Seasonal food intake affecting ^{137}Cs levels in white-tailed deer at Brookhaven National Laboratory

Esperanza V. Florendo, Community College Institute Program,
Los Angeles Mission College

Dr. Timothy Green, Brookhaven National Laboratory,
Environmental and Waste Management Services Division

Introduction

Food intake by ruminants is mainly controlled by photoperiod, meaning that food intake is higher during the summer months when days are longer than in the winter months. The resulting increase in body weight and fat help the deer prepare for the winter months when food and essential nutrients are scarce.

^{137}Cesium, a radionuclide, is similar to potassium, an element that plays an essential role in maintaining proper body functioning. Therefore, ^{137}Cs can effectively compete with potassium for absorption. After being absorbed by a plant, ^{137}Cs is subsequently distributed throughout various parts, such as twigs and leaves. Consequently, animals that eat these contaminated parts have higher ^{137}Cs levels in their body composition. In deer, ^{137}Cs has a biological half-life of 100 days. This means that, by 100 days, the amount of ^{137}Cs leaving the body would be the same as the amount entering it.

While ^{137}Cs continues to be present in the environment due to radioactive fallout, at Brookhaven National Laboratory (BNL), there are increased levels of ^{137}Cs levels due to soil contamination. Figure 1 shows areas of contaminated soil. Previous studies have shown that BNL deer have higher ^{137}Cs levels than deer that are too far away to graze on contaminated soil. Though soil remediation was implemented at BNL in 2000 and clean up continued until 2003, there are still some contaminated areas that are awaiting clean up.

Four different deer groups are being assessed: 1) BNL deer; 2) deer <1 mile from BNL; 3) deer >1 mile from BNL; and 4) the combined group of BNL deer and deer <1 mile from BNL. The fourth group was formed because the home range of deer is approx. ½ to 1 ½ square miles; thus, there is a possible interaction between BNL deer and deer <1 mile from BNL as there is no physical barrier separating them.

The remediated areas where deer are allowed to graze upon have been cleaned up so that ^{137}Cs levels are ≤ 67 pCi/g. This means that, just below the cleaned soil, areas may contain ^{137}Cs levels that are ≤ 67 pCi/g. Since ^{137}Cs is still present deep in the soil, plants that may have deeper root systems can still reach beyond the clean surface soils, thereby absorbing and transferring ^{137}Cs to the above ground biomass.

Figure 1.

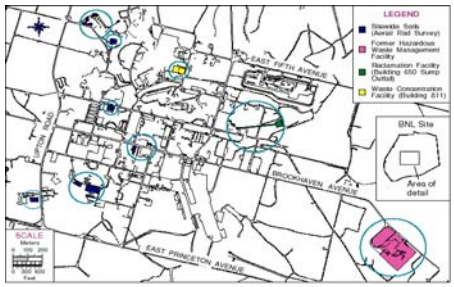
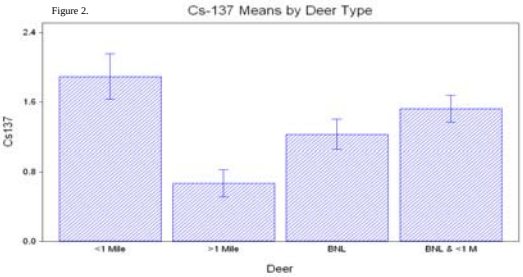


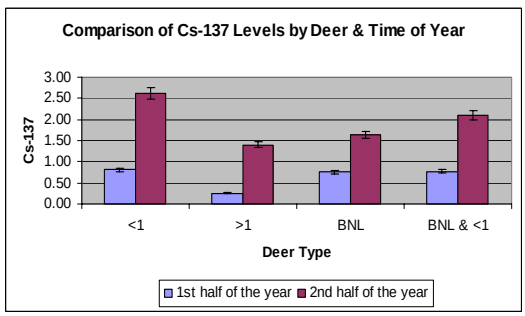
Figure 2.



Hypotheses

Considering the continued accessibility of ^{137}Cs to living organisms, BNL deer and deer <1 mile from BNL should have significantly higher ^{137}Cs levels than deer >1 mile from BNL. Since their home ranges can potentially overlap, there should be no significant differences between BNL deer and deer <1 mile from BNL, even though a general trend of higher ^{137}Cs levels for BNL deer is likely. Within each deer type, it is expected that ^{137}Cs levels would increase during the second half of the year. During the summer, deer increase their food intake, which, in turn, increases ^{137}Cs levels. Since the biological half-life of ^{137}Cs is 100 days (about 3 months), elevated ^{137}Cs levels should continue towards the end of the year.

Figure 3.



Methods

Between 2000 and 2003, deer samples were taken from road kill on and near BNL, hunter donations, and deer killed in or near Fish & Wildlife Service (FWS) properties in Long Island, namely Wertheim National Wildlife Refuge. BNL sampling technicians collected and analyzed the samples. "Wet" weight values were used for analyses as these were the values that were likely to be found in consumed meat .

Results

Data from all years (2000 to 2003) were combined and divided into the four deer types (BNL, <1 Mile Deer, BNL and <1 Mile Deer combined, and >1 Mile Deer). Arithmetic means and standard errors are shown in Figure 2. A one-way ANOVA showed that mean ^{137}Cs levels for the four groups differed significantly ($p < 0.05$). Individual t-tests indicate that deer >1 mile from BNL had a lower ^{137}Cs mean than the other three groups. No significant differences were found within the following group sets: 1) BNL and BNL & <1 mile, and 2) <1 mile and BNL & <1 mile.

Within the four deer types (BNL, <1 mile, >1 mile, and BNL & <1 mile), the data was divided into the first half (January to June) and the second half (July to December) of the year. Individual t-tests showed that, within all four groups, ^{137}Cs levels significantly increased ($p < 0.05$) from the first half to the second half of the year (see Figure 3). A one-way ANOVA showed that there were significant differences between groups during the first half of the year. T-tests showed that deer found >1 mile from BNL had significantly lower ^{137}Cs levels than the other three groups. On the other hand, there were no significant differences between groups during the second half except for the following: 1) BNL and <1 mile and 2) <1 mile and >1 mile.

Discussion

While BNL has made efforts to remediate contaminated lawn soils in 2000, some areas will continue to contain contaminated soil until their scheduled clean up from 2003 to 2005. Though these areas are fenced in and unavailable to deer, plants surrounding enclosed sites may continue to absorb ^{137}Cs that are below cleaned soil. Because of soil contamination within BNL property, deer that consume vegetation growing on or near these contaminated areas would be expected to have higher ^{137}Cs levels. As predicted, BNL deer, deer <1 mile from BNL, and their combined group had significantly higher ^{137}Cs levels than deer found >1 mile from BNL. An unexpected finding showed that deer <1 mile from BNL had a significantly higher ^{137}Cs level than BNL deer. Many of these samples are from deer that have been hit along William Floyd Parkway, which is on the western boundary of BNL. It is possible that the majority of deer killed <1 mile from BNL are deer that are actually from BNL. The deer could simply be grazing along the boundary of BNL and then subsequently hit by a moving vehicle. Regardless, a closer examination is warranted to determine if there are possible factors, such as sex, age, and mating season, that could drive BNL deer away from the property. At present, data relating to age and sex were not recorded for all deer samples.

Within the four groups, ^{137}Cs levels significantly increased during the second half of the year as expected. Due to the need to increase food intake during the summer months, the likelihood of eating contaminated plants at the BNL site also rises. Though food intake begins to decrease around October, the biological half-life of ^{137}Cs is approximately 100 days and therefore, ^{137}Cs levels continue to be elevated until the end of the year.

By the beginning of the year, deer are eating less, which results in less intake of ^{137}Cs. While it is expected that ^{137}Cs levels are lower during the first half of the year for all four groups, deer >1 mile from BNL continue to have significantly lower ^{137}Cs levels than the other three groups. This was expected since this group is only exposed to global ^{137}Cs and not exposed to contaminated soil whereas BNL deer and deer <1 mile from BNL continue to have access to contaminated areas. Analysis for the second half of the year did not yield all the expected results. It is unclear why the deer <1 mile from BNL has a significantly higher mean than BNL deer and deer >1 mile from BNL. Further analysis is necessary to determine possible reasons for these results.

Acknowledgements

Thanks to the Department of Energy for the opportunity to participate in the Community College Institute (CCI) Program. Special thanks to Dr. Timothy M. Green, my mentor, for allowing me to be involved in this research, and Mr. Benny Hooda for his assistance with the statistical analysis. Thanks also goes to Glenn Williams for teaching the enrichment component of the CCI experience. A very special thank you goes to Mr. Noel Blackburn, the Educational Programs Administrator, for all his dedication to his interns. Special thanks to my biology professor, Mike Reynolds, for guiding me in my college career and for encouraging me to pursue my interest in scientific research.

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