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BIOTA OF URANIUM MILL TAILINGS NEAR THE BLACK HILLS

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Abstract - "Reclamation" often implies the enhancement of the land as wildlife habitat or for other productive uses. However, there are situations where revegetation to stabilize erosion is the only desired goal. Uranium mining and mill sites may fall into this later category. Data pertaining to plant and animal components on revegetated uranium mill tailings was collected. Four sites were selected for this study: three uranium mill tailing areas reclaimed between 1973 and 1978 and a control site in a crested wheatgrass (Agropyron cristatum) pasture 6.4 km west of the mill. Estimated biomass production was not different between the four sites in June. During August, grass production was higher ($a \leq 0.05$) on one of the mill tailing sites than on the others. Rank orders of plant species canopy cover were significantly correlated ($r > 0.71$) between all sites. Similarity indices were low between the revegetated tailing sites and the control site, but were higher for comparisons between sites on the tailings. Radionuclide concentration in vegetation collected from mill tailing sites was not excessively high. Birds were not common on any of the sites, and only one nest was located. Small mammals inhabiting the mill tailings included meadow voles (Microtus pennsylvanicus), house mice (Mus musculatus), western harvest mice (Reithrodontomys megalotis), deer mice (Peromyscus maniculatus), thirteen-lined ground squirrels (Spermophilus tridecemlineatus). Few small mammals were captured on the control site. Western harvest mice were the most common mammal species, followed by deer mice. Gama exposure from thermoluminescent dosimeters (TLD's) implanted in small mammals averaged from 1.3 to 3.3 mR/day on the tailing sites. Exposure on the control site was less than 0.5 mR per day. Numbers of harvester ant (Pogonomyrex spp.) colonies, which represent potential to move contaminated tailings material to the surface, were higher on the revegetated tailing sites versus the control site. The potential for wildlife transmittal of radionuclides away from the tailing area was not excessive because there were few species of wildlife inhabiting the tailing area.

Introduction

Waste material from uranium milling processes (tailings) contain low amounts of radioactive material and should be treated as potentially hazardous material (Yamamoto, in press). Law requires that some reclamation activity be taken of tailings on a site-specific basis. Reclamation, which encourages the establishment of plants and use by animals of uranium mill tailings, has the potential for transfer of radionuclides off the tailings area by the plants and animals that inhabit the areas. Such transfer is well documented. O'Farrell et al. (1973) noted mammals burrowing into waste burial sites on the Hanford Site in south central Washington and exposing plants and animals to the radionuclides. Harvester ants (*Pogonomyrex occidentalis*) prefer disturbed sites (Wheeler and Wheeler, 1963) and represent considerable potential to transport radionuclides to the surface of burial sites (Rogers, 1972; Fitzner et al., 1973). Deer mice (*Peromyscus maniculatus*), and house mice (*Mus musculus*) were a greater threat to transport radioisotopes of strontium and cesium away from waste management area on the Hanford Site in Washington than pocket mice (*Perognathus parvus*) because of habitat and dietary preferences (Gano, 1979). Halford and Markham (1978) found radiation exposures to small mammals decreased as the distance away from the radioactive waste burial grounds increased.

Plants growing on sites containing transuranic elements have been documented as taking up some amounts of the radioactive material (Price, 1973). Osburn (1965) suggested there was a paucity of information concerning the terrestrial transport of naturally occurring nuclides (uranium and thorium) from soil to plants, animals, and eventually, humans. Recent investigations have found that plant uptake of uranium radioisotopes is dependent on the plant species (Dreesen et al., 1978; Schreckhise and Cline, 1980). Rickard et al. (1977) and Schreckhise and Cline (1980) found higher concentrations of uranium in stems and leaves than in seeds of plants. Concentations of uranium and radium-226 were reported in species of grasses growing on uranium mill tailings in Canada (Moffett and Tellier, 1977) and in New Mexico (Rayno et al., 1980). These as well as other studies indicate that plants translocate uranium and uranium daughter products from contaminated soil to above ground parts. However, plants apparently do not actively concentrate the uranium decay series radioisotopes (Rickard et al., 1977).

"Reclamation" as often implied (i.e., to enhance land for wildlife habitat or other productive uses) may not be desirable on uranium mill tailing disposal sites due to the presence of radionuclides. There is a need to determine the biotic transport elements on or near uranium mill tailing sites so that the potential for contamination of surrounding areas with radionuclides can be determined. This information can then be used in determination of food chain contamination.

The objectives of this study were as follows:

1. Compare the biotic components of revegetated uranium mill tailings to those of similar habitats in a grassland ecosystem.
2. Determine the levels of radiation exposure to small mammals inhabitating the mill tailing sites and compare them to normal background levels.

Study Area

This study was conducted in southwestern South Dakota at the uranium mill site scheduled for decommissioning near Edgemont. Silver King Mines, Inc. operates the mill site for the Tennessee Valley Authority (TVA). An acid leach was used by the operations to remove the uranium oxide (U_3O_8) from the ore.

Predominant vegetation types of the surrounding area are mixed-grass prairie and coniferous forest. The mixed-grass prairie is dominated by western wheatgrass (*Apropyron smithii*), little bluestem (*Andropogon scoparius*), buffalograss (*Buchloe dactyloides*), Sandberg bluegrass (*Poa sandbergii*), and blue grama (*Bouteloua gracilis*), (Johnson and Nichols, 1970). The coniferous forest areas are dominated by ponderosa pine (*Pinus ponderosa*), Rocky Mountain juniper (*Juniperus scopulorum*), and sedges (*Carex* spp.) (TVA 1979).

Four sites were selected for this study: three sites on the uranium mill tailings and one control site. The site descriptions were as follows: site l--uranium mill sand tailings covered with 30 cm of top soil; site 2--uranium mill sand tailings covered with 30 cm of top soil, but with a higher gama radiation count than site one; site 3--uranium mill sand tailings covered with 30 cm shale and 60 cm top soil; and control--crested wheatgrass pasture on the Buffalo Gap National Grasslands grazed lightly during the winter months by cattle. Site 1 was broadcast seeded in 1974 with a mixture of 30 pounds crested wheatgrass/acre, 15 pounds yellow sweetclover (*Melilotus officinalis*)/acre, and 15 pounds rye/acre (used for a cover crop). Fifty pounds/acre of amonium nitrate and 12 tons/acre of livestock manure were applied for fertilizer. Site 2 was broadcast seeded in 1973 to the same seed mix and fertilizer as site one. Site 3 was drilled in 1978 with 4 pounds pure live seed (PLS) crested wheatgrass/acre, 8 pounds PLS western wheatgrass/acre, and 3 pounds PLS yellow sweetclover/acre. Forty pounds/acre of amonium nitrate were added for fertilizer. Seed mixes for the control site were not available but the best information available suggests a crested-wheatgrass-dominated mix seeded in the 1930-1940's.

Methods

Six, 50-m line transects were established, spaced about 17 m apart on each of the four sites. Canopy cover and frequency of occurrence (Daubenmire, 1959) by species of vegetation were estimated in 50, 0.1-m^2 (.2 m x .5 m) quadrats spaced at 1-m intervals along each transect. Plant production was determined by clipping at ground level all plant species in 5, 0.125-m^2 circular hoops spaced at 10-m intervals along each transect. Clipped vegetation was put in paper bags, oven dried at 60°C and weighed. Vegetation data were collected during June and again in August.

Bird surveys were conducted monthly (June-September) for three consecutive days starting at sunrise each day. Bird survey plots were 42 x 66 m, and were walked in a zig-zag manner. Birds that were flushed were identified and located on an area map as described by Svenson and Williamson (1960).

Small mammals were trapped at monthly intervals (June–September) with Sherman live traps on a 7 x 11 trap–grid spaced 7 m apart on each site. Traps were baited with peanut butter and rolled oats and were opened for 4 consecutive nights. Animals captured were toe clipped for identification, and age, weight, sex, and species were recorded. The captured animals were anesthetized and surgically implanted with a packet of 2 dosimeters (Gano, 1979; Halford and Markham, 1978). Dosimeters used were thermoluminescent lithium floride (LiF_2) (TLD-700, Harshaw Chemical Company)[1], 0.32x 0.32 cm chips enclosed in a waterproof and biologically inactive sealed plastic wrapper. In recaptures 30 or more days later, the old packet was removed and a new packet put in. Packets were labeled and stored in a lead containter until radiation exposures were determined at a qualified laboratory. Radiation exposure levels were determined for a separate set of dosimeter chips stored in a lead container until shipping, and the amount was subtracted from the exposures determined from dosimeters implanted in the animals to account for irradiation of dosimeters during handling and shipping. In June, 30 additional small mammal traps were set in a sagebrush–grassland habitat to assure more returns on dosimeters from a control area.

The number of harvester ant colonies were determined by surveying the 42- x 66–m plots, marking and counting all active ant colonies.

Results and Discussion

Production of grasses on the tailings and control site was equal for June (Table 1). Grass production by August on site 3 was significantly higher than on the other sites. This was due to a break in a pipe that was used to pump rain water from pond areas which in affect accidentally irrigated a large portion of that site. Forb production on the mill tailing sites was not different from the control site. Litter, during June, was significantly higher ($\alpha \leq .05$) on site 3 than site 1 on the tailings, but neither site 1 nor site 3 was different from site 2 or the control site. In August, the mill tailings at site 2 had the highest amount of litter, which was statistically different only from site 1. Overall production on these crested wheatgrass areas was higher than had been reported for crested wheatgrass pastures on the northern Great Plains (Looman and Heinrichs, 1973; Rauzi, 1975).

Rank order correlations of canopy cover by species (Figure 1) show consistent high correlation of vegetation composition between all sites. These results indicate a high degree of parallelism in the order of species composition between the sites. However, similarity indices based on the amounts of vegetation by species (canopy cover) were much lower. Similarity indices were highest between the sites on the mill tailings, but lower when tailing sites were compared to the control site. Sites 1 and 2 on the mill tailings showed the greatest degree of homogeniety of vegetation composition. This would be expected, as the two sites were seeded to the same mix originally and had the same top soil treatment.

The highest plant diversity index of 2.18 (based on frequency of occurrence data) was found on site 3, whereas the lowest plant diversity index was on the control site (1.53). Overall, more species of plants (15) were found on the control site. However, the distribution of the data were concentrated among four species, crested wheatgrass, red threeawn (*Aristida longiseta*), sand dropseed (*Sporobolus cryptandrus*), and scarlet globemallow (*Sphaeralcea coccinea*). On the mill tailings there were 12, 10, and 12 plant species for sites 1, 2, and 3 respectively. Whereas, on these latter sites the plant species were more evenly distributed resulting in higher diversity indices.

Translocation of radionuclides by plants on areas near site 2 averaged 1.31 µg ^{238}U/g (dry matter plant material), 0.18 pCi ^{230}Th/g, and 11.3 pCi ^{210}Pb/g. Radionuclide content in plants near site 3 averaged 0.67 µg ^{238}U/g, 0.74 pCi ^{230}Th/g, and 5.35 pCi ^{210}Pb/g (Unpublished data, TVA, Environmental Radiological Monitoring, Edgemont Mill, Edgemont, SD). These values were higher than those published by Moffett and Tellier (1977) for grasses growing on uranium mill tailings in Canada but lower than found in vegetation near a tailing pond in New Mexico (Rayno et al., 1980). However, radionuclide uptake data may not just express the translocation of radionuclides by plants from soil through their root systems; instead it may also reflect the attachment of wind blown particles to the plants (Cataldo et al., 1981).

Birds were scarce on the study areas (Table 2), perhaps because structural and horizontal patchiness were nonexistent in this grassland habitat. Rotenberry and Weins (1980) reported that avian communities in grassland environments respond to variation in vertical and horizontal patchiness. Therefore, it is not surprising to have so few birds inhabiting the tailing sites.

Six species of small mammals were caught during the study (Table 3). One species, the sagebrush vole, (*Microtus ochrogaster*) was found only on the control site. Western harvest mice (*Reithrodontomys megalotis*) made up 57% of all individual animals caught, followed by deer mice (*Peromyscus maniculatus*) at 27%. Three to six times more small particularly harvest mice, were caught on the mill tailings sites. Reynolds (1980) noted higher numbers of harvest mice on seeded crested wheatgrass areas that were ungrazed and Birkenholz (1967) suggested that harvest mice were associated with pioneer grass species on recently disturbed sites. Phillips (1936) reported fewer numbers of the thirteen-lined ground squirrels (*Spermophilus tridecemlineatus*) and deer mice in undisturbed grassland habitats than in moderately disturbed pastures, and Verts (1957) showed that deer mice populations drop as the time since mining on coal mine spoils increases. Black (1968) suggested that non-native grasses provide more suitable habitat for harvest mice than did native species and that both harvest mice and deer mice would be favorably affected by reseeding programs if heavy livestock use were permitted. As time progresses, and vegetation composition on the tailing sites approaches that of the control site through invasion of native grasses and forbs, a decrease in the small mammal population would be expected. Captures from the extra traps set near the control site are noted in parentheses on Table 3.

Radiation exposure levels (Figure 2) for small mammals were significantly higher ($\alpha \leq 0.05$) on two mill tailing sites than on the control site. Also, small mammals inhabiting site 1 received less radiation ($\alpha \leq 0.05$) than small mammals inhabiting site 2. There were no returns of dosimeters from the mill tailings site 3. The highest exposure of small mammals from control site and surrounding area was 0.5 mR/day. Average exposure on the mill tailing sites was slightly above the 1.4 mR per day recommended maximum to the general public (U.S. Department Health, Education, and Welfare 1970). However, the U.S. Department of Energy (1977) recommends that the current radiation protection standard for individuals and population groups in uncontrolled areas is 170 millirem/year. This would be equivalent to 0.5 mR/day if one assumes that an exposure of 0.5 mR/day willresult in an absorbed dose of 0.5 millirem/day. Levels of radiation exposure vary among species of small mammals (Halford and Markham, 1978; Gano, 1979) and depend on foraging and habitat preferences (Gano, 1979). Rates of exposure of 160 mR/day were reported for deer mice inhabiting areas adjacent to a radioactive waste pond at a nuclear facility on the National Engineering Laboratory in Idaho (Halford and Harkham, 1978). Gano (1979) reported exposures of 120 mR/day to deer mice near radioactive waste pond on the Hanford Site in Washington. Exposures of small mammals inhabiting uranium mill tailings in other regions were not available.

Harvester ants (*Pogonomyrex spp.*) prefer sites that have been recently disturbed (Wheeler and Wheeler, 1963). Over the life span of a colony, harvester ants can dig to depths of 2.7 m (Fitzner, et al., 1979), and transport up to 3.2 kg of soil to the surface (Rogers, 1972). They represent considerable potential to initiate the process of transporting radionuclides away from tailing disposal areas. Considerably more harvester ant colonies were established on the tailing sites than on the control site in this study (Figure 3). Shade from plants as a site becomes more evenly covered with vegetation may be the cause for fewer ant colonies on areas that have been undisturbed for longer periods of time. Bare ground on the mill tailings averaged 46% versus 33% on the control site. Harrison and Gentry (1981) reported that colonies of the Florida Harvester Ant (*P.badius*) would move the colony if it became shaded.

Conclusion

The potential for transfer of radionuclides off site appears to be minimal, even though there was more biotic activity (in terms of number of animals) on the uranium mill tailings. The levels of radionuclides in plant materials were low, as were levels of exposure to gama radiation of the small mammals inhabiting the tailing sites. Larger numbers of harvester ant colonies on the mill tailings represent the greatest potential for direct movement of tailings material to the surface and making them available for further transport away from the site. The animal biological activity may decrease through time as the vegetation and animal communities become more similar to the grassland habitat used for the control (provided soil characteristics are similar). The maintenance of a homogenous grassland habitat (free from structural diversity) will reduce soil and wind erosion and yet discourage abundant animal activity.

[1] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.

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Table 1. Mean vegetation biomass (g/m^2) on three seeded uranium mill tailing sites and a control site at Edgemont, SD.[1]

Category	Site 1	Site 2	Site 3	Control
June 1980				
Grasses	97.04[a]	91.76[a]	88.88[a]	91.68[a]
Forbs	7.52[a]	1.04[a]	1.68[a]	6.72[a]
Total	104.56[a]	92.80[a]	90.56[a]	98.40[a]
Litter	124.64[a]	133.04[a,b]	195.28[b]	155.28[a,b]
August 1980				
Grasses	59.52[a]	72.32[a]	117.04[b]	74.88[a]
Forbs	5.28[a]	1.68[a]	9.44[a]	0.32[a]
Total	64.80[a]	74.00[a,b]	126.48[b]	75.20[a,b]
Litter	107.84[a]	187.52[b]	155.84[a,b]	126.40[a,b]

[1]Means with same letter for superscript in the same row are not different from each other (a <0.05).

Table 2. Numbers of birds on sample plots (42 x 66 m) on three uranium mill tailing sites and a control site near Edgemont, SD.

Month	Species	Number of Birds Mill Tailing Sites 1	 2	 3	Control
June	Western meadowlark	2	1	1	1
July	Mourning dove	1	0	0	0
	Western kingbird	0	1	0	0
	Western meadowlark	0	0	0	2
August	Mourning dove	2[a]	0	0	0
	Western meadowlark	0	2	0	0
September	Unidentified sparrow	1	0	0	0
	Western meadowlark	0	1	0	0
	Total	6	5	1	3

[a]One nest was located on the site.

Table 3. Numbers of small mammals caught on three uranium mill tailing sites and a control site near Edgemont, SD.

Species	Mill tailing site 1	Mill tailing site 2	Mill tailing site 3	Control ( )[a]
Sagebrush vole	-	-	-	- (2)
Meadow vole	3	-	-	-
House mice	1	6	1	-
Deer mice	5	4	17	1 (2)
Western harvest mice	11	30	16	4 (1)
Thirteen-lined ground squirrel	-	-	2	2
Total	20	40	35	7 (5)

[a] Numbers in parentheses represent individuals from 30 traps off the trap grid.

Figure 1. Rank order correlations (solid line) and similarity indices (doted line) of species canopy cover for vegetation on the uranium mill tailings and control site near Edgemont, SD.

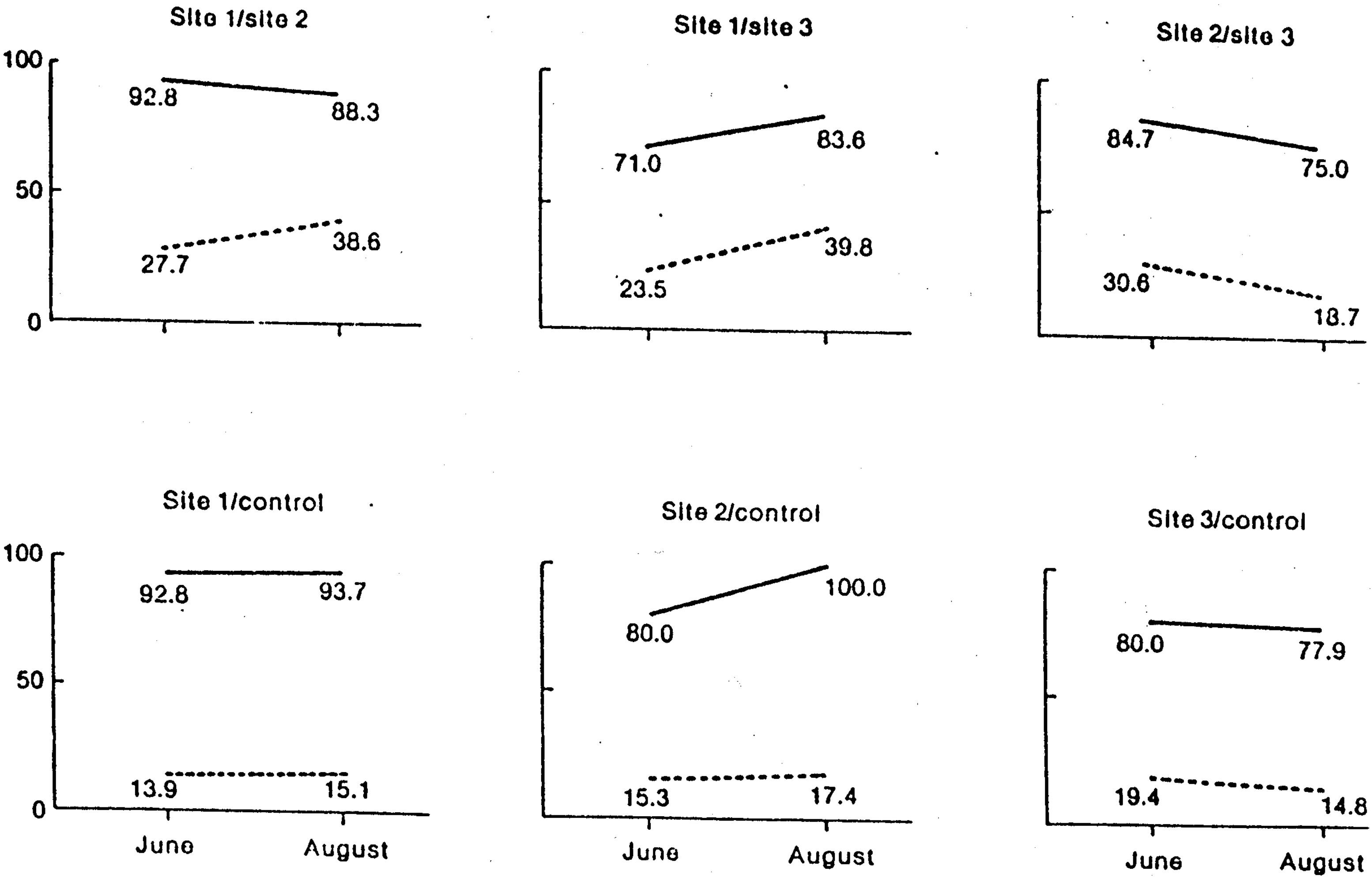

Figure 2. Radiation exposures to small mammals inhabiting Uranium mill tailings and control site near Edgemont, SD.

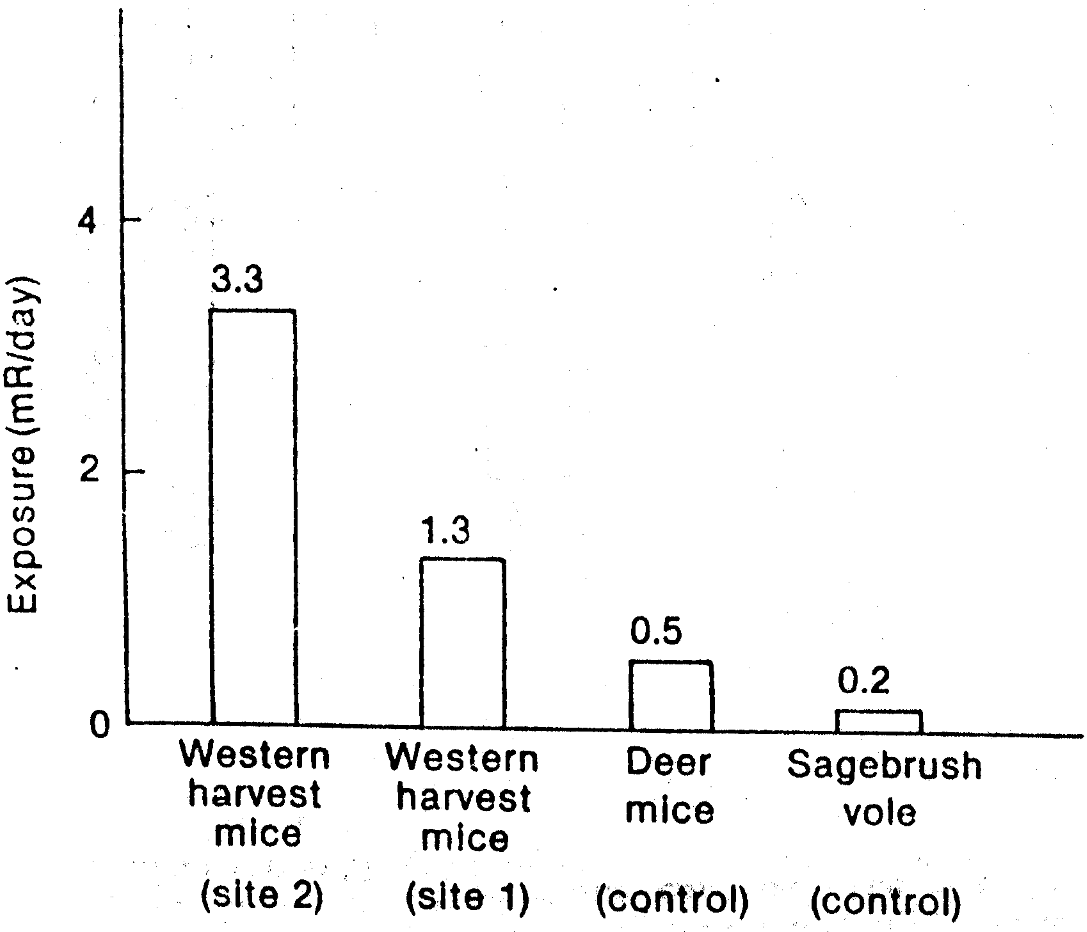

Figure 3. Numbers of active harvester ant colonies on uranium mill tailings and control site near Edgemont, SD.