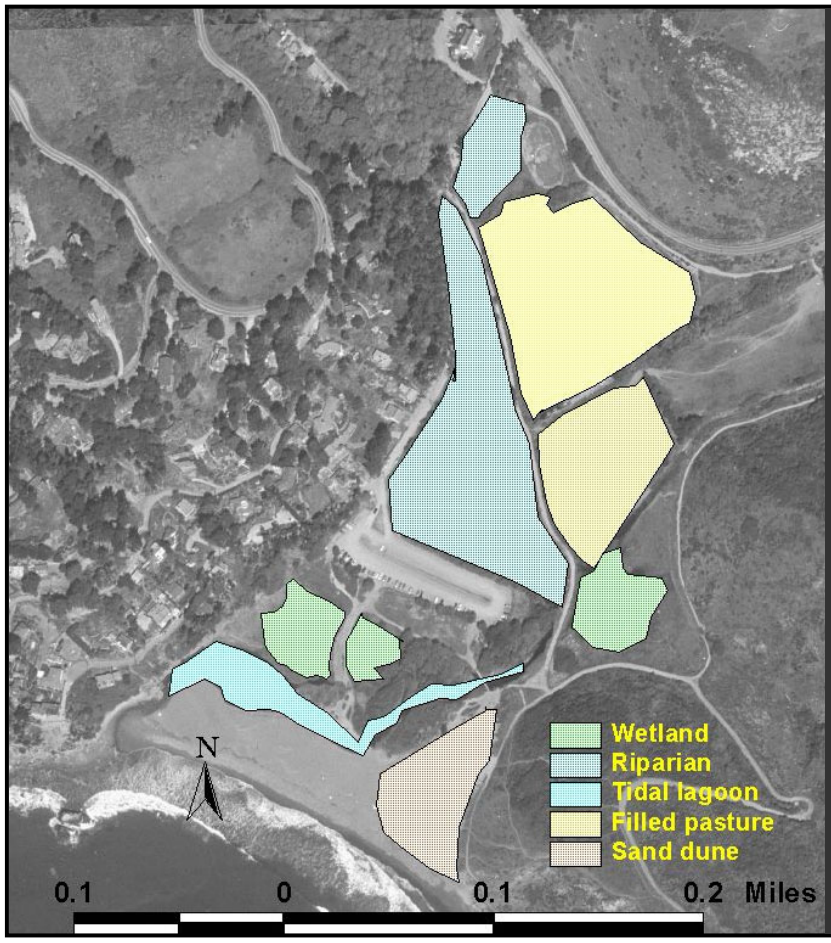


# A SMALL MAMMAL SURVEY AT BIG LAGOON

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# A SMALL MAMMAL SURVEY AT BIG LAGOON, Muir Beach, Marin County, CA

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Vallejo, California
[2003]

U.S. DEPARTMENT OF THE INTERIOR

GALE A. NORTON, SECRETARY

U.S. GEOLOGICAL SURVEY

Charles G. Groat, Director

Please cite as: Takekawa, J. Y., M. A. Bias, I. Woo, S. A. Demers, and E. E. Boydston. 2003. Small mammal survey at Big Lagoon, Muir Beach, Marin County, CA. Unpubl. Progr. Rep., U. S. Geological Survey, Vallejo, CA. 25pp.





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# Executive Summary

- Small mammals were live-trapped with 96 traps at 24 grid locations throughout Big Lagoon for 4 nights (384 trapnights) from 28 October to 1 November 2002. Five habitat types (dune, pasture, riparian, tidal lagoon, and wetland) were identified and grids were assigned to each habitat type according to the proportion of the area represented.
- Four small mammal species were detected during the small mammal trapping session: western harvest mouse (*Reithrodontomys megalotis*), deer mouse (*Peromyscus maniculatus*), California vole (*Microtis californicus*), and roof rat (*Rattus rattus*).
- The most abundant small mammal was the western harvest mouse (7.8 new captures / 100 trapnights), followed by the deer mouse (0.5 / 100 trapnights) and California vole (0.5 / 100 trapnights). The federally endangered salt marsh harvest mouse (*Reithrodontomys raviventris*) and the state species of special concern Point Reyes jumping mouse (*Zapus trinotatus orarius*) were not detected at Big Lagoon.
- Small mammals were detected in pasture, wetland, riparian and dune areas. Western harvest mice were detected in pasture and wetland habitat types and to a lesser extent in riparian and dune habitat types. California voles were trapped in pasture and wetland habitat types. Deer mice were detected only on the sand dunes, and roof rats occurred only in riparian areas.
- Pasture and wetland areas were similar in vegetation type, vegetative height structure, and small mammal captures. Abundance of western harvest mice was significantly related to habitat and vegetation ($F_{3,36}$= 4.37, p = 0.01, $R^2$= 0.21), primarily vegetative cover ($t_{36}$=2.66, p = 0.01), but not height ($t_{36}$= 0.34, p = 0.74).

# Introduction

Big Lagoon at Muir Beach, in Marin County, California is part of the Golden Gate National Recreation Area (GGNRA) and is a popular destination for park visitors, receiving approximately 440,000 visitors annually. The 12-hectare site (Fig. 1) is located at the mouth of the Redwood Creek watershed, which drains a 14.4 square kilometer area of the southwestern slopes of Mt. Tamalpais. Historically, the area of Big Lagoon and the adjacent lowland pastures were part of the Redwood Creek floodplain. The historic habitat types included a freshwater lagoon, seasonal freshwater wetlands, an intermittent tidal lagoon, a riparian corridor, and dunes.

During the mid 1800s, much of the surrounding wetlands areas had been replaced by agricultural fields and grazing lands. Roads were constructed in the upper watershed. Overgrazing of the adjacent hillsides and upstream riparian communities and runoff from road cuts resulted in sedimentation of Big Lagoon. By the late 1960s, grazing ended and Redwood Creek was no longer a meandering stream but channelized and confined by roads and levees. The floodplain was altered by agriculture and grazing. An additional impact to wetland areas included the placement of a visitor's parking lot perpendicular to the flow of the watershed and over riparian and wetland areas (PWA et al. 1994).

Today, Big Lagoon consists of fragmented habitat types including dune, pasture, riparian, tidal lagoon, and wetland environments (Fig. 1). Big Lagoon is fed by intermittent freshwater flows from the Redwood Creek watershed, which slows to a trickle during summer months. A seasonal tidal lagoon at Muir Beach remains isolated from ocean waters except during high winter creek flows. The GGNRA is preparing a conceptual plan for the Big Lagoon Wetland and Redwood Creek Restoration, due in February 2004, to address restoration and enhancement of natural resources. One of the restoration goals consists of restoring a functional, self-sustaining ecosystem that include wetland, aquatic, dune, upland, and riparian communities.

As part of a biological inventory for restoration planning, the National Park Service requested that the U. S. Geological Survey conduct small mammal surveys at Big Lagoon

to determine the distribution and abundance of small mammals and to identify special status mammal species. Species of special concern reported in nearby locations included the federal and state endangered salt marsh harvest mouse (*Reithrodontomys raviventris*) and the state species of special concern Point Reyes jumping mouse (*Zapus trinotatus orarius*). Although probably misidentified, salt marsh harvest mice were reportedly found in Rodeo Lagoon, roughly 3.5 miles southeast of Muir Beach (Semenoff-Irving and Howell, *in press*). The closest reported occurrence of the Point Reyes jumping mouse was Fort Cronkhite and Fort Barry, roughly 3.5 miles southeast of Muir Beach, in the same vicinity as Rodeo Lagoon (CDFG 1986).

## Methods

Small mammal surveys were conducted in the fall to reduce detection of non-resident dispersing individuals and prior to the winter rainy season. We conducted small mammal surveys from 28 October to 1 November 2002 in dune, pasture, riparian, tidal lagoon, and wetland areas to determine the presence or absence of small mammal species. In addition we characterized the small mammal community that occurred among different habitat types previously defined in the preliminary Environmental Assessment (PWA et al. 1994). One pasture parcel (Green Gulch) was not sampled because of active horse grazing. In addition, the central sand flat on Muir Beach was not sampled because of extensive public use.

The number of trap grids was established in proportion to the area of each habitat type in accessible locations. Each trap grid consisted of 4 Sherman live traps placed 5 m away from a location in each of the cardinal directions (*c.f.* Padgett-Flohr 1999). Grid locations were randomly determined in ArcView 3.3 (ESRI, Inc.) and adjusted for accessibility (Fig. 2). Twenty-four grids were live-trapped for four consecutive nights for a total of 384 trapnights. The distribution of trap grids included dune (2), pasture (11), riparian (6), tidal lagoon (1), and wetland (4). Traps were set prior to dusk, checked the following morning, closed to avoid captures during the heat of the day, and reset each evening (see Takekawa et al. 2002). Traps were baited with a mixture of birdseed and ground walnuts. Polyester bedding material was placed inside the trap for warmth, and

bedding material and a protective cedar shingle were placed on top of each trap to reduce solar heat gain or nocturnal heat loss. Bait and bedding material were removed and replaced between successive captures. Captured mammals were identified to species, sexed, weighed to the nearest 0.5 grams, aged (juvenile, sub-adult, or adult), examined for reproductive status, and fur-clipped to distinguish recaptures. Additional measurements, listed below, were taken for *Reithrodontomys* spp. to help identify different species.

The western harvest mouse (*Reithrodontomys megalotis*) and the endangered salt marsh harvest mouse (*Reithrodontomys raviventris*) are difficult to distinguish; however, the tail characteristics have been used as the most reliable means for differentiating these species (Shellhammer 1984). Specifically, tail characteristics including the diameter 20 mm from the body, level of shading from top to bottom, presence of white hairs on the ventral side, and shape were all coded for species identification. Tail traits were assigned numeric scores, and the total score for all tail characteristics were used to differentiate between the two species. The total score can range from 0 to 8 with this system. The salt marsh harvest mouse usually scores between 0 and 2, while the western harvest mouse generally scores between 6 and 8. For remaining individuals with intermediate scores, between 3 and 5, behavior can be assessed and used to distinguish species. Salt marsh harvest mice are generally calm and docile when handled, while western harvest mice are active and aggressive (Fisler 1965, Shellhammer 1984, Wertz-Koerner 1994). Bias (1994) developed a suite of morphological measurements that supported the findings of Fisler (1965) and Shellhammer (1984). Results for all species are presented as number of captures per unit effort or number of new captures per 100 trapnights (TN).

We characterized the vegetation at each small mammal grid location with 10-m long point-intercept transects extending from the north trap to the south trap with plant species determined at 0.5 m intercept points along the transect. In addition, we calculated percent cover for plant species, litter, and bare ground, and recorded height for each species. In riparian areas with an overstory canopy, vegetative height was recorded for understory plants shorter than 1 meter. Percent cover was calculated by adding the number of "hits" for a species, dividing by the total number of points, and multiplying by

100. Each point represented roughly 5% vegetative cover. Mean percent cover was calculated for each grid and summarized by habitat. A multiple linear regression was used to examine the relationship among vegetation cover and height to the number of new western harvest mouse captures per unit effort (new western harvest mice / 100 TN).

## Results and Discussion

*Small mammals detected* — In order of abundance our surveys detected, the western harvest mouse (7.8 new captures / 100 TN), deer mouse (0.5 / 100 TN), and California vole (*Microtus californicus*: 0.5 / 100 TN) (Table 1, Fig. 2). Roof rats (*Rattus rattus*) were captured three times but were not marked to distinguish recaptures, so numbers ranged from 0.3 to 0.9 new captures / 100 TN. The number of species (4) captured at Big Lagoon and the new captures / 100 TN (9.6) were less than the number of species (7) and new captures (20.5) trapped in the winter at the Tolay Creek restoration site on northern San Pablo Bay (Takekawa et al. 2002).

*Special status species* —The Point Reyes jumping mouse represents the southernmost subspecies of the Pacific jumping mouse (*Zapus trinotatus*) (Hooper 1944). Jumping mice have long tails that are approximately 150% of their body length, long hind legs, and small ears that project slightly beyond their fur (Hooper 1944, Ingles 1965, Krutzsch 1954, Maser 1981). The Point Reyes jumping mouse occurs in moist areas (Krutzsch 1954) and the bunchgrass marsh uplands of Point Reyes. Likewise the Pacific jumping mice are found in riparian alder communities with tall, dense vegetative cover (Maser et al. 1981, CDFG 1986). Although Big Lagoon has a riparian corridor, we did not capture any Point Reyes jumping mice during the 96 trapnights in the riparian areas, nor in the total 384 trapnights in the project area.

The salt marsh harvest mouse is the only obligate salt marsh mammal (Greenberg and Maldonado 2003), and it occurs only in the San Francisco Bay estuary (Fig. 3: Fisler 1965, Shellhammer 1984). Our results did not indicate salt marsh harvest mice were present at Big Lagoon. We verified captured mice were harvest mice (*Reithrodontomys* spp.) by their characteristic grooved upper incisors with no external cheek pouches

(Ingles 1965). The Shellhammer (1984) tail score for harvest mouse at Big Lagoon ranged from 3 to 7, intermediate tail characteristics (Fig. 4) that are not characteristic of salt marsh harvest mice. In addition, all of the *Reithrodontomys* were very active and aggressive, behavior indicative of western harvest mice. Typical tidal marsh plants associated with salt marsh harvest mice (Fisler 1965, Shellhammer 1982, Bias 1994) such as pickleweed (*Salicornia virginica*), fat hen (*Atriplex triangularis*), gumplant (*Grindelia stricta*), or coyote bush (*Baccharis pilularis*) were not found at Big Lagoon.

The range of the salt marsh harvest mouse is discontinuous and not reported to encompass the California coast (Fig. 3). Fisler (1965) had trapped over 1,200 individuals in the genus *Reithrodontomys* and mapped the distribution of both salt marsh and western harvest mice. In his surveys, western harvest mouse had a broad distribution throughout Point Reyes and Inverness as well as Rodeo Lagoon and Fort Barry (Fig. 3), while Corte Madera in Marin County bound the western extent of the salt marsh harvest mice range. Thus, Big Lagoon and Rodeo Lagoon occur outside the known species range (Fisler 1965, Shellhammer 1982). Although (Semenoff-Irving and Howell, *in press*) reported capturing an adult female and three juveniles at Rodeo Lagoon in 1992, Shellhammer (pers. comm., 2003) reviewed all trap records for the species and concluded that the salt marsh harvest mice reported at Rodeo Lagoon were more likely misidentified western harvest mice.

*Vegetation sampling* — Plants (Table 2) were sampled at each trap grid, and the relative percent cover for the greatest 5 species showed similar dominance of grasses, rushes, and sedges in the pasture and wetland types (Fig. 5). Although earlier surveys (PWA et al. 1994) defined five habitat types (dune, riparian, pasture, tidal lagoon, and wetland) at Big Lagoon, we found little distinction between pasture and wetland.

Wetland and pasture parcels were originally distinguished because of grazing by horses; however, the parcels might more suitably be distinguished by their hydrology. The pasture parcels are currently seasonal freshwater wetlands dominated by *Juncus effusus* and contain ponded areas of cattail (*Typha* spp.). Wetland parcels W2 and W3 (Fig. 1) are more brackish wetlands, seasonally inundated during high winter tides, and dominated by *Juncus leseurii*, *Potentilla anserine*, and *Distichlis spicata* (C. Shoulders,

pers. comm., 2003). Wetland parcel W1 more closely resembled a seasonal freshwater wetland similar to the pastures areas because of its distance from the ocean. The earlier classification of habitats (PWA et al. 1994) did not accurately reflect the present conditions; however, we retained the original classification scheme for the following analysis for consistency.

In pasture, Pacific silverweed comprised roughly 4% cover; whereas in the wetland, smartweed comprised roughly 5% relative cover. Currently, pasture areas seem most similar to non-grazed wetland areas. Leaf litter, water parsley, stinging nettle, willow, and rushes dominated riparian understory cover. Dune habitats were dominated by bare sand, American dune grass, yellow sand verbena, and beach bur. The tidal lagoon was 100% bare sand and rocks.

*Small mammal habitat* — The greatest number of total captures were found in pasture (5.5 captures per 100 TN) and wetland (4.2 captures per 100 TN) habitats (Table 3). We detected three and five new captures per 100 TN in the dune and riparian habitat types (Table 3). We did not detect any small mammals in the tidal lagoon area.

Western harvest mice were detected in all habitats with vegetative cover. Western harvest mice were more abundant in pasture (5.2 new captures per 100 TN) and wetland (3.9 new captures per 100 TN) habitats, with fewer individuals detected in dune and riparian habitat types with 0.5 new captures per 100 TN each. One western harvest mouse was detected in the dunes in an area with 38 percent cover and an average height of 15 cm (yellow sand verbena, American dune grass, and beach bur), and another western harvest mouse was detected in the riparian habitats. However, the primary habitat for the western harvest mouse was pasture and wetland, habitats consistent with their diet of seeds, grasses, and leafy plants. California voles were less abundant with one captured in wetland and one in pasture habitat types. Deer mice were detected only on sand dunes (0.5 new captures per 100 TN); similarly, the roof rat was only found in riparian habitat (roof rats were not marked to distinguish recaptures) (Fig. 6).

In addition to percent cover, we sampled habitat structure (Fig. 7) by measuring plant height at each point intercept (for riparian areas we sampled under story vegetation). The average height of vegetation varied from riparian (35 cm), wetland (21 cm), pasture (20 cm), and dune (11 cm). Riparian understory plants, such as blackberry and nightshade, were nearly 50 cm tall. Wetland vegetation was shorter and ranged from a height of 34 cm (smartweed) to 15 cm (white clover). For pasture habitat, cattail was the tallest vegetation reaching nearly 80 cm, while water buttercup was the shortest at 9 cm. The dune habitat had the shortest vegetation, ranging from 28 cm (yellow sand verbena) to 3 cm (beach bur).

The Big Lagoon vegetation reflects the historic land use of wetland grazing, with pasture and wetland habitats dominated by grasses, rushes and sedges. Plant species in wetland parcels seemed nearly indistinguishable from 'pasture' parcels during late summer. Pasture and wetland communities were comprised not only of similar vegetation but similar height structure. Heights in the pasture ranged from 10 to 27 cm, excluding cattail, which occurred along the edge of the trap grid. Similarly, heights in the wetland ranged from 15 to 27 cm. Pasture areas were former wetlands, and although once grazed, the distinction between wetland and pasture were unnoticeable in our late summer vegetation sampling in terms of species composition and structure.

We found that abundance of western harvest mice was significantly related to habitat and vegetation (Fig. 8, $F_{3,36}= 4.37$, $p = 0.01$, $R^2= 0.21$), primarily vegetative cover ($t_{36}=2.66$, $p = 0.01$), but not height ($t_{36}= 0.34$, $p = 0.74$). This supports Fisler's (1965) finding that the western harvest mouse is often found in areas with high vegetative cover of grasses, sedges, or other plant species.

## Recommendations

The greatest number of small mammals was found in the pasture where dense cover provided abundant habitat for western harvest mice. Although dunes had low vegetative cover, deer mice and western harvest mice used this habitat in conjunction with adjacent edge habitats. Increased tidal flows in restoration efforts may result in establishment of

currently absent tidal marsh plants (*Spartina, Salicornia*) and their associated small mammal community. Restoration of the floodplain should encourage natural floodplain hydrology and remove restrictive barriers to flow. Healthy riparian corridors adjacent to seasonal wetlands may support greater numbers and diversity of small mammals, such as the Point Reyes jumping mouse. Predation by the non-native roof rat has caused considerable reproductive loss of riparian passerine populations in the Central Valley (Mokelumne River Preserve). Restoration efforts to enhance the riparian community may warrant the removal or management of roof rats.

## Future Research

Continued trapping during and after restoration actions would be valuable to detect change and allow for adaptive management. Additional trapping in different seasons may provide a better indication of variation of small mammal numbers through time. Trapping along other coastal estuaries such as Rodeo Lagoon would be very useful to confirm the presence or absence of the salt marsh harvest mouse and Point Reyes jumping mouse. The reported presence of salt marsh harvest mice at Rodeo Lagoon should be confirmed by trapping more mice in that location to examine their morphology and genetics. Development of an improved key for intermediate specimens based on genetic analyses (Steinberg 1997) would be valuable.

## Acknowledgments

This study was supported by the National Park Service, Golden Gate National Recreation Area. We give special thanks to Daphne Hatch (GGNRA) for initiating the project and Sarah Allen (Point Reyes National Seashore) for providing funding for the survey. Carolyn Shoulders (GGNRA) guided our efforts, provided detailed review comments, assisted with background information, and provided park access. We appreciate comments from N. Athearn on earlier drafts of the report.

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Table 1. Small mammal species and numbers detected at Big Lagoon from 29 October to 1 November 2002.

| Scientific name | Common name | Code | New Captures male / female | Recaptures male / female | Total |
|---|---|---|---|---|---|
| *Microtis californicus* | California vole | MICA | 0 / 2 | 0 / 0 | **2** |
| *Peromyscus maniculatus* | Deer mouse | PEMA | 0 / 2 | 0 / 1 | **3** |
| *Rattus rattus* | Common rat | RARA | * | * | **3** |
| *Reithrodontomys megalotis* | Western harvest mouse | REME | 17 / 13 | 4 / 5 | **39** |
| **Total** | | | **35** | **10** | **47** |

* Not marked to distinguish recaptures

Table 2. Plants observed at small mammal trap grids at Big Lagoon. Average plant heights (cm) reflect relative numbers as sampling occurred after a high winds and precipitation event that may have matted down some vegetation.

| **Species name** | **Common name** | **Habitat** | **Height (cm)** |
|---|---|---|---|
| *Abronia latifolia* | Yellow sand verbena | Dune | 28 |
| *Alisma plantago* | Water plantain | Riparian | 6 |
| *Alnus rubra* | Red alder | Riparian | 40 |
| *Ambrosia chamissonis* | Beach bur | Dune | 3 |
| *Calocedrus decurrens* | Incense cedar | Riparian | NA |
| *Calystegia purpurata* | Morning glory | Riparian | 23 |
| *Carex* spp. | Sedge spp. | Riparian | 20 |
| *Hydrocotyle ranunculoides* | Marsh pennywort | Pasture | 3 |
| *Juncus effuses* | Bog rush | Pasture, Wetland | 22 |
| *Leymus triticoides* | Alkali rye grass | Dune | 4 |
| *Leymus mollis* | American dune grass | Dune | 7 |
| *Mentha pulegium* | Pennyroyal | Wetland | 24 |
| *Oenanthe sarmentosa* | Water parsley | Riparian | 14 |
| *Poaceae* spp. | Grass spp. | Pasture, Wetland | 18 |
| *Polygonum* spp. | Smartweed spp. | Wetland, Riparian | 29 |
| *Potentilla anserine* ssp. *Pacifica* | Pacific silverweed | Wetland | 12 |
| *Ranunculus aquatilus* | Water buttercup | Pasture, Wetland | 11 |
| *Rorippia nasturtium* | Water cress | Riparian | 5 |
| *Rubus ursinus* | California blackberry | Riparian | 45 |
| *Rumex conglomerartus* | Whorled dock | Pasture | 17 |
| *Salix lasiolepis* | Arroyo willow | Riparian | 76 |
| *Scirpus* spp. | Rush spp. | Pasture, Wetland | 26 |
| *Senecio sylvaticus* | Wood groundsel | Riparian | 3 |
| *Solanum sarrachoides* | Nightshade | Riparian | 50 |
| *Trifolium repens* | White clover | Pasture | 12 |
| *Typha latifolia* | Broad-leaved cattail | Pasture | 69 |
| *Urtica dioica* | Stinging nettle | Riparian | 31 |

Table 3. New captures per 100 trapnights and total number of new individuals captured by species. Species include *Microtus californicus*, *Peromyscus maniculatus*, *Rattus rattus,* and *Reithrodontomys megalotis.*

| **Habitat** | **MICA** | **PEMA** | **RARA*** | **REME** | **Total** |
|---|---|---|---|---|---|
| Dune | 0 | 0.5 | 0 | 0.3 | 3 |
| Pasture | 0.3 | 0 | 0 | 5.2 | 18 |
| Riparian | 0 | 0 | 0.3 - 0.9 | 0.5 | 5 |
| Tidal Lagoon | 0 | 0 | 0 | 0 | 0 |
| Wetland | 0.3 | 0 | 0 | 3.9 | 11 |
| **Total** | 2 | 2 | 3 | 30 | 37 |

*Three rats were captured but were not marked to distinguish recaptures

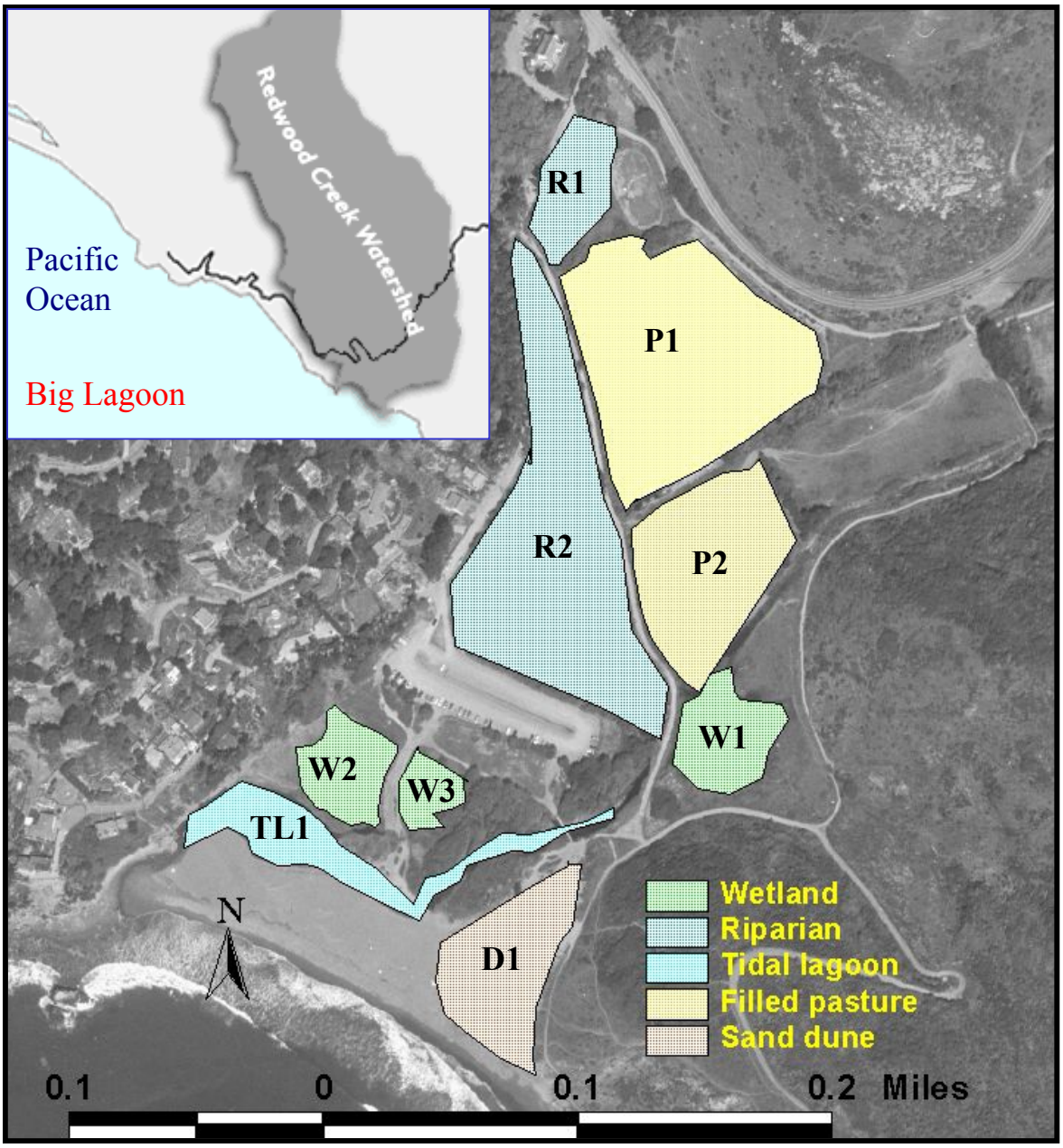


Figure 1. Habitat types occurring at Big Lagoon, including wetland, riparian, tidal lagoon, filled pasture and sand dune.

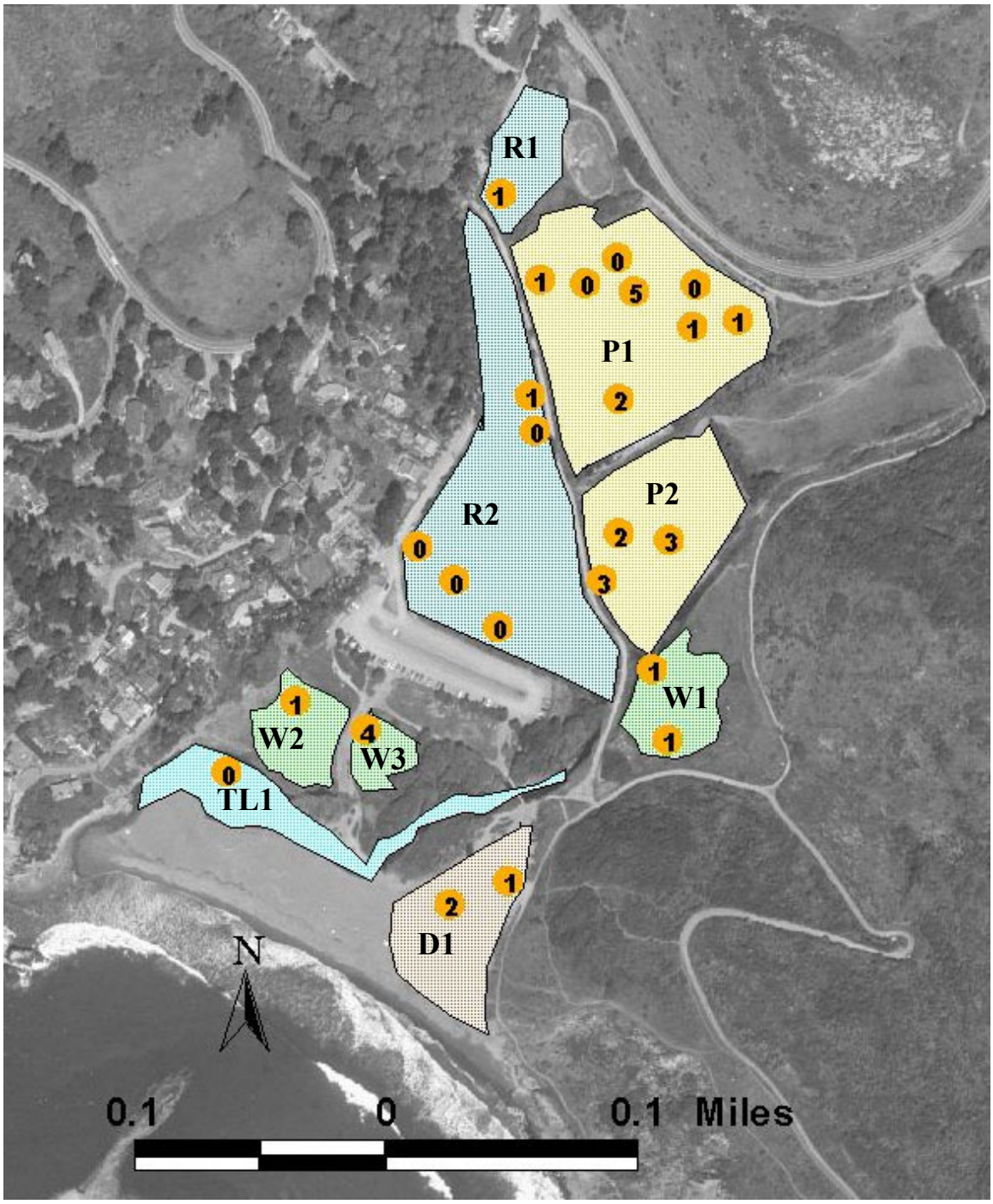


Figure 2. Location and number of new individuals captured at each small mammal trapping grid in riparian (R), pasture (P), wetland (W), tidal lagoon (TL), and dune (D) habitat. The common rat was captured but not marked for recapture in the R2 parcel, and are not represented on this figure.

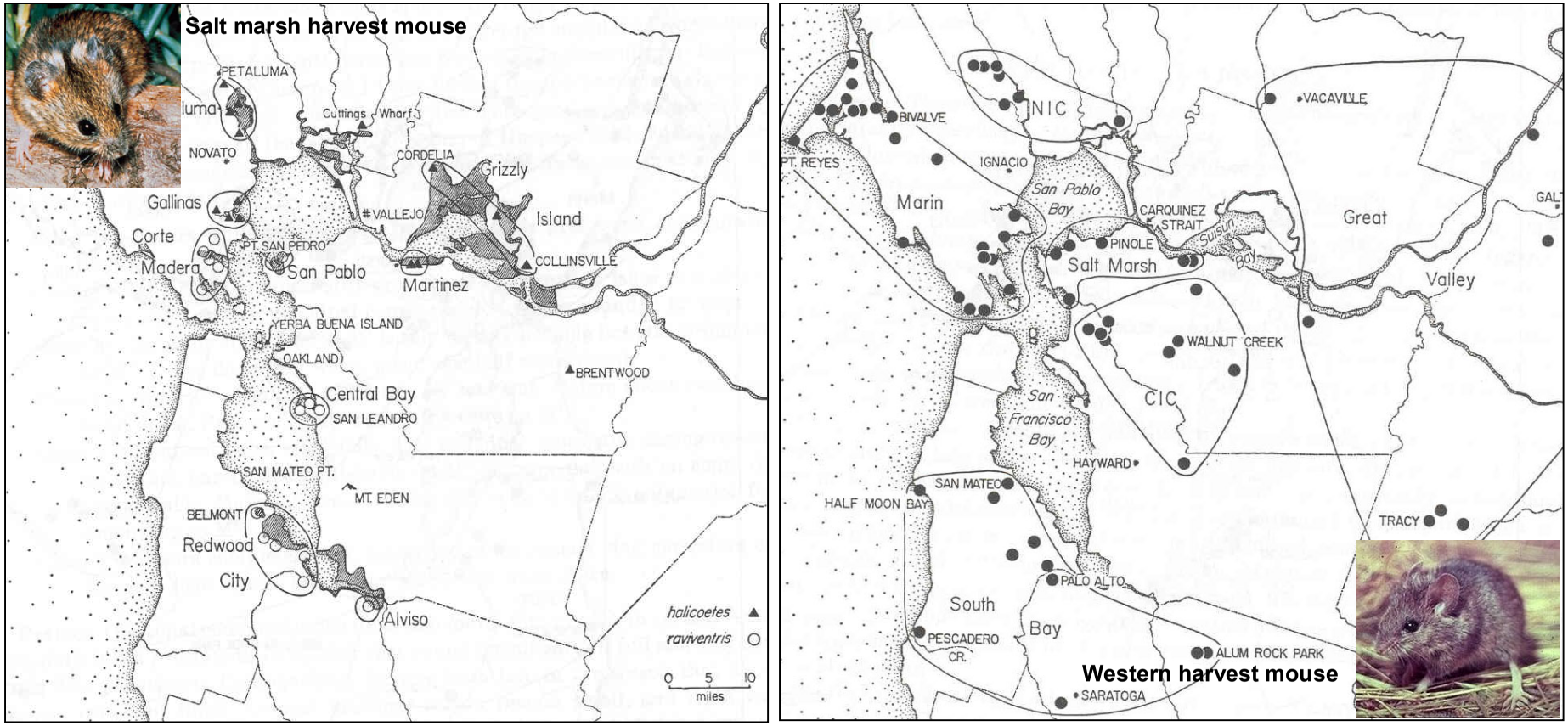


Figure 3. Distribution of the salt marsh harvest mouse (left, *Reithrodontomys raviventris* subspecies *raviventris* and *halicoetes*) and the western harvest mouse (right, *Reithrodontomys megalotis*). Points represent areas of capture; shaded areas indicate marsh environments (Fisler 1965).

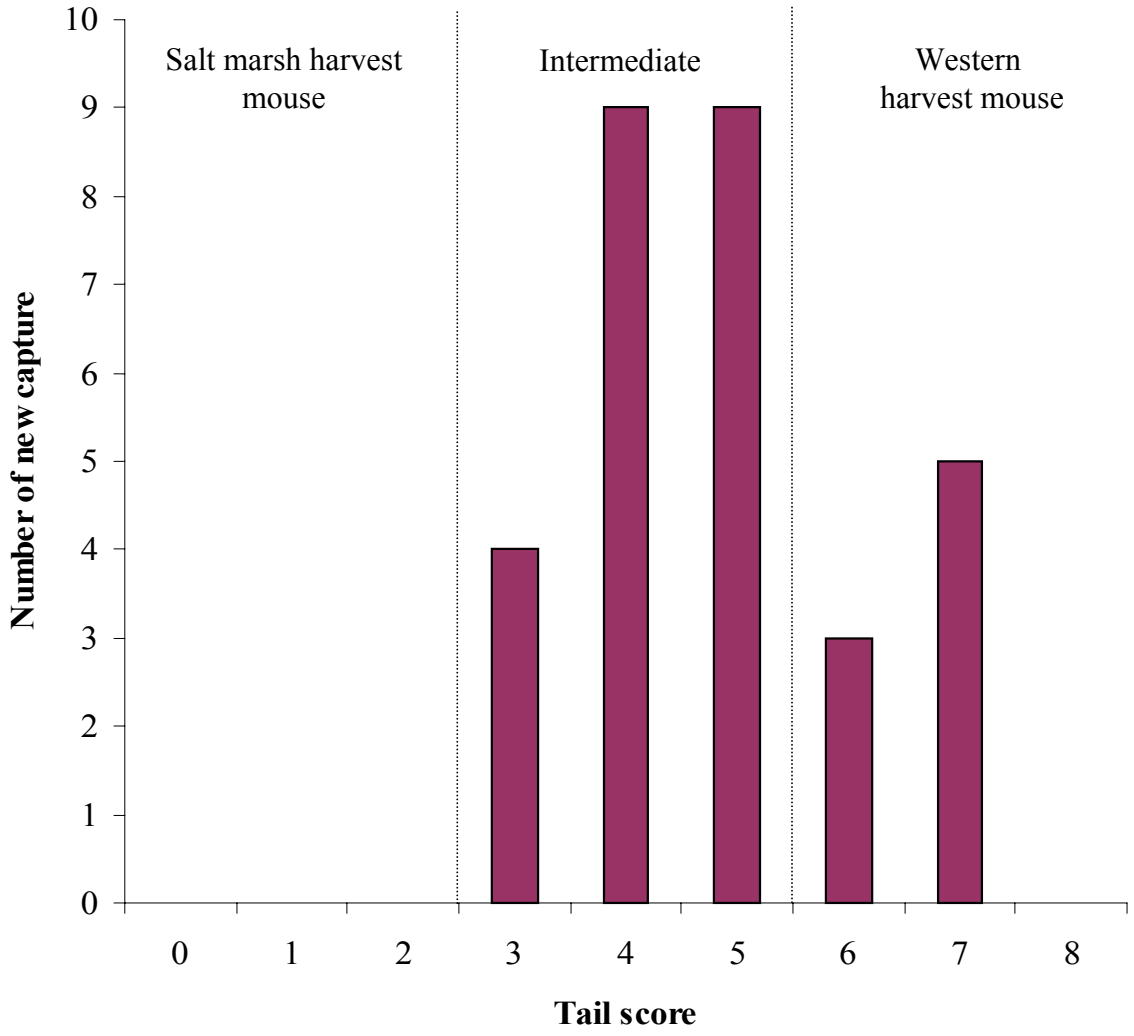


Figure 4. Number of new captures (Y-axis) that have tail scores (along the X-axis) in the categories used to distinguish *Reithrodontomys* species (following Shellhammer 1984).

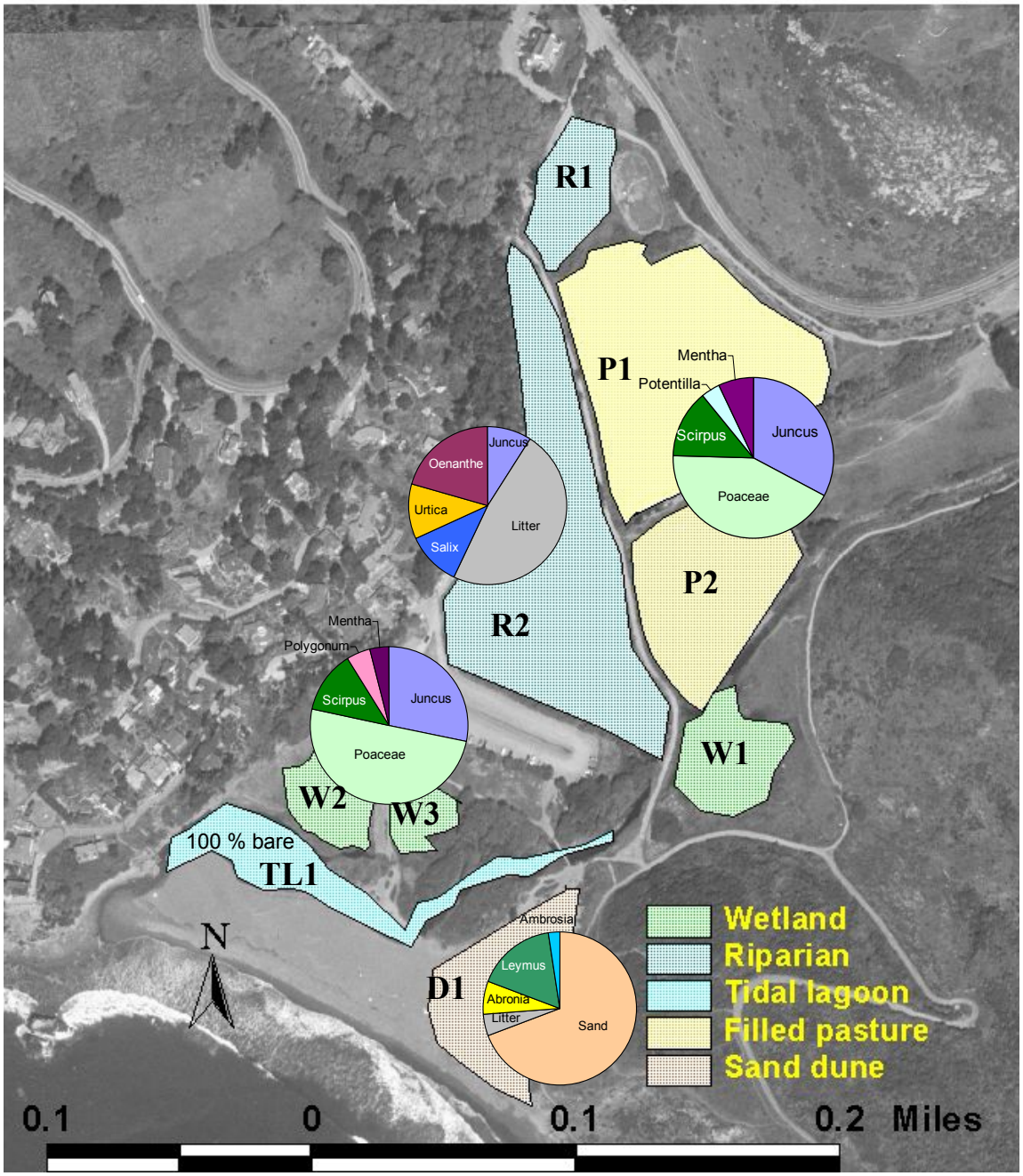


Figure 5. Relative percent cover for the top 5 plant groups by habitat type at Big Lagoon. Tidal lagoon was 100% bare and contained no vegetation.

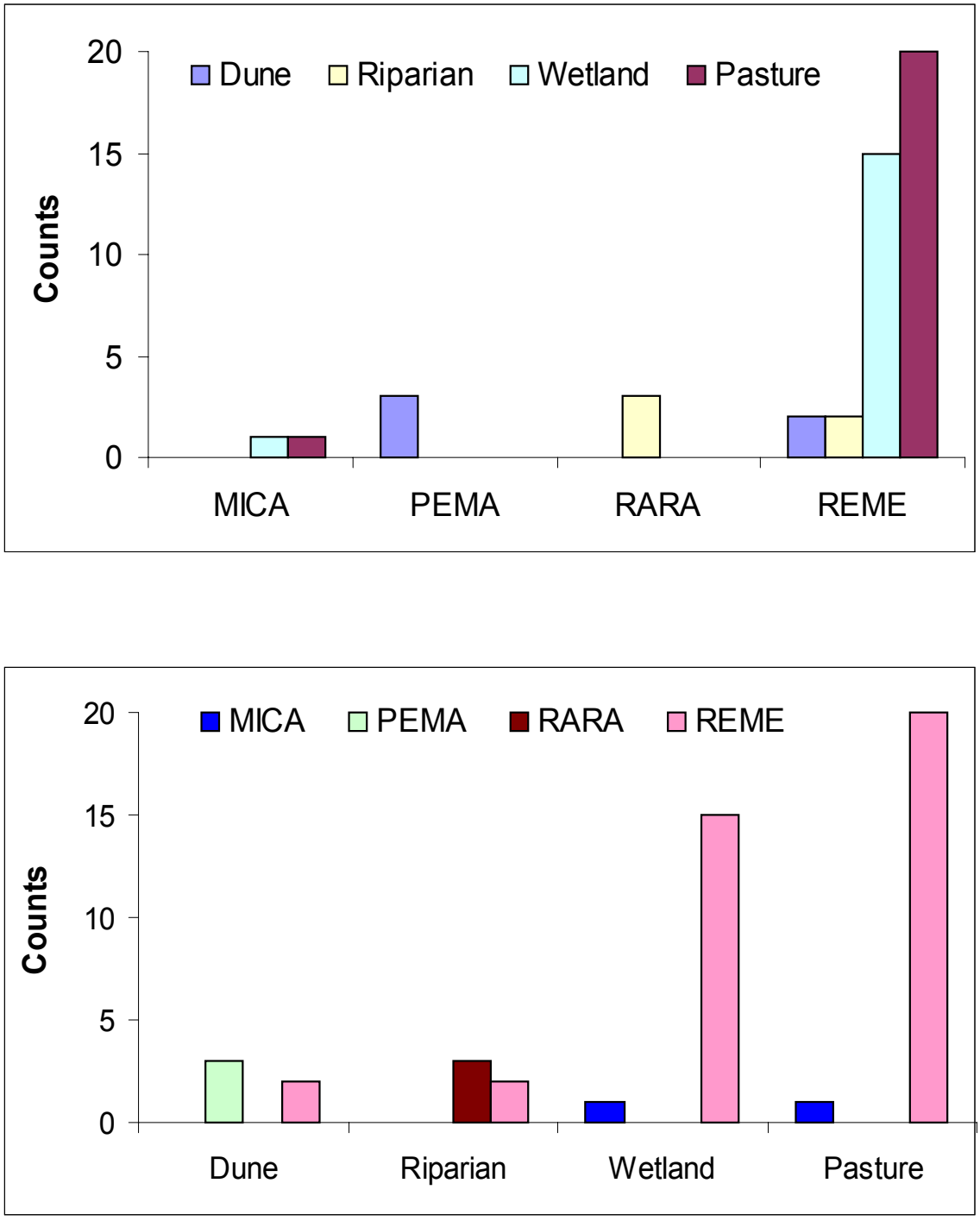


Figure 6. Counts of small mammals (new captures) by species (top) and habitat (bottom) during a 384 trapnight effort.

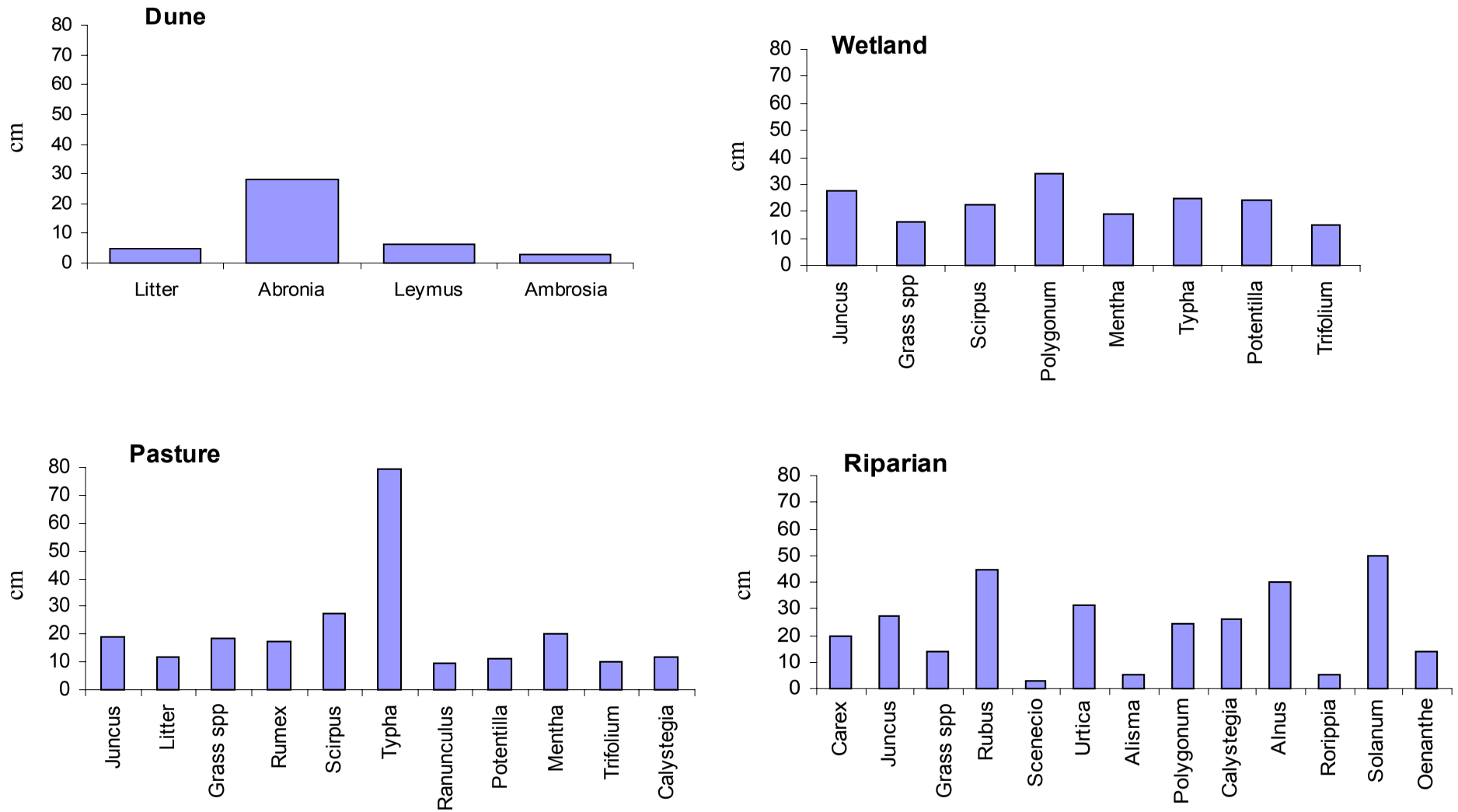


Figure 7. Average heights of plants found in dune, riparian, pasture, and wetland plant communities. Average heights were taken after a high wind and rain event and some plants may have been matted down.

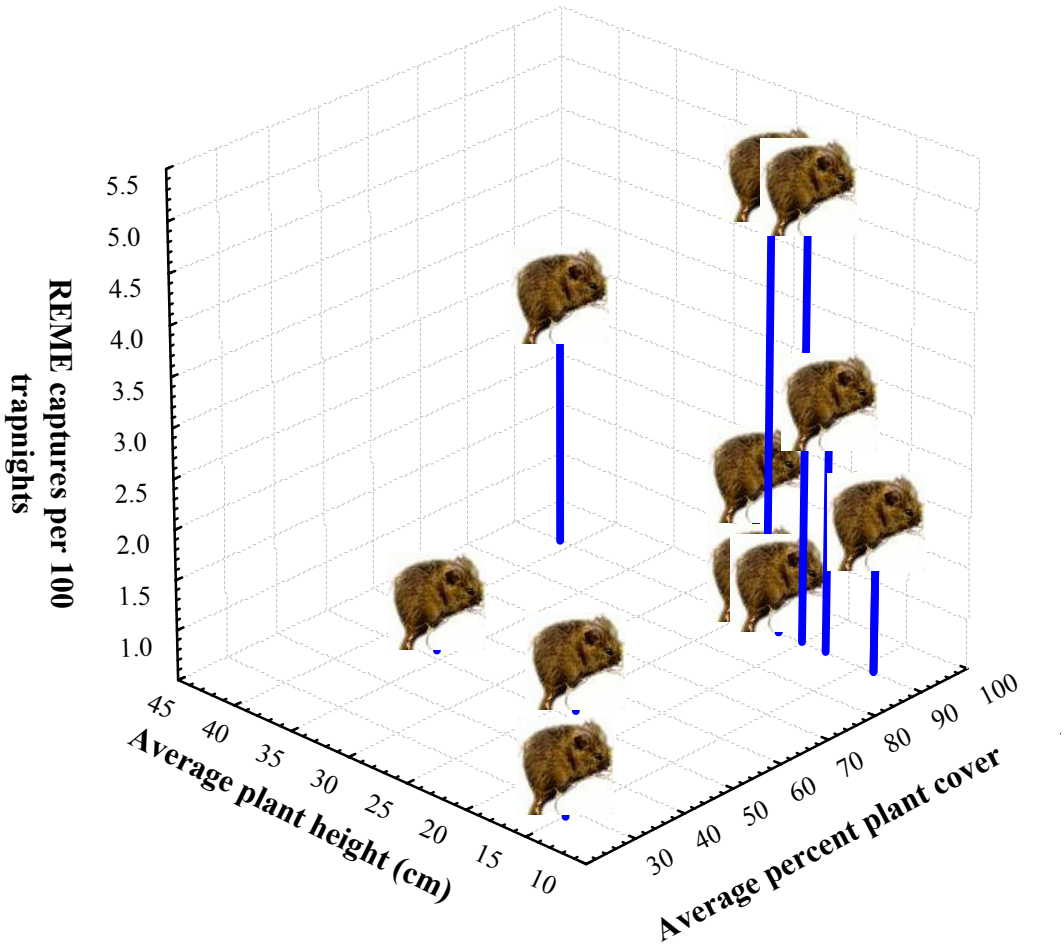


Figure 8. Number of new western harvest mouse captures per 100 trapnights in relation to average plant height and average plant cover.