 100 deer (James Biggs, personal communication, 1998).

There are many technical areas (TAs) within LANL that are known to contain environmental contaminants (ESP 1998), and it is not uncommon to see deer and elk foraging within these areas (Biggs et al. 1998). Many studies have demonstrated that wild ruminants readily accumulate radionuclides from soil and vegetation (Hakonson and Whicker 1969, Longhurst et al. 1967, Cummings et al. 1969, Whicker et al. 1965) and this uptake by deer and elk may constitute an important vector of transfer to humans where they are hunted for food (Whicker et al. 1968). Although past studies have shown little or no radionuclide uptake by deer and elk collected from LANL lands above background concentrations (Meadows and Salazar 1982, Fresquez et al. 1994, Fresquez et al. 1995, Fresquez et al., 1996a), most of these animals were collected as road kills, and it is not conclusively known whether or not these animals spent a significant amount of time on Laboratory lands before they were killed. It was partly because of this reason that a radio telemetry study was initiated in 1996—one of the objectives being to determine where and how much time an elk spends on LANL lands in an effort to gain a better understanding of the radionuclide to large game to human pathway at LANL (Fresquez et al. 1997).

This study reports a host of radionuclide contents in muscle and bone tissues in deer and elk collected from LANL lands from 1991 through 1998, including most of the elk that were radio collared in 1996. These animals were compared to deer and elk collected from background (BG) locations where radionuclide contents in tissues are a result of world wide fallout and natural sources. Also, the committed effective dose equivalent (CEDE) and the risk of excess cancer fatalities (RECF) to members of the public from consuming meat and bone tissues from elk and deer utilizing LANL lands were estimated.

II. METHODS

From 1991 through 1998, approximately 11 deer and 21 elk were collected—mostly as a result of vehicle road kill accidents—from within or just around LANL lands (Figure 1). Background samples of deer (n = 3) and elk (n = 7) from regional locations were collected also as a result of vehicle accidents or hunter kills and donated to LANL by the New Mexico Department of Game and Fish (NMDGF). In 1996, six elk were fitted with global positioning system radio collars (during capture these elk had a small amount of blood drawn for disease and ^3H determinations) and tracked by satellite every 23 h over a one-to-two-year period (Biggs et al. 1996a, Bennett et al. 1996) (Appendix A contains all of the individual movement patterns by TA). Eventually, these radio collared elk were killed by either hunters, NMDGF, or

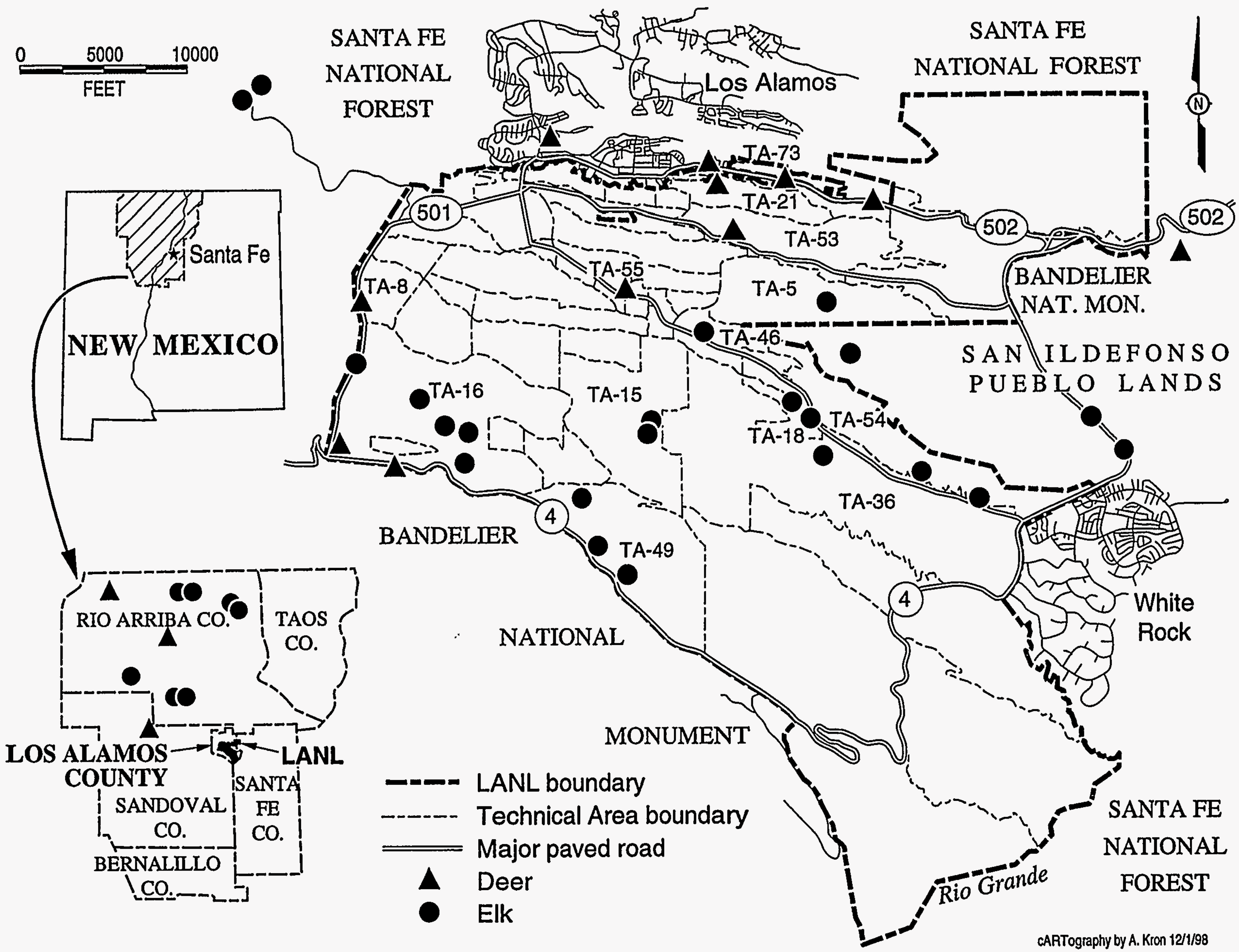

Figure 1. Locations of deer and elk collected within and around Los Alamos National Laboratory 1991 through 1998.

vehicles, and five out of the six were collected for analysis. Total time spent on LANL lands by these five elk ranged from 5% to 90%; the average time was 50%.

In most situations, the front shoulder was collected, placed in a clean plastic bag, and transported back to the laboratory in a locked ice chest cooled to 4°C. At the laboratory, the muscle and bone tissue were removed from the skin portion, and approximately 50 to 100 grams of wet subsample from each material was placed into a ^{3}H distillation unit and heated to collect distillate (water) for ^{3}H analysis. The rest of the muscle and bone sample(s) were then thoroughly rinsed with tap water and towel dried. Approximately 200 to 1000 grams of muscle and bone were placed into tared 2-L beakers and weighed. The beaker contents were oven dried at 75°C for 120 h, weighed, and slowly ashed incrementally to 500°C for 120 h. The sample ash was weighed, pulverized, and homogenized before it was submitted with the distillate samples to an internal chemistry department at the Laboratory (CST-9) for the analysis of ^{3}H, ^{137}Cs, ^{90}Sr, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and total uranium. All methods of radiochemical analysis have been described previously (Fresquez et al. 1994). Results are reported on a pCi mL^{-1} (tissue moisture) basis for ^{3}H and on an oven dry weight basis (g dry) for the rest of the elements. Moisture conversion factors (ash to dry and dry to wet) for elk and deer can be found in Fresquez and Ferenbaugh (1998).

Because both deer and elk could freely move within (contaminated and/or non-contaminated) LANL lands (i.e., the study was not controlled in the standard sense), the variations in the mean radionuclide content for each tissue component from road kill deer and from road kill and radio collared elk collected from LANL and BG areas were tested using a nonparametric Wilcoxon Rank Sum Test at a more conservative probability level (0.10) rather than at the standard 0.05 level (Gilbert 1987). All of the radio collared elk were combined for the statistical analysis; and, although the range of the radio collared elk varied widely (5% to 90%) most of the radioisotopes associated with the meat and bone of these animals, including the bull elk which spent only 5%

(documented) time on LANL lands, were within one standard deviation of each other.

The CEDE was calculated following procedures recommended by the Department of Energy (USDOE 1991) and the Nuclear Regulatory Commission (NRC 1977). The general process for calculating radiological dose from ingestion of deer venison is as follows. First, after converting from dry to wet weight concentrations (Fresquez and Ferenbaugh 1998), the wet concentration of radionuclides in the meat was multiplied by a dose conversion factor that tells how much radiological dose occurs per unit of food ingested (USDOE 1988). Where different dose conversion factors are provided for a radionuclide, the most conservative (highest) factor was employed. The final dose was calculated by multiplying the dose per unit ingested by the total number of units ingested. The dose calculated was the 50-year CEDE. Even though this dose would be received over a 50-year period, the entire dose was reported as though it occurred in the year the deer was ingested. Three calculations were performed: dose per lb of meat or bone consumed, dose per average consumption rate (21 lb for muscle and 3 lb for bone), and dose per maximum consumption rate (51 lb for muscle and 12 lb for bone). The dose per lb of meat or bone consumed was reported so that individuals may calculate their own doses based on their knowledge of their actual consumption rates. Finally, the CEDE was multiplied by 5×10^{-7} excess cancer fatalities per person-mrem (NCRP 1993) to calculate the RECF from whole-body radiation from the consumption of muscle and bone separately or in combination. Now, there is a sizable body of research that indicates that risk calculations typically overestimate the true hazard, and that health effects from radiation, including cancer, have been observed in humans only at doses in excess of 10 rem (10,000 mrem) delivered at high dose rates (HPS 1996). Therefore, these estimates are provided to the reader as a conservative and qualitative guide only.

III. RESULTS AND DISCUSSION

Concentrations of ^{3}H, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{90}Sr, ^{241}Am, and ^{tot}U in muscle and bone tissues collected from deer and elk from LANL and BG areas from 1991 to 1998 can be found in Tables 1 and 2. In general, most radionuclides in muscle and bone tissues of individual animals of deer and elk from LANL lands were either in nondetectable concentrations (where the analytical result was smaller than two times the counting uncertainty; and, therefore, were not significantly different from zero) (Corely et al. 1981), or within upper 95% level (mean plus two standard deviations) BG concentrations. Very few animals contained radionuclide concentrations above BG concentrations; but some, however, contained radioisotopes associated with known contaminated sites at LANL. One deer (TA-21/DP Road/10-02-97/Buck), for example, that was collected within TA-21 contained higher concentrations of ^{137}Cs and ^{90}Sr in muscle and bone tissue than in similar tissue collected from deer at BG locations. TA-21 on DP Road is located between two canyons at LANL that have a known history of ^{137}Cs and ^{90}Sr contamination (Fresquez et al. 1996b, Fresquez et al. 1998). Another example was of an elk (TA-15/EF Firing Site/11-26-97/Cow) that spent over 55% of its time within TAs (TA-15 and TA-16) at LANL associated with firing site activities and, in fact, was collected within 100 meters of EF site—a non-active firing site heavily contaminated with natural and depleted uranium (Hanson and Miera 1976, Hanson and Miera 1978)—and contained over 50 times higher levels of uranium in its muscle than uranium in the muscle tissue of elk collected from BG locations. Although the ultimate deposition site of uranium is the bone (Whicker and Schultz 1982), the uptake of uranium by this particular elk may have been recent because the levels of uranium in the bone were relatively low and just slightly higher than uranium concentrations in bone from BG elk.

A comparison of radionuclide concentrations in muscle and bone tissue in deer from LANL lands with deer collected from BG areas as a group shows that most radionuclides, with the exception of ^{238}Pu in muscle tissue of deer collected on LANL lands, were not significantly different ($p<0.10$) from muscle and bone tissues in deer collected from areas a great distance away from the Laboratory (Table 1). Although ^{238}Pu levels were significantly higher in muscle tissue of deer collected from LANL lands as compared to BG animals, 10 out of the 11 ^{238}Pu concentrations were in nondetectable quantities; and thus, were not significantly different from zero. The differences between ^{238}Pu in muscle tissue of LANL deer and BG deer, in any case, were very low, and ^{238}Pu concentrations in muscle of LANL deer (6.3E-05 pCi/g dry) were still within ^{238}Pu concentrations of BG deer (<19E-05 pCi/g dry) collected from other parts of New Mexico (WIPP 1995) and Nevada (NTS 1995).

Most radionuclide concentrations in muscle and bone tissue of elk collected from LANL lands, as a group, were not significantly different ($p<0.10$) than tissues from elk collected from BG locations (Table 2). A comparison of elk that were radio collared and have an average time spent of 50% on LANL lands to elk that were killed by automobiles and that have an unknown time factor on LANL lands shows that most radionuclides, with the exception of ^{90}Sr in muscle tissue of radio collared elk, were not significantly higher in muscle and, especially in bone tissue, from road kill elk collected as part of the environmental surveillance program (Tables 3 and 4). It is not completely known why ^{90}Sr concentrations in muscle tissues of radio collared elk were significantly higher than in road kill elk or in BG elk, because ^{90}Sr, an analog of Ca, deposits primarily in the bone (Whicker and Schultz 1982) and has a very low transfer rate from bone to meat of <0.01 (Meadows and Salazar 1982). Also, besides the low sample number (n = 4), all of the ^{90}Sr values in muscle from radio collared elk were in nondetectable quantities and were, therefore, not significantly different from zero and should be viewed with caution.

During the fitting of the radio collars on each of the six elk, which was mentioned previously, approximately 20 mL of blood was extracted and analyzed for ^{3}H (as well as a whole host of disease parameters [Biggs et al. 1998]). The average concentration of ^{3}H in these elk before tracking was 0.60 (±1.10) pCi/mL and compares well with the average ^{3}H concentrations in muscle tissues from these (post tracking) elk (0.20 [±0.36] pCi/mL) a year to two years later. Also, the pretracked elk (TA-15-Firing Site 306/11-19-97/Cow) that had the highest ^{3}H concentration (2.20 [±0.80] pCi/mL) measured from a blood sample at her capture in 1996 (Biggs et al. 1996b), now 1.6 years later, contained a lower ^{3}H amount in her muscle tissue (0.57 [±0.69) pCi/mL). The biological half-life of ^{3}H is seven days (Whicker and Shultz 1982).

The CEDE from the ingestion of varying quantities of muscle and bone of deer and elk can be found in Tables 5 and 6. All of the values were very low, especially estimated using average source terms and consumption rates, and the most conservative (worst case) scenario—a 95% source term (mean of each radionuclide plus two standard deviations) at the maximum consumption rate—shows a CEDE, after the subtraction of background, of 0.220 and 3.762 mrem/y for deer muscle and bone; and, 0.070 and 1.672 for muscle and bone for road kill elk and 0.117 and 1.670 mrem/y for muscle and bone of radio collared elk. Doses of elk were similar to doses estimated from elk muscle and bone in 1980 (Meadows and Salazar 1982), 1992–94 (Fresquez et al., 1994) and 1992–95 (Fresquez et al. 1996a).

The highest combined muscle plus bone dose (from the deer) was <4.0% of the International Commission on Radiological Protection permissible dose limit of 100 mrem/y from all pathways (ICRP 1978). And, based on the highest net CEDE, the RECF was estimated at 2.0E-06 (two in a million), which is far below the Environmental Protection Agency upper bound guideline of 10^{-4} (100 in million) that is deemed acceptable for known or suspected carcinogens in air, drinking water, and at hazardous waste sites (USEPA 1994). Again, the estimates of risk are usually conservative, and health effects from radiation have been observed in humans only at doses in excess of 10 rem delivered at high dose rates (HPS 1996).

IV. CONCLUSIONS

Based on the monitoring of deer and elk for radiological constituents in the LANL area from 1991 through 1998, all radiological constituents detected in muscle and bone tissues were low and most, with the exception of a few elements in a few animals, were within concentrations detected in tissues of deer and elk collected from BG locations. As a result, the radiological doses, estimated at the most conservative levels, show that Laboratory operations do not result in significant impacts to the general public from consuming meat and/or bone from deer or elk that inhabit LANL lands.

Table 1. Radionuclide Concentrations (+/- counting uncertainty) in the Muscle and Bone of Deer from LANL and BG Areas from 1995 through 1997.

Tissue/Location/Date/Sex	^{3}H pCi mL^{-1}	Total Uranium ng dry g^{-1}	^{137}Cs 10^{-3} pCi dry g^{-1}	^{90}Sr 10^{-3} pCi dry g^{-1}	^{238}Pu 10^{-5} pCi dry g^{-1}	$^{239,240}Pu$ 10^{-5} pCi dry g^{-1}	^{241}Am 10^{-5} pCi dry g^{-1}
MUSCLE							
LANL							
TA-16/State Road 4/8-7-95/Doe	0.00 (0.30)	0.36 (0.05)	18.5 (5.4)	4.5 (13.5)	0.0 (1.8)	4.5 (1.8)	
TA -8/State Road 501/9-25-95/buck	0.50 (0.30)	0.50 (0.05)	459.0 (45.0)	4.5 (13.5)	0.0 (1.8)	0.0 (1.8)	4.5 (1.8)
TA-73/State Road 502/10-17-95/Doe	0.80 (0.30)	0.63 (0.05)	10.4 (3.6)	0.0 (9.0)	4.5 (4.5)	0.0 (1.8)	4.5 (1.8)
TA-16/State Road 501/6-25-96/Doe	0.35 (0.14)	0.80 (0.10)	17.6 (3.2)	4.0 (8.0)	1.2 (1.2)	2.8 (1.8)	-1.2 (0.4)
TA-55/Pajarito Roas/8-14-96/Buck	0.13 (0.14)	1.20 (0.12)	25.6 (4.0)	-24.4 (8.0)	0.2 (0.8)	0.8 (0.8)	1.2 (1.2)
San Ildefonso/State Road 502/11-25-96/Buck	0.14 (0.13)	0.45 (0.45)	21.2 (4.5)	0.9 (2.7)	-2.3 (0.9)	0.2 (2.3)	7.2 (2.7)
TA-73/State Road 502/11-25-96/Buck	0.27 (0.14)	0.18 (0.18)	15.3 (3.6)	49.5 (4.1)	0.2 (0.9)	-0.9 (0.9)	2.3 (1.8)
TA-73/State Road 502/12-4-96/Doe	0.03 (0.13)	0.45 (0.45)	19.4 (3.6)	3.6 (1.4)	-1.8 (0.9)	3.2 (1.4)	1.8 (1.8)
TA-53/LANSCE Road/2-10-97/Buck	0.28 (0.14)	0.18 (0.18)	6.8 (10.0)	-19.8 (12.2)	5.9 (2.7)	6.3 (3.2)	1.6 (0.7)
TA-21/DP Road/10-02-97/Buck	0.81 (0.81)	0.90 (0.45)	156.2 (15.8)	307.8 (115.7)	13.1 (9.0)	23.0 (8.6)	4.5 (2.2)
Los Alamos/Diamond Drive/10-29-97/Buck	0.25 (0.67)	1.35 (0.45)	-1.8 (81.0)	210.6 (137.7)	47.7 (10.8)	35.6 (9.9)	3.0 (0.8)
N	11	11	11	11	11	11	10
Minimum	0.00	0.18	-1.80	-24.40	-2.30	-0.90	-1.20
Maximum	0.81	1.35	0.00	307.80	47.70	35.60	7.20
Mean	0.32 a[1]	0.64 a	68.02 a	49.20 a	6.25 a	6.86 a	2.94 a
Std. Dev.	0.28	0.39	136.64	107.69	14.43	11.65	2.33
BACKGROUND							
Cuba, NM /2-12-96/Doe	-0.10 (0.50)	0.50 (0.05)	21.2 (5.6)	0.0 (8.0)	0.0 (1.6)	0.0 (1.6)	0.0 (4.0)
El Vado, NM /3-19-96/Buck	0.40 (0.30)	1.00 (0.10)	15.5 (5.0)	20.0 (30.0)	-5.0 (1.0)	10.0 (5.0)	0.0 (2.0)
Dulce, NM /10-31-96/Buck	0.15 (0.40)	1.80 (0.45)	6.8 (2.3)	22.5 (2.7)	-0.5 (0.9)	0.5 (1.4)	18.5 (10.4)
N	3	3	3	3	3	3	3
Minimum	-0.10	0.50	6.80	0.00	-5.00	0.00	0.00
Maximum	0.40	1.80	21.20	22.50	0.00	10.00	18.50
Mean	0.15 a	1.10 a	14.50 a	14.17 a	-1.82 b	3.48 a	6.17 a
Std. Dev.	0.25	0.66	7.25	12.33	2.77	5.65	10.68

[1]Means within the same column followed by the same letter are not significantly different at the 0.05 probability level using a nonparametric Wilcoxon Rank Sum Test.

Note: Missing data was due to either the sample not being analyzed, lost in analysis, or outlier.

Table 1 (Continued).

Tissue/Location/Date/Sex	^{3}H pCi mL^{-1}	Total Uranium ng dry g^{-1}	^{137}Cs 10^{-3} pCi dry g^{-1}	^{90}Sr 10^{-3} pCi dry g^{-1}	^{238}Pu 10^{-5} pCi dry g^{-1}	$^{239,240}Pu$ 10^{-5} pCi dry g^{-1}	^{241}Am 10^{-5} pCi dry g^{-1}
LEG BONE							
LANL							
TA-16/State Road 4/8-7-95/Doe	0.10 (0.30)	0.90 (0.45)	9.2 (4.6)	1610.0 (138.0)	0.0 (46.0)	0.0 (18.4)	
TA -8/State Road 501/9-25-95/buck	0.30 (0.30)	1.30 (0.15)	8.5 (4.3)	1399.0 (127.0)	127.2 (42.4)	0.0 (17.0)	25.4 (42.4)
TA-21/State Road 502/10-17-95/Doe	1.00 (0.30)	1.30 (0.15)	0.0 (103.0)	2193.0 (129.0)	215.0 (43.0)	0.0 (17.2)	43.0 (17.2)
TA-16/State Road 501/6-25-96/Doe	-0.34 (0.14)	0.43 (0.05)	21.5 (17.2)		17.2 (12.9)	12.9 (12.9)	60.2 (34.4)
TA-55/Pajarito Roas/8-14-96/Buck	0.12 (0.14)	0.86 (0.09)	12.9 (17.2)	8824.0 (473.0)	30.1 (17.2)	8.6 (8.6)	60.2 (25.8)
San Ildefonso/State Road 502/11-25-96/Buck	0.52 (0.14)	8.80 (4.40)	22.0 (35.2)		-4.4 (8.8)	35.2 (17.6)	22.0 (17.6)
TA-73/State Road 502/11-25-96/Buck	0.45 (0.14)	1.76 (1.75)	35.2 (52.8)	651.2 (48.4)	-66.0 (30.8)	-35.2 (4.4)	30.8 (17.6)
TA-73/State Road 502/12-4-96/Doe	0.12 (0.14)	1.76 (1.75)	88.0 (132.0)	541.2 (26.4)	26.4 (26.4)	17.6 (22.0)	61.6 (22.0)
TA-53/LANSCE Road/2-10-97/Buck	0.53 (0.14)	1.76 (1.76)	1.8 (13.2)	1227.6 (136.0)	30.8 (17.6)	22.0 (17.6)	18.5 (7.5)
TA-21/DP Road/10-02-97/Buck	0.92 (0.74)	0.00 (4.40)	39.6 (8.8)	4831.2 (963.6)	83.6 (57.2)	61.6 (61.6)	12.8 (15.8)
TA-1/Diamond Drive/10-29-97/Buck	0.04 (0.66)	0.00 (4.40)	22.0 (4.4)	2195.6 (440.0)	-268.4 (70.4)	-17.6 (123.2)	42.7 (10.1)
N	11	11	11	9	11	11	10
Minimum	-0.34	0.00	0.00	541.20	-268.40	-35.20	12.76
Maximum	1.00	8.80	0.00	8824.00	215.00	61.60	61.60
Mean	0.34 a[1]	1.72 a	23.70 a	2608.09 a	17.41 a	9.55 a	37.72 a
Std. Dev.	0.40	2.44	24.76	2654.89	120.55	25.71	18.48
BACKGROUND							
Cuba, NM /2-12-96/Doe	-0.20 (0.60)	0.40 (0.20)	0.0 (103.2)	989.0 (86.0)	0.0 (17.2)	0.0 (17.2)	43.0 (43.0)
El Vado, NM /3-19-96/Buck	0.30 (0.30)	1.30 (0.15)	-8.6 (103.2)	946.0 (129.0)	0.0 (1.0)	0.0 (17.2)	43.0 (17.2)
Dulce, NM /10-31-96/Buck	0.12 (0.13)	4.40 (4.40)	39.6 (57.2)	787.6 (57.2)	-17.6 (30.8)	1.8 (17.6)	92.4 (30.8)
N	3	3	3	3	3	3	3
Minimum	-0.20	0.40	-8.60	787.60	-17.60	0.00	43.00
Maximum	0.30	4.40	39.60	989.00	0.00	1.80	92.40
Mean	0.07 a	2.03 a	10.33 a	907.53 a	-5.87 a	0.60 a	59.47 a
Std. Dev.	0.25	2.10	25.71	106.07	10.16	1.04	28.52

[1]Means within the same column followed by the same letter are not significantly different at the 0.05 probability level using a nonparametric Wilcoxon Rank Sum Test.

Note: Missing data was due to either the sample not being analyzed, lost in analysis, or outlier.

Table 2. Radionuclide Concentrations (+/- counting uncertainty) in Muscle and Bone of Elk From LANL and BG Areas from 1991 through 1998.

Tissue/Location/Date/Sex	^{3}H pCi mL^{-1}		Total Uranium ng dry g^{-1}		^{137}Cs 10^{-3} pCi dry g^{-1}		^{90}Sr 10^{-3} pCi dry g^{-1}		^{238}Pu 10^{-5} pCi dry g^{-1}		$^{239,240}Pu$ 10^{-5} pCi dry g^{-1}		^{241}Am 10^{-5} pCi dry g^{-1}	
MUSCLE														
LANL														
TA-49/Water Canyon/1-6-92/Cow			-0.60	(0.00)	215.4	(252.4)	0.0	(8.0)	0.0	(12.0)	2.0	(8.0)		
TA-5/Mortandad Canyon/1-16-92/Cow			-0.20	(0.00)	121.5	(170.5)	0.0	(5.0)	1.0	(7.5)	2.5	(5.0)		
TA-18/Pajarito Road/10-20-92/Cow			4.22	(0.30)	-3.9	(52.4)	0.0	(9.0)	0.0	(27.0)	0.0	(18.0)		
TA-46/Pajarito Road/11-14-94/Cow	0.10	(0.40)	2.10	(0.40)	40.3	(60.5)	12.6	(12.6)	-4.2	(12.6)	25.2	(16.8)		
TA-49/State Road 4/12-13-94/Cow	4.70	(0.50)	0.20	(0.10)	11.3	(6.3)	4.2	(8.4)	-11.8	(13.0)	0.0	(13.0)		
TA-16/S-Site Road/1-30-95/Bull	0.50	(0.40)	0.10	(0.10)	-5.9	(11.8)	4.9	(9.8)	0.0	(4.9)	0.0	(1.9)		
TA-16/S-Site Road/6-21-95/Bull	11.10	(1.00)	0.90	(0.10)	25.3	(8.7)	9.2	(9.2)	9.2	(13.8)	4.6	(13.8)		
TA-16/State Road 4/12-18-95/Bull	0.30	(0.30)	0.90	(0.10)	26.7	(6.6)	4.1	(8.2)	0.0	(1.7)	0.0	(1.7)	4.1	(1.7)
San Ildefonso/State Road 4/6-18-96/Cow	0.30	(0.14)	0.10	(0.01)	11.2	(1.6)	-35.0	(8.0)	0.8	(1.2)	1.6	(0.8)	5.6	(2.8)
TA-16/State Road 501/6-25-96/Cow	0.14	(0.14)	0.10	(0.01)	8.8	(1.2)	-14.0	(4.0)	-0.8	(0.2)	2.0	(1.2)	2.0	(1.2)
USFS/Ski Hill Road/9-13-96/Bull[1]	0.32	(0.14)	0.44	(0.44)	29.3	(6.8)	51.9	(6.6)	12.6	(3.2)	1.4	(1.4)	9.2	(2.7)
TA-18/Pajarito Road/12-2-96/Cow	0.41	(0.14)	0.44	(0.44)	15.8	(3.1)	24.2	(2.6)	0.2	(0.9)	0.4	(1.3)	2.6	(1.3)
TA-54/Pajarito Road/12-9-96/Cow	0.24	(0.14)	0.18	(0.18)	9.7	(14.5)	51.9	(5.3)	-1.8	(0.9)	4.4	(2.2)	0.9	(1.3)
TA-36/Pajarito Road/1-9-97/Bull	0.22	(0.14)	0.44	(0.44)	28.2	(42.3)	100.8	(6.2)	0.2	(0.5)	2.2	(1.3)	4.4	(1.3)
San Ildefonso/Scared Area/1-19-97/Cow	0.24	(0.14)	5.72	(0.44)	8.4	(12.3)	-8.4	(13.2)	-1.3	(1.8)	4.8	(2.2)	11.4	(5.7)
San Ildefonso/State Road 4/1-24-97/Cow	1.09	(0.14)	1.76	(0.44)	11.9	(18.0)	16.7	(12.0)	2.6	(2.7)	4.0	(2.7)	0.9	(6.6)
TA-49/State Road 4/1-27-97/Cow	0.01	(0.13)	1.76	(0.44)	4.0	(1.3)	-29.9	(18.5)	2.2	(2.7)	0.2	(2.7)	8.4	(7.5)
TA-54/Pajarito Road/3-12-97/Cow[2]														
USFS/Ski Hill Road/9-14-97/Cow[3]	-0.29	(0.66)	0.88	(0.44)	10.1	(15.0)	63.4	(48.8)	20.7	(10.1)	0.0	(8.8)		
TA-15/Firing Site 306/11-19-97/Cow[4]	0.57	(0.69)	2.20	(0.44)	92.4	(138.6)	141.7	(109.6)	-48.8	(17.2)	-62.9	(29.0)		
TA-15/EF Firing Site/11-26-97/Cow[5]	0.18	(0.67)	44.40	(4.40)	15.8	(23.8)	119.2	(149.2)	-2.6	(5.7)	-7.9	(6.2)		
TA-16/K-Site Road/3-30-98/Cow	0.46	(0.71)	0.88	(0.44)	54.6	(81.8)	-0.9	(36.0)	-11.8	(5.7)	7.9	(7.0)		
N	18		21		21		21		21		21		10	
Minimum	-0.29		-0.60		-5.90		-35.00		-48.80		-62.90		0.90	
Maximum	11.10		44.40		215.40		141.70		20.70		25.20		11.40	
Mean	1.14 a[6]		3.19 a		34.81 a		24.60 a		-1.60 a		-0.36 a		4.95 a	
Std. Dev.	2.71		9.56		51.56		47.27		12.89		15.52		3.65	

Table 2 (Continued).

Tissue/Location/Date/Sex	^{3}H pCi mL^{-1}		Total Uranium ng dry g^{-1}		^{137}Cs 10^{-3} pCi dry g^{-1}		^{90}Sr 10^{-3} pCi dry g^{-1}		^{238}Pu 10^{-5} pCi dry g^{-1}		$^{239,240}Pu$ 10^{-5} pCi dry g^{-1}		^{241}Am 10^{-5} pCi dry g^{-1}	
MUSCLE														
BACKGROUND														
Chama,NM/12-4-91/Cow			0.85	(0.15)	242.8	(333.2)	0.0	(9.0)	0.0	(13.5)	0.0	(9.0)		
Lindreth,NM/12-17-91/Cow			0.05	(0.50)	274.8	(257.4)	0.0	(8.0)	0.0	(12.0)	0.0	(8.0)		
Tres Piedras,NM/2-9-93/Cow			2.20	(0.20)	11.8	(18.1)	0.0	(4.0)	0.0	(12.0)	0.0	(8.0)		
Chama,NM/1-9-96/Bull	0.30	(0.30)	0.50	(0.05)	48.4	(9.2)	4.0	(8.2)	0.0	(1.7)	0.0	(1.7)	4.1	(1.7)
Coyote, NM/11-19-96/Cow	0.12	(0.15)	0.44	(0.44)	16.3	(24.7)	0.0	(2.2)	-0.4	(0.9)	-0.4	(0.2)	-0.4	(2.2)
Coyote, NM/11-20-96/Cow	0.03	(0.14)	0.88	(0.44)	48.8	(8.8)	0.0	(4.4)	-6.2	(0.9)	-2.6	(2.7)	11.4	(4.9)
Tres Piedras,NM/11-13-97/Bull	0.37	(0.68)	0.88	(0.44)	22.9	(3.5)							2.3	(0.8)
N	4		7		7		6		6		6		4	
Minimum	0.03		0.05		11.80		0.00		-6.20		-2.60		-0.40	
Maximum	0.37		2.20		274.80		4.00		0.00		0.00		11.40	
Mean	0.21 a		0.83 a		95.11 a		0.67 b		-1.10 a		-0.50 a		4.35 a	
Std. Dev.	0.16		0.68		113.13		1.63		2.50		1.04		5.05	

[1]radiocollared elk #16038
[2]radiocollared elk # 16036
[3]radiocollared elk # 16037
[4]radiocollared elk # 16034
[5]radiocollared elk # 16033
[6]Means within the same column followed by the same letter are not significantly different at the 0.10 probability level using a nonparametric Wilcoxon Rank Sum Test.
Note: Missing data was due to either the sample not being analyzed, lost in analysis, or outlier.

Table 2 (Continued).

Tissue/Location/Date/Sex	^{3}H pCi mL^{-1}		Total Uranium ng dry g^{-1}		^{137}Cs 10^{-3} pCi dry g^{-1}		^{90}Sr 10^{-3} pCi dry g^{-1}		^{238}Pu 10^{-5} pCi dry g^{-1}		$^{239,240}Pu$ 10^{-5} pCi dry g^{-1}		^{241}Am 10^{-5} pCi dry g^{-1}	
LEG BONE														
LANL														
TA-49/Water Canyon/1-6-92/cow			7.30	(0.80)	259.9	(110.0)	990.0	(110.0)	0.0	(165.0)	0.0	(110.0)		
TA-5/Mortandad Canyon/1-16-92/Cow					53.1	(107.5)	952.0	(112.0)	0.0	(168.0)	0.0	(112.0)		
TA-18/Pajarito Road/10-20-92/Cow			22.00	(2.20)	46.1	(46.7)	1705.0	(110.0)	55.0	(165.0)	55.0	(110.0)		
TA-46/Pajarito Road/11-14-94/Cow	0.70	(0.40)	6.50	(0.85)	12.9	(4.3)	1634.0	(86.0)	129.0	(43.0)	-43.0	(43.0)		
TA-49/State Road 4/12-13-94/Cow	3.10	(0.40)	186.90	(85.00)	0.0	(128.2)	2189.0	(160.0)	427.0	(160.0)	-106.8	(53.4)		
TA-16/S-Site Road/1-30-95/Bull	0.30	(0.40)	4.20	(0.50)	15.6	(20.8)	1404.0	(104.0)	208.0	(52.0)	-52.0	(20.8)		
TA-16/S-Site Road/6-21-95/Bull	12.50	(1.10)	1.50	(0.25)	9.9	(14.8)	1430.0	(98.5)	0.0	(19.7)	49.3	(19.7)		
TA-16/State Road 4/12-18-95/Bull	0.30	(0.30)	0.50	(0.05)	5.3	(10.6)	2173.0	(159.0)	53.0	(21.2)	0.0	(21.2)	53.0	(53.0)
San Ildefonso/State Road 4/6-18-96/Cow	-0.04	(0.13)	5.30	(0.53)	-5.3	(127.2)	3964.0	(318.0)	21.2	(21.2)	58.3	(31.8)	95.4	(58.3)
TA-16/State Road 501/6-25-96/Cow	0.15	(0.14)	1.10	(0.10)	-5.3	(127.2)	2215.0	(159.0)	15.9	(15.9)	10.6	(10.6)	26.5	(68.9)
USFS/Ski Hill Road/9-13-96/Bull[1]	0.23	(0.14)	5.00	(5.00)	25.0	(4.0)	1280.0	(105.0)	45.0	(15.0)	90.0	(20.0)	75.0	(30.0)
TA-18/Pajarito Road/12-2-96/Cow	-0.06	(0.13)	5.00	(5.00)	270.0	(405.0)	1260.0	(105.0)	-20.0	(20.0)	-20.0	(10.0)	10.0	(25.0)
TA-54/Pajarito Road/12-9-96/Cow	0.42	(0.14)	2.00	(2.00)	-40.0	(15.0)	1090.0	(110.0)	2.0	(10.0)	80.0	(20.0)	15.0	(25.0)
TA-36/Pajarito Road/1-9-97/Bull	1.54	(0.15)	2.00	(2.00)	-15.0	(120.0)	625.0	(35.0)	-5.0	(10.0)	15.0	(10.0)	40.0	(20.0)
San Ildefonso/Scared Area/1-19-97/Cow	-0.01	(0.13)	2.00	(2.00)	2.0	(15.0)	955.0	(130.0)	30.0	(35.0)	35.0	(35.0)	65.0	(110.0)
San Ildefonso/State Road 4/1-24-97/Cow	-0.08	(0.13)	15.00	(5.00)	2.0	(15.0)	1375.0	(165.0)	25.0	(35.0)	25.0	(25.0)	50.0	(80.0)
TA-49/State Road 4/1-27-97/Cow	0.14	(0.14)	50.00	(5.00)	10.0	(5.0)	715.0	(110.0)	-25.0	(10.0)	10.0	(20.0)	40.0	(40.0)
TA-54/Pajarito Road/3-12-97/Cow[2]	0.66	(0.15)	10.00	(5.00)	2.0	(120.0)	885.0	(140.0)	15.0	(20.0)	10.0	(20.0)	-25.0	(25.0)
USFS/Ski Hill Road/9-14-97/Cow[3]	0.05	(0.68)	0.00	(5.80)	34.8	(52.2)	2488.2	(661.2)	139.2	(110.2)	150.8	(116.0)		
TA-15/Firing Site 306/11-19-97/Cow[4]	1.07	(0.72)	5.80	(5.80)	-17.4	(1044.0)	1270.2	(400.0)	133.4	(133.4)	-162.4	(92.8)		
TA-15/EF Firing Site/11-26-97/Cow[5]	1.27	(0.74)	11.60	(5.80)	0.0	(1044.0)	2070.6	(632.2)	307.4	(1716.8)	-307.4	(2070.6)		
TA-16/K-Site Road/3-30-98/Cow	0.23	(0.69)	11.60	(5.80)	46.4	(69.6)	2575.2	(597.4)	-162.4	(133.4)	-92.8	(133.4)		
N	19		21		22		22		22		22		11	
Minimum	-0.08		0.00		-40.00		625.00		-162.40		-307.40		-25.00	
Maximum	12.50		186.90		270.00		3964.00		427.00		150.80		95.40	
Mean	1.18 a[6]		16.92 a		32.36 a		1602.05 a		63.35 a		-8.88 a		40.45 a	
Std. Dev.	2.85		40.46		78.43		779.91		124.09		95.76		33.34	

Table 2 (Continued).

Tissue/Location/Date/Sex	^{3}H pCi mL^{-1}		Total Uranium ng dry g^{-1}		^{137}Cs 10^{-3} pCi dry g^{-1}		^{90}Sr 10^{-3} pCi dry g^{-1}		^{238}Pu 10^{-5} pCi dry g^{-1}		$^{239,240}Pu$ 10^{-5} pCi dry g^{-1}		^{241}Am 10^{-5} pCi dry g^{-1}	
LEG BONE														
BACKGROUND														
Chama,NM/12-4-91/Cow			3.60	(0.60)	6.5	(121.6)	2880.0	(192.0)	0.0	(192.0)				
Lindreth,NM/12-17-91/Cow			2.20	(0.40)	210.8	(120.9)	806.0	(124.0)	0.0	(186.0)	0.0	(124.0)		
Tres Piedras,NM/2-9-93/Cow			0.00	(5.50)	3.2	(42.6)	1815.0	(110.0)	55.0	(165.0)	0.0	(110.0)		
Chama,NM/1-9-96/Bull	-0.40	(0.30)	0.40	(0.05)	30.1	(43.0)	1505.0	(86.0)	86.0	(43.0)	0.0	(17.2)	43.0	(17.2)
Coyote, NM/11-19-96/Cow	0.14	(0.13)	2.00	(2.00)	30.0	(45.0)	350.0	(40.0)	-45.0	(10.0)	-15.0	(20.0)	35.0	(20.0)
Coyote, NM/11-20-96/Cow	0.06	(0.13)	2.00	(2.00)	-25.0	(120.0)	450.0	(45.0)	35.0	(25.0)	-15.0	(15.0)	45.0	(20.0)
Tres Piedras,NM/11-13-97/Bull	0.16	(0.67)	5.80	(5.80)	46.4	(5.8)	1299.2	(475.6)	-34.8	(81.2)				
N	4		7		7		7		7		5		3	
Minimum	-0.40		0.00		-25.00		350.00		-45.00		-15.00		35.00	
Maximum	0.16		5.80		210.80		2880.00		86.00		0.00		45.00	
Mean	-0.01 b		2.29 b		43.14 a		1300.74 a		13.74 a		-6.00 a		41.00 a	
Std. Dev.	0.26		1.96		77.51		882.49		47.54		8.22		5.29	

[1]radiocollared elk #16038
[2]radiocollared elk # 16036
[3]radiocollared elk # 16037
[4]radiocollared elk # 16034
[5]radiocollared elk # 16033
[6]Means within the same column followed by the same letter are not significantly different at the 0.05 probability level using a nonparametric Wilcoxon Rank Sum Test.
Note: Missing data was due to either the sample not being analyzed, lost in analysis, or outlier.

Table 3. Mean Radionuclide Concentrations (±SD) in Elk Muscle Collected from Radio Collared (RC) and Road Kill (RK) Elk on LANL Lands as Compared to Elk from BG.

Elk Muscle	^{3}H pCi/mL[1]	Uranium ng/g dry[2]	^{137}Cs 10^{-3} pCi/g dry	^{90}Sr 10^{-3} pCi/g dry	^{238}Pu 10^{-5} pCi/g dry	$^{239,240}Pu$ 10^{-5} pCi/g dry	^{241}Am 10^{-5} pCi/g dry
LANL RC	0.20 (0.36)a	12.00 (21.63)a	37 (38)a	94.10 (43.3)a[3]	-4.52 (31.0)a	-17.4 (30.6)b	
LANL RK	1.42 (3.03)a	1.12 (1.64)a	34 (55)a	8.30 (30.9)b	-0.91 (4.9)a	3.6 (6.0)a	4.2 (3.5)a
BG	0.21 (0.16)a	0.83 (0.68)a	95 (113)a	0.67 (1.6)b	-1.10 (2.5)a	-0.5 (1.0)b	4.4 (5.1)a

[1]pCi per mL of tissue moisture.
[2]The ash to dry and the dry to wet weight ratios for muscle is 0.044 and 0.255, respectively.
[3]Means within the same column followed by the same letter are not significantly different at the 0.10 probability level using a nonparametric Wilcoxon Rank Sum Test.

Table 4. Mean Radionuclide Concentrations (±SD) in Elk Bone Collected from Radio Collared (RC) and Road Kill (RK) Elk on LANL Lands as Compared to Elk from BG.

Elk Bone	^{3}H pCi/mL[1]	Uranium ng/g dry[2]	^{137}Cs 10^{-3} pCi/g dry	^{90}Sr 10^{-3} pCi/g dry	^{238}Pu 10^{-5} pCi/g dry	$^{239,240}Pu$ 10^{-5} pCi/g dry	^{241}Am 10^{-5} pCi/g dry
LANL RC	0.66 (0.52)a[3]	6.5 (4.6)a	8.9 (21)a	1599 (658)a	128 (114)a	-43.8 (188.6)a	
LANL RK	1.37 (3.32)a	20.2 (46.2)a	39.3 (88)a	1603 (831)a	44 (124)b	1.4 (51.5)a	47 (26.0)a
BG	-0.01 (0.26)b	2.3 (2.0)b	43.1 (78)a	1301 (883)a	14 (48)b	-6.0 (8.2)a	41 (5.3)a

[1]pCi per mL of tissue moisture.
[2]The ash to dry and the dry to wet weight ratios for bone is 0.580 and 0.792, respectively.
[3]Means within the same column followed by the same letter are not significantly different at the 0.10 probability level using a nonparametric Wilcoxon Rank Sum Test.

Table 5. The CEDE for the Ingestion of Deer Collected from LANL and BG Locations.

Tissue/Location	mrem/lb (±2SD)	Average[1] Mrem/y (±2SD)	Maximum[2] mrem/y (±2SD)
MUSCLE			
LANL	0.00120 (0.00394)	0.02520 (0.08274)	0.06000 (0.19700)
BG	0.00036 (0.00039)	0.00756 (0.00819)	0.01800 (0.01950)
BONE			
LANL	0.10890 (0.22783)	0.54450 (1.13915)	1.41570 (2.96179)
BG	0.03850 (0.00883)	0.19250 (0.04415)	0.50050 (0.11479)

[1]Average consumption rate for muscle and bone is 21 lb (9.5 kg) and 5 lb (2.3 kg), respectively, per person per year.

[2]Maximum consumption rate for muscle and bone is 50 lb (22.7 kg) and 13 lb (5.9 kg), respectively, per person per year.

Table 6. The CEDE for the Ingestion of (Radio Collared [RC] and Road Killed [RK]) Elk Collected from LANL and BG Locations.

Tissue/Location	mrem/lb (±2SD)	Average[1] Mrem/y (±2SD)	Maximum[2] mrem/y (±2SD)
MUSCLE			
LANL RC	0.00180 (0.00358)	0.03780 (0.07518)	0.09000 (0.17900)
LANL RK	0.00041 (0.00304)	0.00861 (0.06384)	0.02050 (0.15200)
BG	0.00060 (0.00145)	0.01260 (0.03045)	0.03000 (0.07250)
BONE			
LANL RC	0.07700 (0.18540)	0.38550 (0.92700)	1.00230 (2.41020)
LANL RK	0.07830 (0.19540)	0.39150 (0.97700)	1.01790 (2.54020)
BG	0.06270 (0.08240)	0.31350 (0.41200)	0.81510 (1.07120)

[1]Average consumption rate for muscle and bone is 21 lb (9.5 kg) and 5 lb (2.3 kg), respectively, per person per year.

[2]Maximum consumption rate for muscle and bone is 50 lb (22.7 kg) and 13 lb (5.9 kg), respectively, per person per year.

V. ACKNOWLEDGMENTS

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APPENDIX A

PERCENT TIME SPENT BY RADIO COLLARED ELK ON LANL LANDS BY TECHNICAL AREA

Elk 16033

Collar_id	Count
16033	307

Total Number of Locations for Elk 16033

Technical_are	Count	Count_Animal_id	Percent
TA-05	23	23	7.49
TA-06	16	16	5.21
TA-08	13	13	4.23
TA-09	7	7	2.28
TA-11	4	4	1.30
TA-14	3	3	0.98
TA-15	74	74	24.10
TA-16	96	96	31.27
TA-22	5	5	1.63
TA-28	4	4	1.30
TA-36	21	21	6.84
TA-37	3	3	0.98
TA-40	6	6	1.95
TA-46	2	2	0.65
TA-49	6	6	1.95
TA-53	3	3	0.98
TA-54	1	1	0.33
TA-67	3	3	0.98
TA-68	2	2	0.65
TA-69	1	1	0.33

Percent of Locations by TA

Elk 16034

Collar_id	Count	Count_Animal_id
16034	328	328

Total Number of Locations for Elk 16034

Technical_area	Count	Count_Animal_id	percent
TA-05	1	1	0.30
TA-06	5	5	1.52
TA-08	2	2	0.61
TA-09	1	1	0.30
TA-14	6	6	1.83
TA-15	12	12	3.66
TA-16	15	15	4.57
TA-18	17	17	5.18
TA-36	57	57	17.38
TA-40	3	3	0.91
TA-46	1	1	0.30
TA-51	4	4	1.22
TA-54	82	82	25.00
TA-65	8	8	2.44
TA-69	1	1	0.30

Percent of Locations by TA

Elk 16035

Collar_id	Count	Count_Animal_id
16035	192	192

Total Number of Locations for Elk 16035

Percent of Locations by TA

Technical_are	Count	Count_Animal_id	percent
TA-15	1	1	0.52
TA-18	1	1	0.52
TA-36	44	44	22.92
TA-49	1	1	0.52
TA-54	22	22	11.46
TA-65	1	1	0.52
TA-68	8	8	4.17
TA-71	1	1	0.52
TA-72	1	1	0.52

Elk 16036

Animal_id	Count	Count_Collar_id
1603601	250	250

Total Number of Locations for Elk 16036

Percent of Locations by TA

Technical_are	Count	Count_Animal_id	Percent
TA-02	1	1	0.40
TA-05	5	5	2.00
TA-15	5	5	2.00
TA-16	1	1	0.40
TA-18	1	1	0.40
TA-21	2	2	0.80
TA-36	48	48	19.20
TA-46	4	4	1.60
TA-51	4	4	1.60
TA-54	46	46	18.40
TA-68	3	3	1.20
TA-72	11	11	4.40

Elk 16037

Collar_id	Count	Count_Animal_id
16037	320	320

Total Number of Locations for Elk 16037

Technical_are	Count	Count_Animal_id	Percent
TA-02	1	1	0.31
TA-09	2	2	0.62
TA-15	1	1	0.31
TA-16	27	27	8.44
TA-21	1	1	0.31
TA-36	78	78	24.38
TA-39	1	1	0.31
TA-54	7	7	2.19
TA-71	17	17	5.31
TA-73	2	2	0.62

Percent of Locations by TA

Elk 16038

Collar_id	Count	Count_Animal_id
16038	78	78

Total Number of Locations for Elk 16038

Percent of Locations by TA

Technical_are	Count	Count_Animal_id	percent
TA-05	2	2	2.56
TA-16	3	3	3.85