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*Biodiversity Letters*, Vol. 1, No. 5 (Sep., 1993), 149-155.

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# Anthropogenic extinction of the endemic woodrat, *Neotoma bunkeri* Burt

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**Abstract.** Here we report on several lines of evidence that lead us to suspect the anthropogenic extinction of the woodrat *Neotoma bunkeri* Burt from Isla Coronados, Mexico. This species is represented by only six adult specimens housed at the Museum of Systematic Biology, UCLA, and appeared to be unique in that it had attained a very large body size relative to other insular or mainland woodrats. Our analysis suggests that depletion of food resources and/or the presence of

feral cats have led to the decline. Similar combinations of habitat destruction and predator introduction on other small islands in the Gulf of California are probably endangering many extant insular populations, and may ultimately lead to the extinction of an array of unique flora and fauna.

**Key words.** Historical extinctions, *Neotoma*, feral animals, Baja California Mexico, Sea of Cortez.

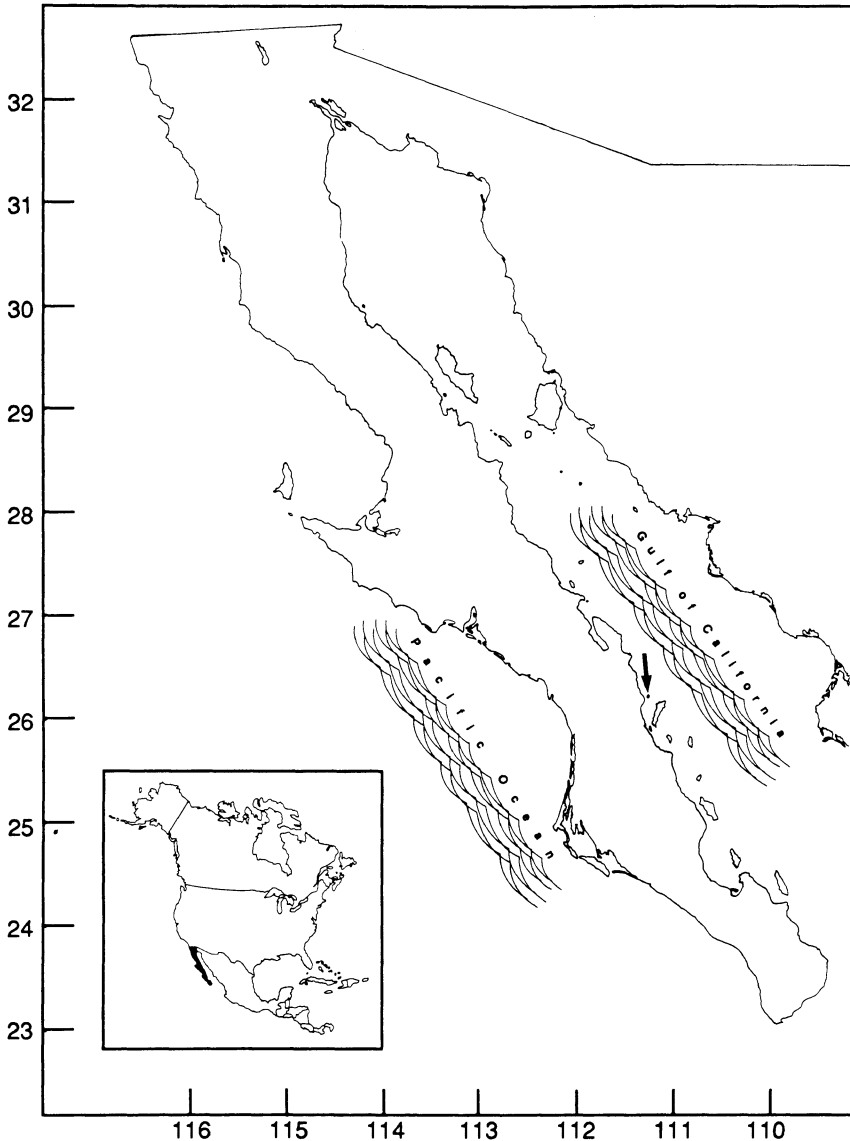
## INTRODUCTION

The group of islands in and around the Gulf of California has been called the 'poor man's Galapagos' because of its unique flora and fauna, fairly pristine condition, and relative proximity to researchers (Fig. 1). In recent decades, however, increasing population pressure and greater accessibility have resulted in increased usage of the Gulf islands by both tourists and local fisherman, and consequently, have exacerbated the impacts of humans on endemic species (Lindsay, 1983; Bahre, 1983). Population density in the Mexican state of Baja California Norte, for example, has grown two orders of magnitude during the last century (Bahre, 1983). As has been reported for other island archipelagos (e.g. James *et al.*, 1987; Steadman, 1986; Whitten & Bishop, 1987), this accelerated use of Gulf islands may be resulting in the rapid degradation of some very unique ecosystems. The current status of many of the endemic mammalian species, for example, is completely uncertain. Many are known only from study specimens collected in the late 1800's and early 1900's, and even on the most accessible islands, only limited field work has occurred since that time (e.g.

Banks, 1964a, b; Lawlor, 1971; Vaughan & Schwartz, 1980; Gill, 1981; Lawlor, 1982, 1983).

We report here the results of what is tantamount to a case study of anthropogenic extinction for an endemic Gulf woodrat species, *Neotoma bunkeri*. Our work was conducted on Isla Coronados, in the state of Baja California Sur (Figs 1 and 2). We begin by outlining the evidence that leads us to conclude population levels are either extremely low or nonexistent, and then speculate on likely proximate causes. Our observations are based on a combination of live trapping, field work and interviews with local fisherman, and lead us to suspect that harvesting of woodrat food resources as firewood, combined with the deliberate introduction of predators, has led to the population decline. As in many other island archipelagos (e.g. Diamond, 1984, 1987, 1992; Steadman, 1986; Whitten & Bishop, 1987), the indirect and direct effects of human habitat alterations have thus combined to decimate the local fauna. The tremendous growth in tourism and in the resident human population of this historically depauperate area probably mean that similar fates ultimately await the flora and fauna of even the most remote of the Baja California islands.

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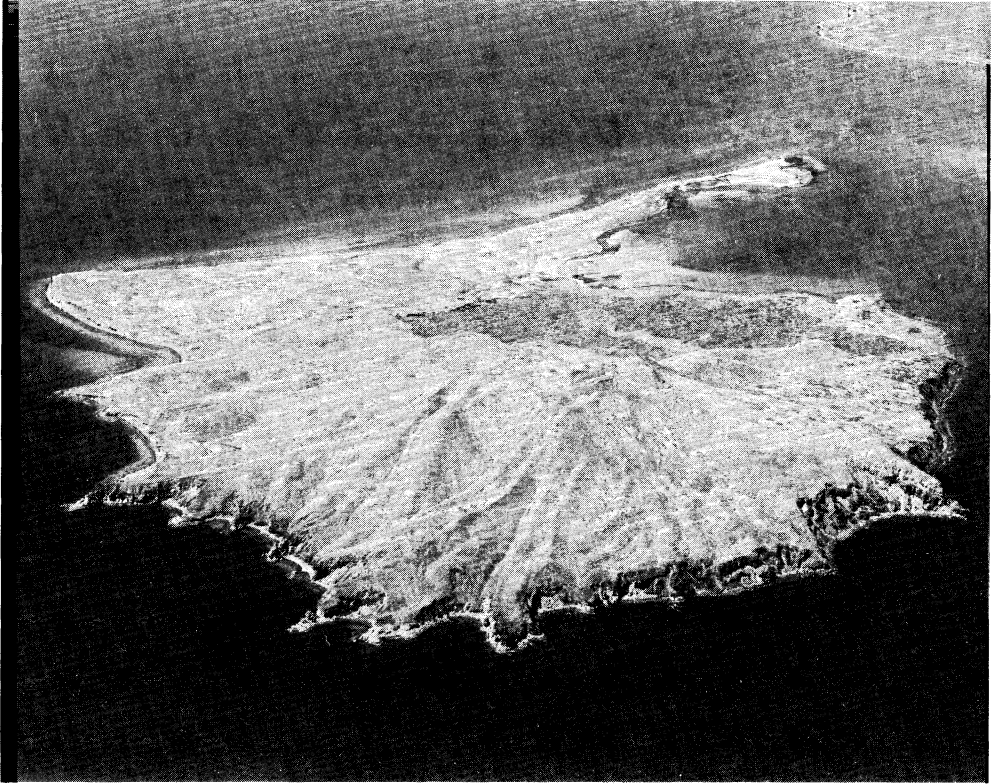


**FIG. 1.** Map of Baja California, Mexico and surrounding islands. Most are of continental origin and were isolated from the mainland by the raising of the sea level some 6 to 10,000 years ago. Woodrats are found on fifteen islands in and around Baja California. For a description of the islands and (sub)species, see Smith (1992). The arrow indicates the location of Isla Coronados.

## BACKGROUND AND METHODS

In the course of an investigation on geographic size variation among insular and mainland populations of *Neotoma* from Baja California, Mexico (Smith, 1991, 1992), it became apparent that very little information existed regarding several endemic species. In particu-

lar, the Coronados Island woodrat, *N. bunker*i, was represented by only six adult museum specimens collected in 1931, of which only one was male. This animal was particularly interesting because it had evolved the largest body size of any insular woodrat. The single male specimen, for example, measured 222 mm in body length (exclusive of tail) and probably ex-



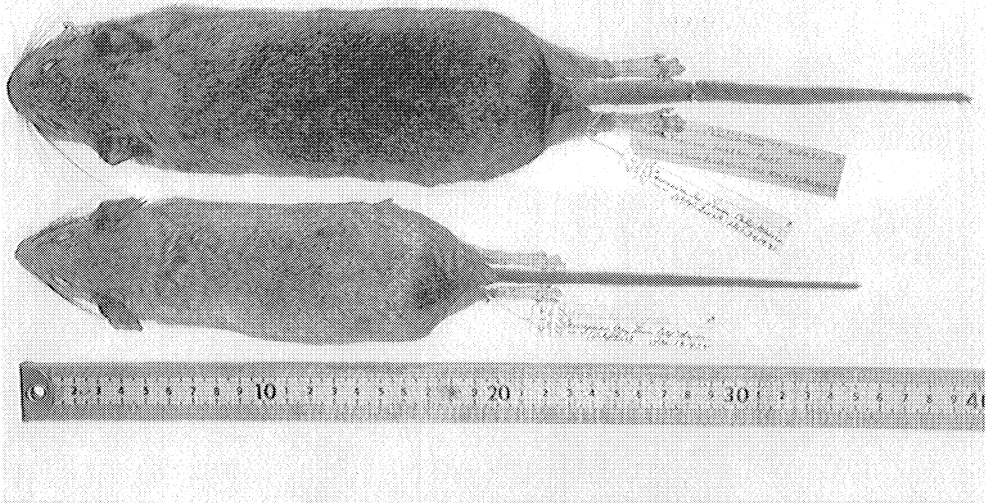
**FIG. 2.** Aerial photograph of Isla Coronados ( $111^{\circ}18'$  longitude and  $26^{\circ}06'N$  latitude). Reprinted with permission from *The Baja Traveller*. Note that much of the island is covered with large volcanic boulders. The type specimen of *Neotoma bunkeri* Burt was trapped in this area.

ceeded 400 g in mass (Fig. 3; Smith, 1991, 1992). In fact, its large size and dark colouration led Burt (1932) to originally conclude it was related to *Neotoma fuscipes*, a species characteristic of chaparral and coastal riparian habitats. Later authors placed it within the *Neotoma lepida* group (Huey, 1964; Hall, 1981). The lack of museum specimens prompted several field expeditions on Isla Coronados, as well as several other small islands off the Baja California coast, during March of 1989 and again in June of 1990. Our primary aim was to obtain additional morphometric and ecological information about *N. bunkeri*.

Woodrats, or 'packrats' as they are sometimes called, are small herbivorous rodents that inhabit arid regions of North America. They are solitary and nocturnal animals that characteristically build large conspicuous 'dens' composed of sticks, cactus joints, rocks and other materials. When available, these are constructed under or around boulders and serve primarily as predator refuges, although dens also moderate the effects of

inhospitable weather conditions (Rainey, 1956; Lee, 1963; MacMillen, 1964; Cameron & Rainey, 1972; Finley, 1990; Vaughan, 1990; Smith, 1991). It is fairly easy to determine whether a woodrat den is occupied by visual inspection. Unoccupied houses often have spider webs extending across the runways, while those in current use typically have fresh plant clippings and/or scats in the runways or midden piles (Cameron 1971; Cameron & Rainey, 1972; Finley, 1990; F.A. Smith, personal observation).

Coronados is a small (c. 8.5 km<sup>2</sup>) landbridge island situated approximately midway along the Baja peninsula and roughly 2 km offshore (Figs 1 and 2). A long sand spit extends from the southwestern edge of the island toward the mainland, and dark lava boulders are particularly prevalent on the western slope. Three resident mammalian species were described by Burt (1931, 1932) consisting of a pocket mouse belonging to the *Perognathus spinatus* group, a deer mouse, *Peromyscus pseudocrinitus*, and the woodrat, *Neotoma*



**FIG. 3.** Type specimen of *Neotoma bunkeri* (top) and presumed mainland ancestral species, *Neotoma lepida ravida* (bottom). This is the only adult male specimen of *N. bunkeri* known to exist. The dark colouration was attributed by Burt (1932) to substrate matching.

*bunkeri*. The latter two were accorded full endemic status by Burt (1932), Huey (1964), and Hall (1981), although the designation was based solely on morphometric characteristics such as size and pelage coloration. Woodrats had been described by Burt (1931, 1932) as 'common [on Coronados] with their nests around the large lava boulders and in the brush' and indeed notations on the museum collection tag indicated that the type specimen was trapped in lava rocks at the south end of the island. Initial efforts were thus concentrated in this area and consisted of both live trapping and visual inspection of habitat for woodrat sign.

A total of 7 days was spent on Coronados, which considering its small size, allowed us to visually inspect much of the island, and virtually all of the boulder fields, for evidence of woodrat occupation. Groups consisting of three persons hiked in roughly parallel lines for 2 to 4 h at least once each day. Additionally, on three evenings a total of eighty-three large Sherman traps were set, baited with fresh apple wedges and peanut butter mixed with oats. A complete lack of woodrat sign discouraged further trapping efforts on additional nights.

## RESULTS AND DISCUSSION

Despite considerable effort, not a single woodrat or den was found. In fact, the only mammal observed was a single adult female *Perognathus spinatus pullus*, trapped in March of 1989. This species was the smallest of the three reported endemics, and the individual caught weighed only 14 g. The subsequent expedition in 1990 failed to yield further evidence of the pocket mouse, despite trapping in the same locality. Because our sampling techniques were geared towards locating woodrats we can not report on the current status of the other rodent species with any degree of authority. It is clear, however, that population densities must be very low.

Previous investigators had described other insular *Neotoma* species as common (Townsend, 1912; Sheldon, 1930; Burt, 1931, 1932, 1938), and Townsend (1912) went so far as to call them 'especially numerous'. The complete lack of midden piles or even debris from old houses on Coronados suggests that the animals have been extinct for years or even decades. Although it is generally very difficult to determine both the timing and proximate cause of a historical extinction

(James *et al.*, 1987; P.S. Martin, personal communication), in this instance we can reasonably implicate several factors in the population decline.

First, vegetation quantity and quality were very low, even by comparison with the other relatively depauperate Gulf islands of approximately the same size, such as Danzante (roughly 100 km further south; F.A. Smith, personal observation). In particular, ironwood (*Olneya tesota*), which forms the bulk of the diet for the Danzante island woodrat (Vaughan & Schwartz, 1980; F.A. Smith, personal observation) was conspicuously absent from Coronados. Ironwood had been reported on this island by Cody, Moran & Thompson (1983), and we did find several stumps that may have been the remains of old trees. We suspect that its utility as a firewood source may have caused its removal. A number of old fire rings were present on the island, for example, and it seems doubtful that combustible materials were transported from the mainland.

Second, we found abundant evidence indicating the presence of feral cats on the island, although interestingly enough these animals too appear to have died out. Old scats were ubiquitous, especially throughout the southern portion of Coronados. Dissection of available fecal pellets indicated the felines had consumed small rodents and in one instance, twine. The latter observation is certainly consistent with starvation. It was not possible to date the material, although a whitish colouration suggested they were not of recent occurrence. Cats are particularly effective predators. The devastating effects of predator introductions on insular fauna has been well documented for avian species as well as for the native Australian mammalian fauna (e.g. Parker, 1972; Jehl & Parkes, 1983; Diamond, 1984; Steadman, 1986). Diamond (1984), for example, has estimated that feral predators (primarily cats and rats) are responsible for 50% of all historical bird extinctions.

From the fragmented bits of evidence available and from interviews with local fisherman who visited the island, we were able to piece together what we feel is a likely scenario for the extinction of this species. It appears that the island has been used for quite some time as a site for fish camps. The temporary structures in which the fisherman clean and gut their catch occupy virtually every cove and are in varying degrees of repair. According to the locals we spoke with, 'mice used to overrun the camps' and cats were imported in order to reduce the problem. Such descriptions are consistent with our own experiences. On neighbouring islands *Perognathus* often chew or inspect our field

gear. The fisherman also confirmed that ironwood and other island vegetation have been collected for camp fires. The end result was both the expiration of woodrat food resources and the introduction of previously unknown mammalian predators, a combination that has repeatedly proved disastrous for native fauna (e.g. Parker, 1972; Jehl & Parkes, 1983; Diamond, 1984, 1987, 1992; Steadman & Olson, 1985; Steadman, 1986). Both Vaughan & Schwartz (1980) and Smith (1991, 1992) have reported that Danzante island woodrats do not display typical anti-predator avoidance behaviours, and unlike animals in mainland habitats, spent much of the evening outside of their dens where they can be observed easily. Such behaviour is common to insular animals that have evolved in the absence of mammalian predators and if also true of the Coronados island woodrat would certainly have led to high predation loss (Diamond, 1992).

It is of course possible despite our observations that *N. bunkeri* subsist at very low densities within more inaccessible portions of Isla Coronados. We did not visit the northernmost regions. Our concentration on the area covered by lava boulders (Fig. 2) is justified, however, by numerous earlier accounts. Burt (1931, 1932) had reported that the Coronados island woodrat was closely associated with the boulders. In fact, he attributed their 'extremely dark coloration' to substrate matching. Work on other populations and reports from other collectors (e.g. Sheldon, 1930; Huey, 1964, Vaughan & Schwartz, 1980, F.A. Smith, personal observation) also indicated that insular woodrats are largely confined to rocky or boulder covered areas. Sheldon (1930), for example, described insular *Neotoma* as 'common in all rocky areas', but stated that he 'did not find any nests in the brush'. In any case, woodrat dens are very conspicuous and their complete absence points to an extremely limited woodrat presence. In describing the population density of *Neotoma* on other Gulf islands, Townsend (1912) stated that woodrats were 'more in evidence than any other mammal ... by reason of its conspicuous brush nest', and that they were 'seen by the dozen'. The absence of suitable food resources would also argue against a sustained population, even in more remote regions. Lastly, areas that are inaccessible to humans are not necessarily so to felines, and so, given the small size of Coronados it is difficult to envision localities that could be inhabited by woodrats but not by feral cats.

Whether or not we are correct in our view that *Neotoma bunkeri* is extinct, the anthropogenic factors likely to jeopardize any insular population of *Neotoma*

— destruction of vegetation and importation of alien predators or competitors — continue unabated. Without some sort of intervention, other unique animals and plants of Baja California will undoubtedly face similar fates. In response to heightened usage, the Mexican government declared a portion of the archipelago, the Midriff islands, a national wildlife refuge in 1978 (Bahre, 1983). Unfortunately, not only does little funding exist for enforcement, but many other islands also containing unique species remain completely without protection.

Finally, it should be pointed out that if Burt had not visited this island in December of 1932, it is possible that both the existence and probable extinction of the Coronados Island woodrat would have passed quite unnoticed.

## ACKNOWLEDGMENTS

Support for the work described here was provided by grants from the National Science Foundation (BSR-8815175) and the University of California Consortium on Mexico and the United States (UC-MEXUS) to F.A. Smith. Monty Navarre of Airguide Publications graciously granted permission to reprint Fig. 2 from *The Baja Traveller*, as well as providing other valuable aerial photographs. We thank Scott M. Elliott, Gene Philips, and Kim Ryder for their invaluable field assistance, and Alfredo (of Alfredo's Sportfishing, Loreto, B.C.S.) for his frequent inspections of our outboard motor. We are especially grateful to Paul S. Martin for his interest in the subject, and to James H. Brown, Jared M. Diamond, Scott M. Elliot and Paul S. Martin for their insightful comments on the manuscript.

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