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Comparison of Small Mammal Species Diversity Near Wastewater Outfalls, Natural Streams, and Dry Canyons

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COMPARISON OF SMALL MAMMAL SPECIES DIVERSITY NEAR WASTEWATER OUTFALLS, NATURAL STREAMS, AND DRY CANYONS

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ABSTRACT

A wide range of plant and wildlife species utilizes water discharged from facilities at Los Alamos National Laboratory (LANL). The purpose of this study was to compare nocturnal small mammal communities at wet areas created by wastewater outfalls with communities in naturally created wet and dry areas. Thirteen locations within LANL boundaries were selected for small mammal mark-recapture trapping. Three of these locations lacked surface water sources and were classified as "dry," while seven sites were associated with wastewater outfalls ("outfall" sites), and three were located near natural sources of surface water ("natural" sites). Data was collected on site type (dry, outfall or natural), location, species trapped, and the tag number of each individual captured. This data was used to calculate mean number of species, percent capture rate, and species diversity at each type of site. When data from each type of site was pooled, there were no significant differences in these variables between dry, outfall, and natural types. However, when data from individual sites was compared, tests revealed significant differences. All sites in natural areas were significantly higher than dry areas in daily mean number of species, percent capture rate, and species diversity. Most outfall sites were significantly higher than dry areas in all three variables tested. When volume of water from each outfall site was considered, these data indicated that the number of species, percent capture rate, and species diversity of nocturnal small mammals were directly related to the volume of water at a given outfall.

1. INTRODUCTION

A wide range of plant and wildlife species utilize water discharged from facilities at Los Alamos National Laboratory (LANL). Discharges from these outfalls are regulated by the National Pollutant Discharge and Elimination System (NPDES) under the Clean Water Act. Pending NPDES regulatory revisions and shifts in research activities at LANL could change the discharge volume from some outfalls, create new outfalls, and eliminate others. These changes will have impacts on vegetation and wildlife. The purpose of this study was to compare nocturnal small mammal communities at wet areas created by wastewater outfalls with communities in naturally created wet areas and dry areas. This information may be useful in assessing the environmental impacts of LANL activities.

2. METHODS

Thirteen locations within LANL boundaries were selected for small mammal mark-recapture trapping during the summer of 1992 (Fig. 1). Three of these locations lacked surface water sources and were classified as "dry," while seven sites were associated with wastewater outfalls ("outfall" sites), and three were located near natural sources of surface water ("natural" sites). (See Table 1 for a list of outfall number by type.) A

Table 1: Sites Selected for Small Mammal Sampling

Site	Type	Location	EPA#[1]	OU# [2]	TA Numbers
1	Outfall	del Valle Canyon	05A-054	1082	11, 13, 16, 24, 25, 28, 37
2	Outfall	TA-16 Mesa	04A-157 05A-072		
3	Outfall	Los Alamos Canyon	03A-020	1106	21
4	Outfall	TA-22 Mesa	128-128	1111	6, 7, 22, 40, 58, 62
5	Outfall	Sandia Canyon	01A-001 03A-027 03A-148 04A-094 04A-109 04A-140 SSS-01S	1114	3, 30, 59, 60, 61, 64
6	Outfall	Mortandad Canyon	051-051	1129	4, 5, 35, 42, 48, 52, 55, 63, 66
7	Outfall	Effluent Canyon	03A-181		
8	Dry	Rendija Canyon: Forest Service Land	-NA-	1071	0, 19, 26, 73, 74
9	Dry	Three Mile Canyon	-NA-	1086	15
10	Dry	Cañada del Buey	-NA-	1148	51, 54
11	Natural	Three Mile Canyon	-NA-	1093	18, 27, 65
12	Natural	Los Alamos Canyon	-NA-	1114	3, 30, 59, 60, 61, 64
13	Natural	Los Alamos Canyon	-NA-	1136	43

[1] EPA# = the number assigned to each wastewater outfall by the Environmental Protection Agency.
[2] OU# = the Operable Unit number, assigned to specific areas by the Environmental Restoration program at LANL.

5 meter (m) x 20 m (16.4 ft x 65.6 ft) grid was established at each site and Sherman live traps were set for three consecutive nights at each area for a total of 100 traps and 300 trap nights. Traps were placed 10 m (33 ft) apart. If appropriate, each grid also contained 10 shrew pit traps, each consisting of a plastic bucket 18 cm (7 in) deep and 15 cm (6 in) in diameter. These were buried beside logs or cattail ponds. Sherman traps were baited with sweet feed in late afternoon and checked in early morning to record nocturnal species. Incidental captures of diurnal

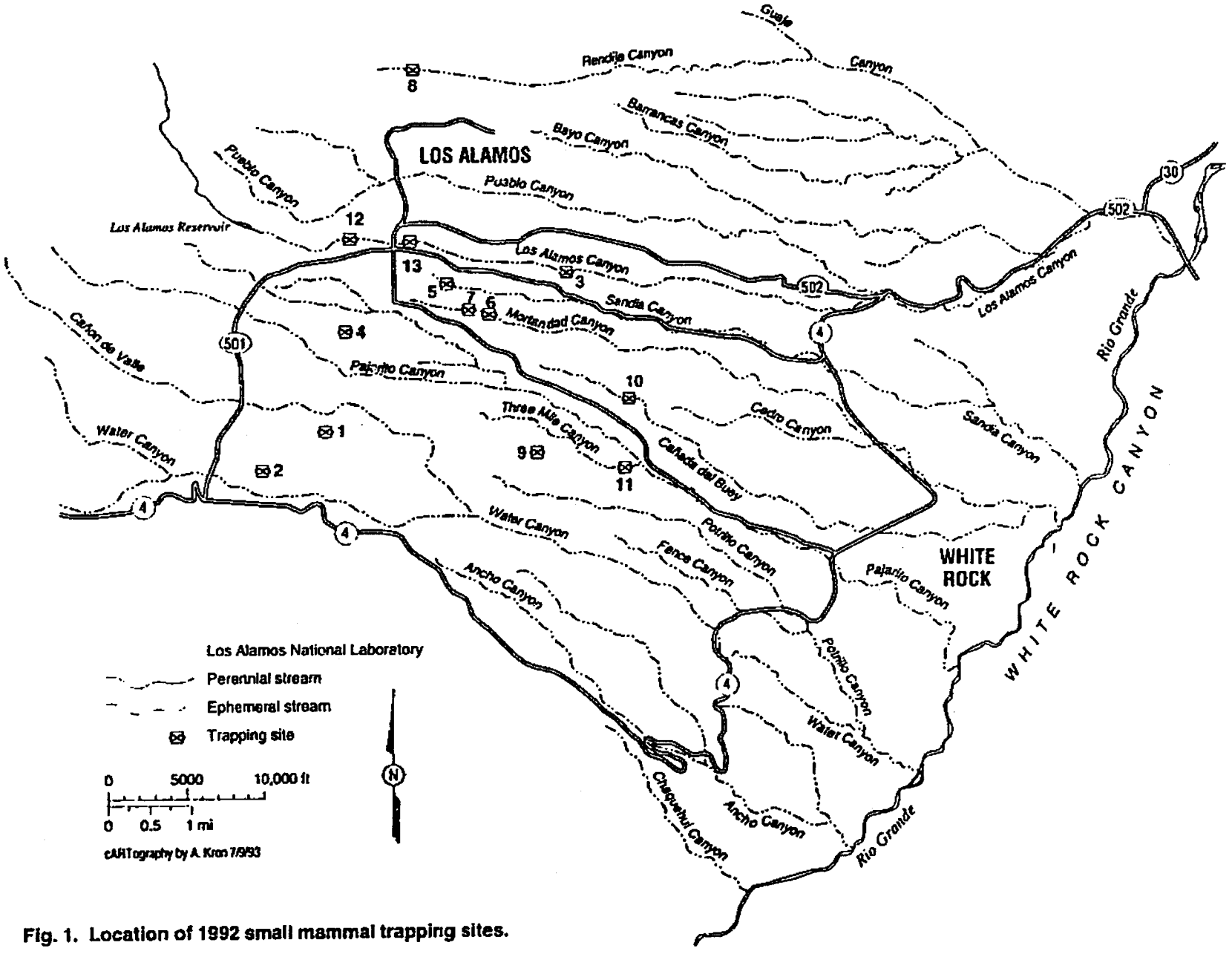

Fig. 1. Location of 1992 small mammal trapping sites.

species were not included in analysis. Location of capture, species name, sex, weight, body length, tail length, ear length, foot length and tag number were recorded. Animals were marked with #FF rodent ear tags from Salt Lake Stamp Company, Salt Lake City, Utah. The dominant overstory, shrub story, and understory vegetation species within 7 m (23 ft) of each trap station were also recorded for each site.

Data Analysis

Information on site type (dry, outfall or natural), location, species, and tag number were used in data analysis. Species name and tag number were used to determine the daily and total number of species caught at each site and the daily and total percent capture rate for each site. Species name and tag number were also used to calculate species diversity indices using the Shannon-Wiener method (Hair 1980), also known as the Shannon-Weaver function. Incidental captures of diurnal and unidentified species were omitted from analysis.

Data from one dry area (Site 10) and one natural area (Site 11) were omitted from analysis. The Cañada del Buey site (Site 10) did not meet the criteria for dry site designation because of the presence of several hydrophytic plant species and the proximity of an outfall that could act as a small mammal colonization source. The Three Mile Canyon site (Site 11) was omitted due to an unusually low sample size.

Data was initially entered into a Microsoft Excel spreadsheet and then converted for compatibility with the Statistical Analysis System (SAS). To determine which kind of test was most appropriate for the data, the SAS univariate normal procedure was used to find out if the data for individual animal captures and frequency of captures were normally distributed at each type of site. In most cases, sample sizes were inadequate for a determination, but the data was not normally distributed at the majority of site types where sufficient sample sizes were available. Consequently, a multiple stage test (MST) was determined to be appropriate for analyzing and comparing ranked capture frequency data among types. The Student-Newman-Keuls (SNK) multiple range test was selected to test all main-effect ranked means. Differences between

types were tested at the 0.05 level of probability for three variables: total number of species, percent capture rate, and species diversity.

The univariate normal procedure of SAS was also used to determine if daily total number of species, daily percent capture rates and daily species diversity data were normally distributed at each site. For this site-specific data, the test showed that the data were normally distributed. Therefore a multiple stage test was deemed appropriate for analyzing and comparing nonranked data among sites. The SNK was again selected and differences between mean daily number of species, mean daily percent capture rate, and mean daily species diversity were tested at the 0.05 level of probability.

3. RESULTS

Number of Species

There were no significant differences in total number of species between dry, outfall, and natural site types. However, significant differences ($p=0.001$) were found between some individual sites. For example, the number of species caught daily in the two dry sites (Sites 8 and 9) was significantly lower than the number of species caught at all natural and outfall sites. At the other end of the spectrum, the number of species caught at Site 13 (natural) was significantly higher than at all other sites. An outfall site (Site 5) was next highest in daily mean number of species, with a significantly greater number than the other natural site (Site 12). Site 6 (outfall) and Site 12 (natural) were statistically equal in number of species caught daily. Outfall Sites 1, 3, and 4 were not significantly different from each other but were significantly higher than dry sites and lower than natural sites. Statistical differences and similarities in mean daily number of species are shown in Table 2.

Table 2: Student-Newman-Keuls (SNK) Groupings for Each Daily Variable (Shaded Areas Represent Statistically Equal Mean Values).

Site	Type	Mean
13	N	5.67
5	O	4.33
1	O	3.33
3	O	3.33
4	O	3.25
7	O	2.67
6	O	2.50
9	D	1.33
8	D	1.00

Mean Daily Number of Species (p=0.0001)

Site	Type	Mean
13	N	32.00
5	O	27.67
2	O	18.00
7	O	10.67
6	O	7.00
8	D	3.33
9	D	3.33

Mean Daily Percent Capture Rate (p=0.0001)

Site	Type	Mean
5	O	1.87
13	N	1.79
12	N	1.47
6	O	1.46
2	O	0.48
9	D	0.33
8	D	0.24

Mean Daily Species Diversity (p=0.0008)

Percent Capture Rates

Analysis did not indicate a significant difference in percent capture rates between site types, but did show significant differences (p=0.001) between individual sites. The two dry sites (Sites 8 and 9), which were not significantly different in terms of percent capture rate, were significantly lower than all other sites in this variable. The highest percent capture rate among all sites was found at Site 13 (natural). This site and outfall Site 5 did not differ significantly, and these two sites were higher than all other sites. Outfall Site 2 was significantly higher in percent capture rate than natural Site 12, which was statisitically equal in percent capture rate to outfall Sites 1, 3 and 4. Statistical differences and similarities in mean daily percent capture rate are shown in Table 2.

Species Diversity

Once again, although there were no significant differences in species diversity between site types, analyses showed significant differences (p=0.0008) in species diversity between some individual sites. Site 8 (dry) was significantly lower in species diversity than all other sites. Species diversity at Site 9 (dry) was not significantly different in species diversity from Site 2 (outfall) but both were significantly lower than all

other sites except Site 8. No significant difference was found between Sites 5 (outfall) and 13 (natural) and no significant difference was found between Site 6 (outfall) and 12 (natural). However, Sites 5 and 13 were higher in species diversity than Sites 6 and 12. There were no significant differences in species diversity between the remaining outfalls (1, 3, 4 and 7). Statistical differences and similarities in mean daily species diversity are shown in Table 2.

Species Composition

Only two species—deer mouse (*Peromyscus maniculatus*) and brush mouse (*P. boylei*)—were found in the dry areas (Fig. 2). Outfall areas supported deer mouse, brush mouse, white-footed mouse (*P. leucopus*), vagrant shrew (*Sorex vagrans*), long-tailed vole (*Microtus longicaudus*), montane vole (*M. montanus*), white-throated woodrat (*Neotoma albigula*) and Mexican woodrat (*N. mexicana*). Deer mouse, brush mouse, vagrant shrew, water shrew (*S. palustris*), long-tailed vole, and montane vole were trapped in the natural areas. White-footed mice were only caught at Site 4 (outfall) and water shrew was only caught at Site 13 (natural). Woodrats, both white-throated and Mexican, were found only at outfall sites.

4. DISCUSSION

Dry, outfall, and natural site types did not differ in terms of the mean number of species, percent capture rate, or species diversity. This was probably because of high variability within each site type and because dry sites and natural sites were not as well represented in the data as outfall sites. However, when individual sites were compared, there were significant differences in daily mean number of species, percent capture rate, and species diversity.

Dry areas (Sites 8 and 9) were significantly different from all other areas for all three variables tested, with the exception of Site 2, which did not differ from Site 9 in terms of mean species diversity. The daily mean number of species, percent capture rate, and species diversity were always lower at dry areas than at outfall or natural areas (Figs. 3, 4 and 5). On the other hand, natural areas

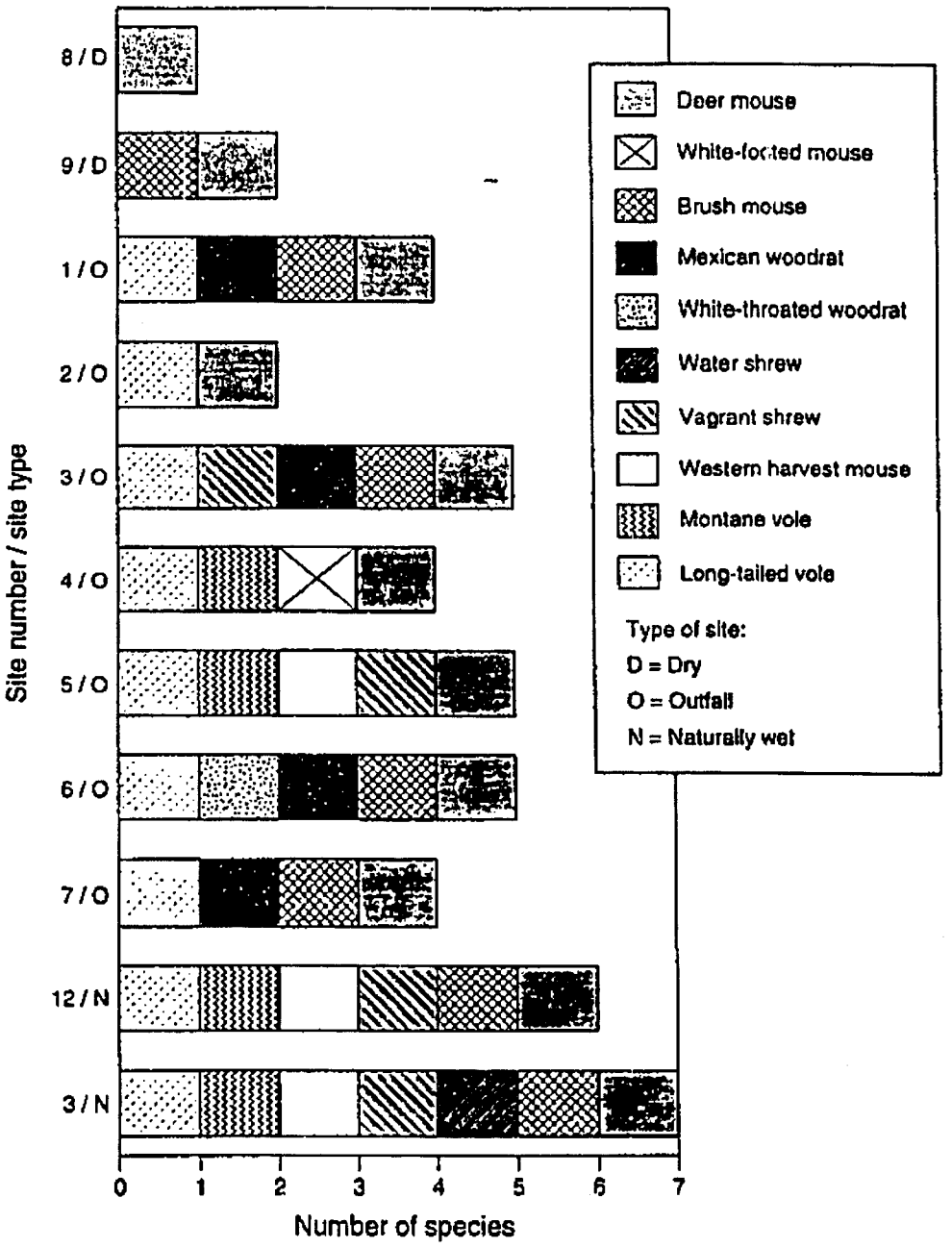

Fig. 2. Number of species found at each site.

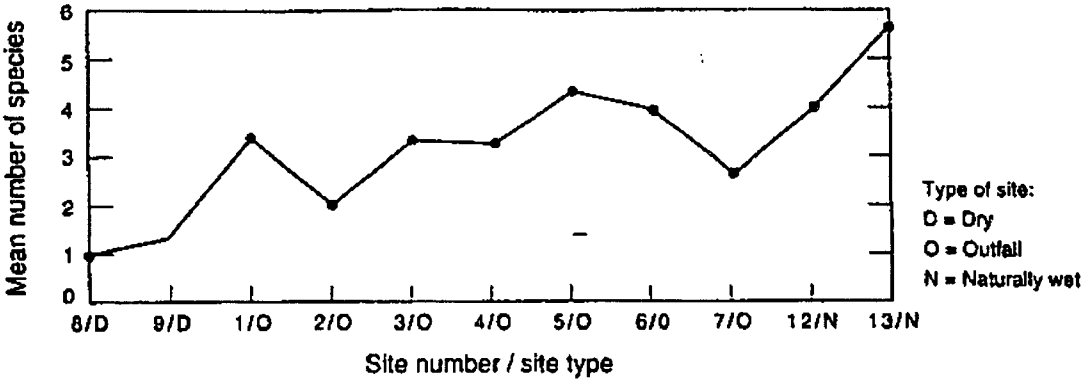

Fig. 3. Daily mean number of unique species at each site.

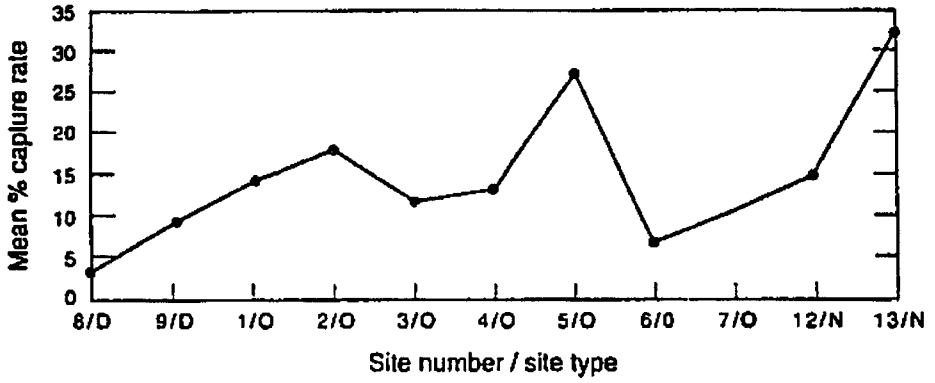

Fig. 4. Daily mean percent capture rate at each site.

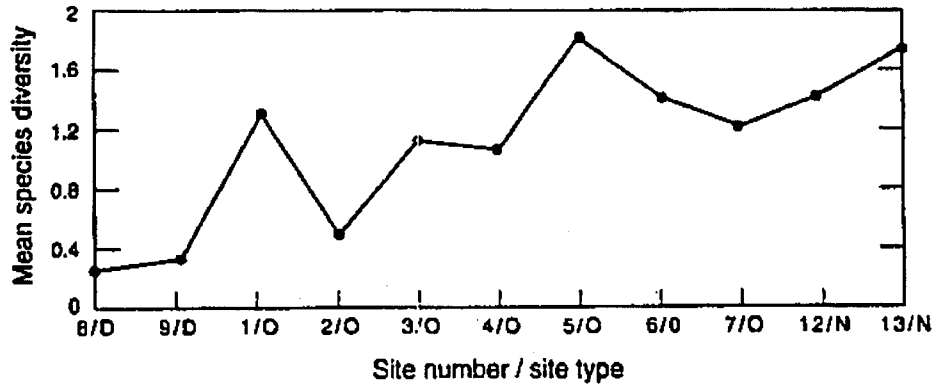

Fig. 5. Daily mean species diversity at each site.

exhibited some of the highest values for daily mean number of species, percent capture rate, and species diversity. Outfall Sites 5 and 6 were similar to natural areas in terms of all three variables. Most other outfall areas were intermediate between natural areas and dry areas in terms of number of species, percent capture rate and species diversity.

Outfall Sites 5 and 6, where daily mean number of species and species diversity were similar to natural sites, receive more water from outfalls than most other outfall sites (Table 3). Effluents discharged to outfall Site 1 have also been relatively high and this site was statistically equal to a natural area in daily mean percent capture rate. (The significantly lower daily mean number of species and species diversity at outfall Site 1 may have resulted because shrew pit traps were not present during the trapping session.)

Table 3: Historic And Recent Total Average Daily Input of Water (Including All Contributing Outfalls) At Each Outfall Site (in Gallons/Day)

Site	Historic Input (at 14 years)	Recent Input (at 2 years)
1	47.0	47.0
2	0.04	13.94
3	18.4	18.4
4	1.12	1.12
5	275.38	306.12
6	11.6	22.29
7	12.5	20.77

In contrast to these well-watered outfall sites, most outfall areas receiving lower water input showed significantly lower daily mean number of species, percent capture rate and species diversity than natural areas. However, even the outfalls that receive relatively low water inputs showed higher values for the three variables than the dry areas, which once again suggests that these outfall areas are in an intermediate state between natural wetlands and dry areas.

Another outfall area of particular interest is Site 2 (TA-16 Mesa). Data from the site indicated daily mean number of species and species diversity were significantly lower than at other sites. However, because of a large number of deer mouse captures, this site was not significantly different from natural areas in daily

mean percent capture rate. The high numbers of deer mice and extremely low species diversity at this site suggest that the area may be inaccessible to colonization. The outfall-created stream at Site 2 does not reach the main water course of any canyon (Edeskuty, Foxx and Raymer 1992). This may effectively prohibit colonization so that the site cannot support a species diversity comparable to less isolated outfall areas with similar water input.

Four of the nocturnal small mammal species (white-footed mouse, water shrew, white-throated woodrat and Mexican woodrat) were found only in some areas. White-footed mouse has been previously found at locations throughout LANL property. The white-footed mouse had been found prior to 1992 near sites 2, 5, and 6. The species may be under represented in capture data because in the field it is extremely difficult to distinguish from other *Peromyscus* species. The water shrew may have been poorly represented in capture data because it is difficult to capture and is only found near permanently running water (Findley 1987). Its presence in Los Alamos Canyon may be a consequence of the fact that the species hibernates in winter, when the Los Alamos Canyon stream dries up. However, the study year was a very wet year, which maintained flow in the stream well into summer, and this shrew may have only recently colonized Site 13 by traveling down from the Los Alamos reservoir, where water is present year-round. The woodrat species were caught only at four of seven outfall sites and not dry or natural sites, probably because of the topography of individual sites rather than a dependence on water. Woodrats use crevices in rock and cliffs for their houses, so their presence at the outfall sites may be because of the local availability of these features.

Vegetation data from each trap site indicate that some species have a preference for certain vegetation types. Long-tailed voles, montane voles and vagrant shrews were most often caught in the presence of cattails (Fig. 6), suggesting that these animals are either dependent on wetland vegetation or surface water. This is further supported by the fact that these species were only caught in outfall and natural areas. The western harvest mouse lives only in moist grassy areas (Burt and Grossenheider 1976) and was also caught only in outfall and natural areas (Table 4). Brush mice were captured most often near

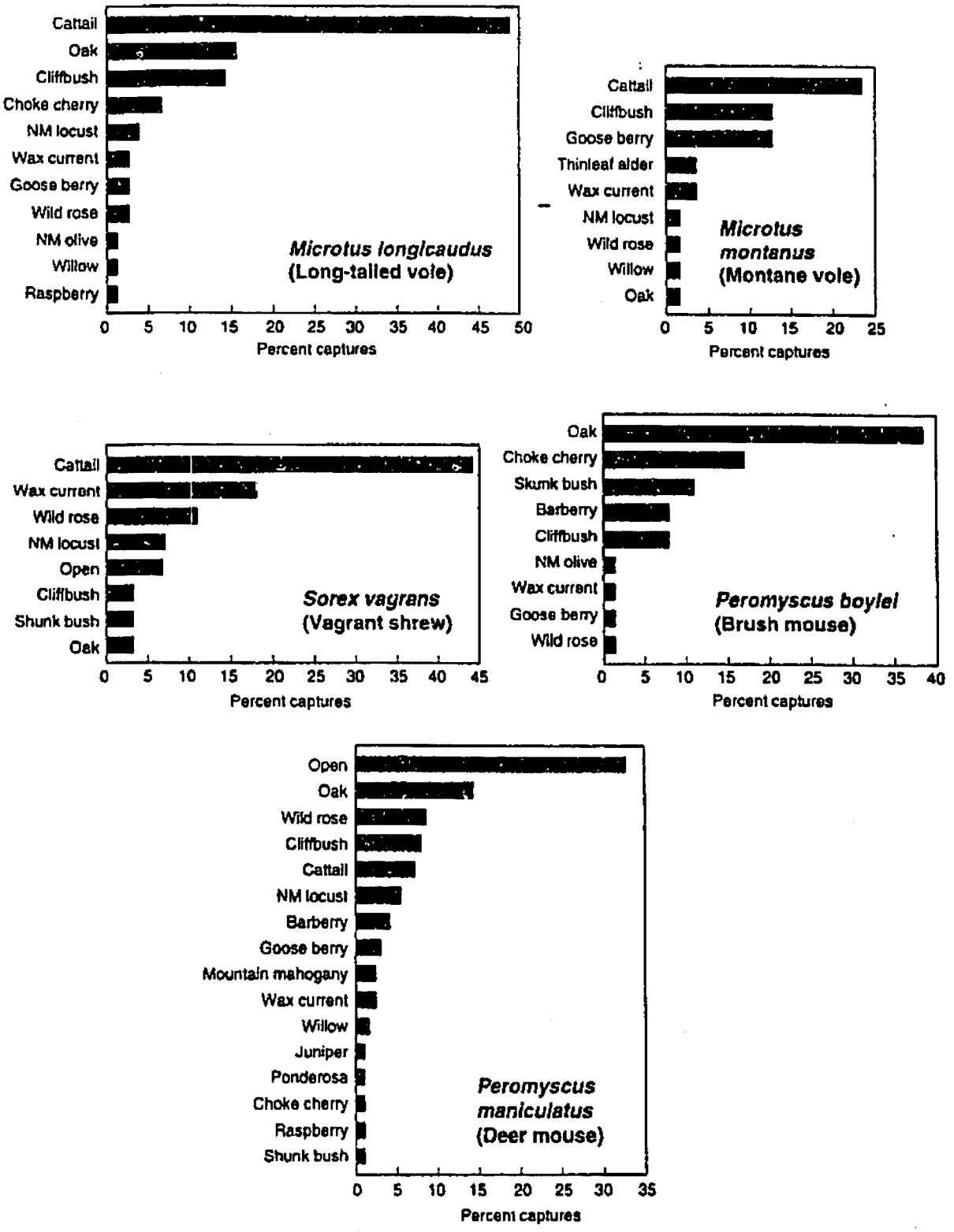

Fig. 6. Percent capture rate (for individual species) in vegetation dominated by various plant species.

oaks, while deer mice were found most frequently in open areas (Fig. 6). (Open areas are dominated by low growing herbaceous vegetation rather than trees or shrubs.) Brush and deer mice were caught in both wet and dry areas, suggesting that these species have no specific dependence on surface water or wetland vegetation.

Table 4: Occurrances of Common Water Dependent Species			
	Dry	Outfall	Natural
Long-tailed vole	Absent	Abundant	Abundant
Montane vole	Absent	Abundant	Abundant
Western harvest mouse	Absent	Abundant	Abundant
Vagrant shrew	Absent	Abundant	Abundant

The data also indicate that the number of water-dependent species present varies directly with the volume of water discharged to an area. Outfall Site 5 received more water than any other outfall area and all four water-dependent species were trapped at this site. On the other hand, only one or two water-dependent species were trapped at sites receiving lower inputs of water (Fig. 7).

5. MANAGEMENT IMPLICATIONS

Because species diversity is almost always higher in wet areas (outfall and natural) than in dry areas, the elimination of wet areas could cause a significant reduction in species diversity at LANL. For example, if species diversity data is recalculated without water-dependent species, all wet areas show a reduction in species diversity (Fig. 8) and species diversity at three areas is reduced to zero. Reductions in water flow could also significantly decrease small mammal species diversity and eliminate water-dependent species at outfall-watered sites. Additionally, species diversity may be reduced in other animal groups including medium-sized mammals, birds and insects. While changes in volume and location of discharged waste water may not affect species diversity of large mobile animals, such as black bear, deer, and elk, such changes could greatly disrupt the local migration patterns of these animals. Laboratory wildlife biologists should coordinate with waste water managers to ensure continued wildlife species diversity at LANL.

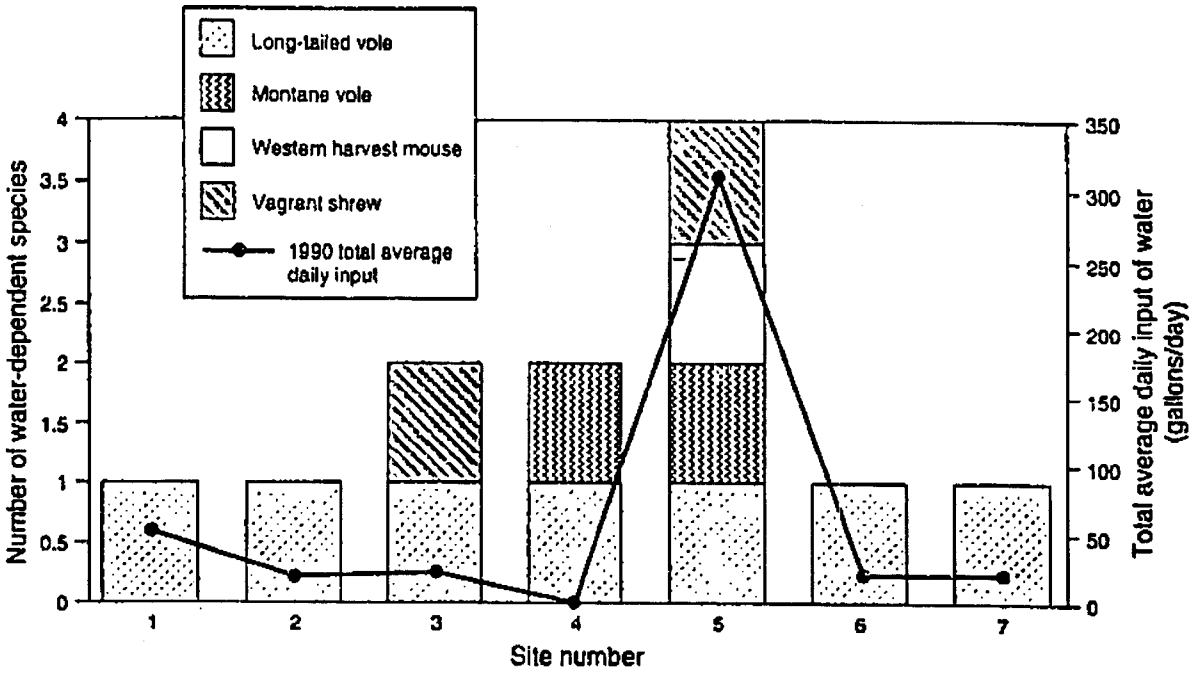

Fig. 7. 1990 total average daily inputs of water and number of common water-dependent species caught at each outfall site.

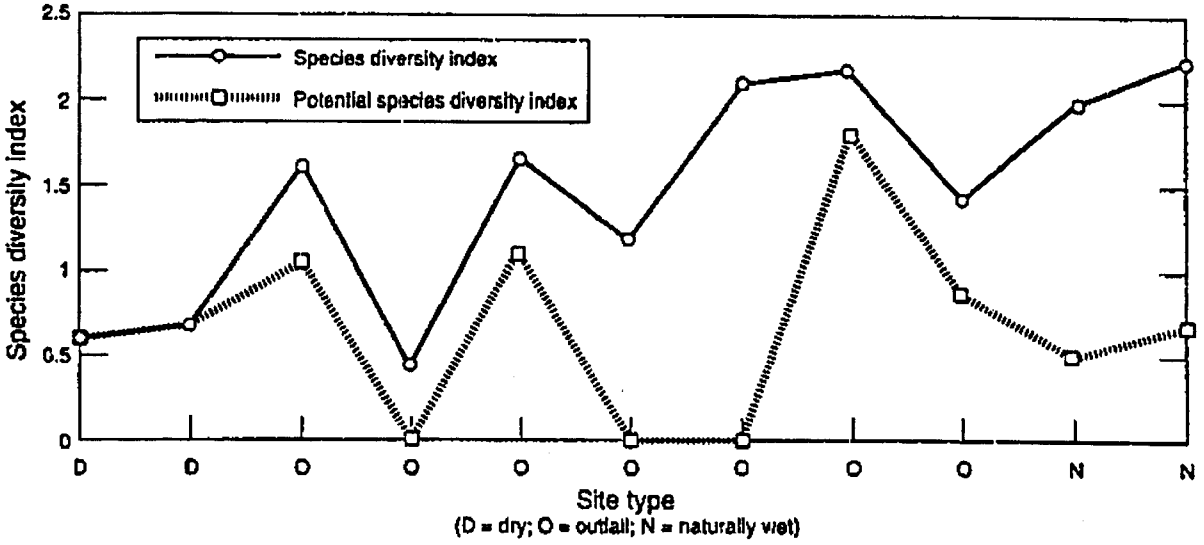

Fig. 8. Current species diversity indices and potential indices excluding water dependent species.

6. AKNOWLEDGMENTS

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