# Habitat and Conservation Status of the Beaver in the Sierra San Luis Sonora, México

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**Abstract**—*The status of beaver (*Castor canadensis*) in northeastern Sonora, Mexico, is uncertain. We surveyed the Cajon Bonito River to assess the beaver's status and habitat and found five colonies. Limiting factors appear to be pollution due to animal waste, deforestation of riparian trees, and human exploitation. Beavers did not appear to require habitat diversity as much as dense riparian and aquatic vegetation in waters with low organic content. These kinds of studies are imperative to understanding the natural history and ecology of the species in this unique region.*

## Introduction

Increased water demands for irrigation, industrial and domestic uses already threaten freshwater resources in many parts of the world where major rivers are dammed, diverted, and overused, leading to the degradation and loss of freshwater habitats. Several species dependent on these freshwater habitats are in danger of disappearing, unless they become protected (Saunders et al. 2002); among these species is the American beaver (*Castor canadensis*). This species is associated with freshwater streams and rivers that have riparian forests of willow and cottonwood trees and plenty of aquatic vegetation (Jenkins and Busher 1979, RIC 1998).

Beavers are abundant and widely distributed across much of North America, but due to landscape changes and habitat fragmentation beaver populations have been decimated in many areas (Kendi et al. 2001). Beavers are considered keystone modifiers or ecosystem engineers, having a profound and long-lasting impact on their environment that is beneficial to a wide variety of wildlife species like fish, river otters, beetles, and aquatic invertebrates (Jenkins and Busher 1979, Melquist and Hornocker 1983, Middleton 1999, Power et al 1996, RIC 1998, Whitham 2001). Therefore in order to keep such an important species, it is imperative to characterize the habitat and to determine the conservation status of the species, including its distribution and abundance (Grigera 2002).

In Mexico, isolated beaver populations have been documented along the U.S.-Mexico border (Leopold 1977, Hoffmeister 1986, RIC 1998). Beavers are protected by federal laws in Mexico and are classified as endangered of extinction (SEMARNAT 2002). However, the knowledge of their status in northeastern Sonora, as in most of Mexico, is not well known.

The populations of beaver in northeastern Sonora are located in the Sky Island region, encompassing southeastern Arizona, southwestern New Mexico, northeastern Sonora and northwestern Chihuahua. This area is biogeographically unique, formed by the crossroads of the Rocky Mountains, the Sierra Madre Occidental, Sonoran and Chihuahuan Deserts.

The Sky Island region provides habitat for charismatic species such as mountain lion (*Puma concolor*) and black bear (*Ursus americanus*). In addition, the region functions as a biological corridor for many species such as jaguar (*Panthera onca*), pronghorn (*Antilocarpa americana*, [Imhoft 2003]) and bighorn sheep (*Ovis canadensis*) (data on file with Karla Pelz Serrano and Eduardo Ponce Guevara).

Our objectives were to describe the relative abundance and habitat characteristics of beavers in the Sierra San Luis, Sonora.
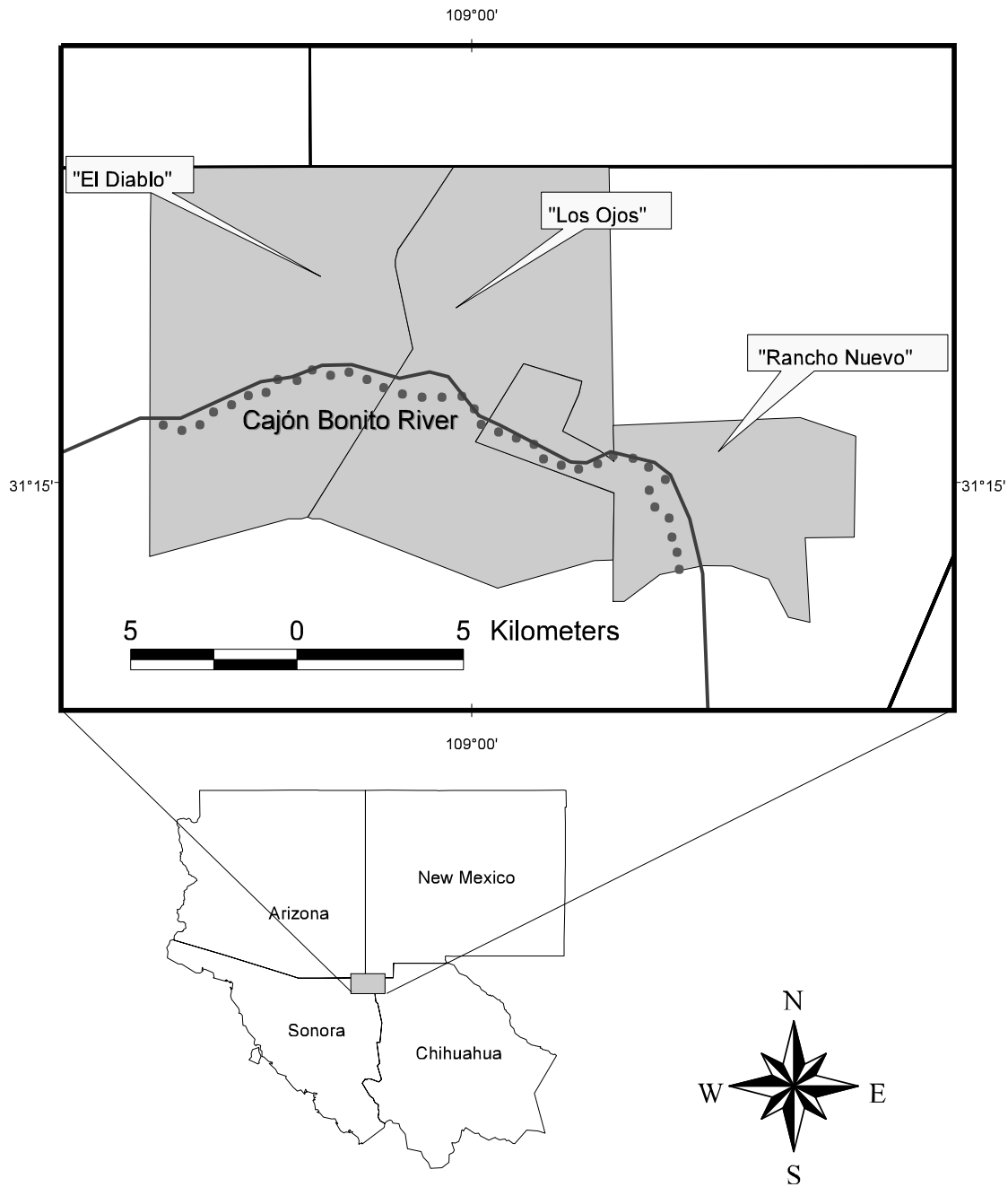
## Study Area

We concentrated our efforts in the Cajon Bonito River (figure 1). This river system is part of the largest area without fragmentation in northern Mexico (The Wildlands Project 2000). A large portion of the Cajon Bonito is located in private property, where no livestock presence has occurred for the past seven years. Consequently restoration has taken place and good ecological conditions are present, with large populations of fish, reptiles, and amphibians (Robert Minckley pers. comm.). However, upstream the river is diverted for trout aquaculture and used by livestock. We selected 3 sites (fig. 1): (1) Rancho Nuevo Ranch, which has livestock influence, and no beavers, (2) Los Ojos Ranch which has no livestock and no beavers, and (3) El Diablo Ranch, which has no livestock but has beavers.

## Methods

### Presence and Abundance

To determine the presence of beavers, we surveyed 18.5 kilometers of the Cajon Bonito River, between July and December 2003. Beaver spoor was identified as tracks, fallen trees, and gnawed branches, dams, and food caches (RIC 1998). The geographic location of the spoor was obtained with a handheld GPS unit (Garmin 12XL) and recorded in Universal Transverse Mercator units. Additionally, we

● Survey points

**Figure 1**—Study area along the Cajon Bonito River within the three ranches. Dots indicate survey points.

performed interviews with neighboring ranchers where we found current beaver activity, to document if these people had previous contact with the species.

We estimated beaver colony size based on the criteria of a fall food cache consisting of branches stored underwater to be used for winter feeding (RIC 1998). Using one fall food cache per colony, we estimated the total number of beavers by multiplying the numbers of colonies in an area by the mean colony size (McTaggart and Nelson 2003, RIC 1998). A typical beaver colony is composed of 2 breeding adults, 1-2 yearlings and 2 kits (RIC 1998). Colony size estimates for selected studies in North America range from 3.4 to 4.6 beavers per colony,

including adults and kits (RIC 1998). For this study we used a mean colony size of 4 individuals: 2 breeding adults, 1 yearling, and 1 kit (McTaggart and Nelson 2003, RIC 1998).

## Habitat Characterization

The river was described according to riparian vegetation structure and water quality characteristics. To determine the chemical characteristics of water we used a Shallow water test kit (Forestry Suppliers, Inc.). We took a water sample every 0.5 km. Thus in Rancho Nuevo, which has 5.5 km of running water, we took 11 water samples. In Los Ojos and El Diablo,

**Table 1—**Comparison of the chemical characteristics of the three ranches.

| Ranch | O$_2$ (ppm) | Temperature (ºC) | Turbidity | pH | Width (m) | Depth (cm) |
|---|---|---|---|---|---|---|
| Rancho Nuevo | 6.87 ± 0.50 [a] | 15 ± 1.68 [a] | 0 ± 2.61 | 7.5 ± 0.39 [a] | 2.5 ± 4.84 | 20 ± 56.5 |
| Los Ojos | 7.31 ± 0.42 | 16 ± 0.61 | 0 ± 2.40 | 8 ± 0.26 | 2.5 ± 0.70 | 20 ± 34.1 |
| El Diablo | 7.4 ± 0.45 | 15.5 ± 0.68 | 0 ± 0* | 8 ± 0 | 2.5 ± 1.02 | 20 ± 55.3 |

[a] denotes those variables with significant differences between ranches.

we took 13 samples. For each water sample we measured temperature, pH, dissolved oxygen, and water turbidity. The dissolved oxygen was determined by the Winkler method and is given as ppm, and the turbidity is given as Jackson turbidity units (Brower et al. 1998). We also measured the depth and width of the river at each sampling site.

The chemical parameters of all sampling points were compared with an analysis of variance (ANOVA) or Kruskal Wallis ANOVA on ranks, depending on the normality of each variable, in order to test for significant differences. In the case of the ANOVA test, all pairwise multiple comparison procedures were made with the Tukey Test, and in the case of the Kuskal-Wallis, tests were made with Dunn's Method (Zar 1999).

At each site we made three transects of 10 X 50 m along the riverside in order to characterize the riparian vegetation of each ranch. We measured the cover, DBH (diameter at breast high), and height of each tree (>5 cm DBH) within each transect. We calculated density, abundance, importance value, dominance, coverage area, and Simpson and Shannon indexes as measures of diversity (Krebs 1999). We also recorded the presence or absence of aquatic vegetation within transects.

# Results

## Presence and Abundance

At 6 locations in El Diablo Ranch, we found beaver spoor, including tracks, scats, and food caches for a total of 38 records. The other two ranches lacked beavers. Interviews with residents revealed that all of the Cajón Bonito used to have beavers until a few years ago, and residents reported that they saw a beaver dam in 2003, 3 km upstream from where we found dams in the present study. Of the 38 records of beaver sign in Cajon Bonito, 5 were food caches, indicating 5 different beaver colonies.

Multiplying the number of colonies found by a mean colony size of 4, we estimated that the number of individuals present in this population is 20.

## Habitat Characterization

We found significant differences in all four water quality variables: dissolved oxygen, temperature, pH, and turbidity (table 1). The most polluted place was Rancho Nuevo, having the highest level of turbidity and the lowest level of dissolved oxygen. Rancho Nuevo also had the lowest pH level, and so was less basic than the other two sites.

In the case of the vegetation structure analysis, we found that the most diverse site was Rancho Nuevo, but it was the least dense and had the least cover (table 2). Los Ojos and El Diablo were not very diverse, but they were dense, had more cover than Rancho Nuevo and had old and young trees (table 2). However, El Diablo had the highest density of willows and cottonwoods. In fact these tree species had the highest importance values of all species of the entire tree community (table 2). The tree species found in the three sites surveyed were the same, but only Rancho Nuevo had *Carya* sp. and *Liquidambar* sp. Sites did vary only in vegetation density and cover.

In all transects of Rancho Nuevo, there was aquatic vegetation, such as duckweed (*Lemmna minor*), horned pondweed (*Zannicchellia pallustris*), and some algae (Clorophyta). These plants are indicators of organic material in the water, and therefore this result is further evidence that Rancho Nuevo had water pollution. In Los Ojos, we recorded horse tail (*Equisetum* sp.), mint (*Mentha* sp.) and some grasses, all of them abundantly. On the other hand, El Diablo presented aquatic vegetation covering most of the water, including algae (Clorophyta and Rodophyta), horse tail, mint, and another aquatic plant from the Lamiaceae family. Los Ojos and El Diablo did not have duckweed.

**Table 2—**Comparison of vegetation characteristics in the three ranches.

| Ranch | H′ | λ | Cover (100 m²) | Importance value | Density (ind/m²) | Aquatic plants |
|---|---|---|---|---|---|---|
| Rancho Nuevo | 0.63 | 0.30 | 1848.07 | *Salix* sp. (168.42) *Carya* sp. (153.74) | 0.086 | *Lemmna minor, Zannichellia pallustris* and algae |
| Los Ojos | 0.45 | 0.42 | 4523.40 | *Salix* sp. (280.12) *Populus fermontii* (160.44) | 0.522 | *Equisetum* sp. and *Mentha* sp. |
| El Diablo | 0.24 | 0.66 | 2347.34 | *Populus fermontii* (389.66), *Salix* sp. (183.06) | 0.338 | *Equisetum* sp. and *Mentha* sp., algae and an aquatic from the family Lamiaceae |

# Discussion

Beavers were considered a threat to road maintenance in the study area, because trees cut by beavers for dam construction could block the roads and cause flooding. As a result, ranchers began to kill beavers. Now these rodents survive only in remote ranches, without livestock where the habitat is in good ecological condition.

Our estimate of only one colony/km is in accordance with other studies. Rosell and Houde (2001) found 0.83/km in Gvarv River, 0.71/km in Lunde River, and 0.52/km in Saua River in Norway. On the other hand, Lizarralde and Venegas (2001) found introduced beaver colonies at a density of 0.7/km in Tierra del Fuego. Whitham (2001) reported an average density of colonies of 0.8/km along 300 km in Minnesota. Smith (1998) found in the Yellowstone River in Wyoming an average density of beaver colonies of 0.35/km. In Canada, the maximum averaged density of beaver as a whole was estimated at 1.0-1.2 colonies/km (Müller-Schwarze and Sun 2003). This means that the density of colonies in the Cajon Bonito rests within those reported for other North American sites and for an introduced population in South America. However, it is important to highlight the fact that we found only five beaver colonies in the entire Cajon Bonito River, which means that there were only five reproductive pairs; consequently these beavers may confront a problem of genetic variability if there is not enough genetic interchange. According to Withham (2001), the Cajon Bonito should have 60 individuals in its 20 kilometers of running water, if the whole river were suitable for beavers. With this potential density, the population could have a better future.

Rancho Nuevo had the highest levels of pollution, presumably because of the presence of livestock. Animal wastes contain suspended solids, nitrates, and faecal coliform bacteria (Stauffer 1999). Cattle waste cause eutrophication in surface-water as well as increased turbidity and the pH becomes less basic (Stauffer 1999). Los Ojos was more polluted than El Diablo because it received pollutants that flowed downstream from Rancho Nuevo. However, without additional pollutant input, water arrived cleaner in El Diablo. Furthermore beaver ponds probably helped to clean the water.

Apparently, beavers did not depend on the vegetation species diversity of the sites, because beavers were found in the least diverse site. Beavers were in a dense area where the most important plants were those that they eat (*Populus fermontii* and *Salix* sp.). Also, beavers were in a site with more vegetation cover than Rancho Nuevo, which indicates that they need areas with a high density of edible plants and with sufficient cover. Los Ojos was the site with more cover and was denser than the other ranches, probably because it has older trees and it has been without cattle a longer time than El Diablo. Beavers in El Diablo were eating the trees, perhaps contributing to less tree cover at this ranch. However, this feeding may help spread seeds from trees cut by beavers, and so beavers may be helping in the restoration process of riverine systems (Fink 2000). In addition, the least dense site with the least cover was Rancho Nuevo, which also had aquatic vegetation such as *Lemmna minor*, which is an indicator of water polluted with organic material and with poor levels of oxygen (Mathias Dos Santos y Banzatto 2001). On the other hand, El Diablo had vegetation that did not indicate water pollution. Beavers eat pond vegetation during most of the summer (Jenkins and Busher 1979), so places like El Diablo that have many aquatic plants and water quality in good conditions may be seasonally suitable sites for occupation by these mammals. After a period of time, beavers tend to move to other sites; if the upstream part of the river is not in good ecological condition, they are not going to be able to live there.

According to Gallo-Reynoso et al. (2002), beavers in the Bavispe River were more abundant where the riparian vegetation was intact and undisturbed including the presence of cottonwood (*Populus* sp.), and willow (*Salix* sp.), and they were less abundant in areas perturbed by farming, livestock, and human activities. Therefore the removal of natural riparian vegetation and the presence of livestock in the Cajon Bonito River seem to have limited beaver distribution.

There are few published records of beavers from the northeastern watershed of the Sierra Madre Occidental of Mexico (Gallo-Reynoso et al 2002); therefore additional studies about the status of the species are imperative to understanding the natural history of the species in this unique region, and to learn more about their seasonal distribution (Long 2002).

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