A large, multi-armed cactus in a desert landscape with a person standing at its base for scale.

KING CACTUS

THE GIANT
CARDON CACTUS
OF BAJA
CALIFORNIA

photos & article

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Giant cardon cactus with many branches, on Catalina Island near La Paz with one of the authors as reference of the size.

RIGHT: A typical cardon habitat in the mountains near La Paz, Mexico.



desert
under
siege

UPON

first encounter with the giant cardon cactus *Pachycereus pringlei*, many foreign visitors to the Baja California peninsula mistake this "king of the desert" with the perhaps more familiar saguaro *Carnegiea gigantea* of the Arizona desert. The visitor may concede to some differences, perhaps the cardon is more massive, but in



general they appear to be the same aweinspiring plant. However, they are wrong. The cardon cactus, the undisputed emblem of the Baja California peninsula, is a different species from a different botanical genus and only barely resembles its northern cousin.

On one point everybody agrees, it is a majestic plant. With a wide distribution over the entire peninsula, often occurring in dense stands, it is impos-

Left photo /Ronald Wauer

sible to visit Baja California without being continuously exposed to scenic views framed by this huge tree-like cactus. However, because the peninsula is sparsely developed with many remote and inaccessible areas, unless you have a helicopter handy or you are a cowboy with a horse and protection against the spiny flora, most of the cardons will remain out of reach. This inaccessibility has allowed most populations of cardon to remain intact, even

after five centuries of European settlement. They are destroyed mainly where they grow close to the several urban areas on the peninsula, or in areas that are thought to have a potential for agriculture. Despite the futility of crop cultivation in the harsh desert conditions, local farmers keep trying and are destroying many cardon stands in the process.

We are not the first generation to be deeply impressed by this magnificent cactus. The Jesuit priest Miguel Del



cardón

*Pachycereus
pringlei*

RANGE MAP



Barco, the founder of the still-standing and functioning Mission San Javier near the small town of Loreto on the Gulf of California, was inspired to pen the first description of the cardón in 1768. In poetic prose, Don Miguel wrote:

This tree, although full of moisture, is found only on dry lands, on level and sloped ground alike, provided that there is no moisture nearby, for this it shuns Whence then does it draw that moisture and the sap with which it is replete? Not from the rains, since these are very scant in California, and therefore, where there is no permanent spring and one must rely on rainwater alone, nothing can be sown or planted... The cardón, however, even though years may pass without rain, shows no sign of distress: it perseveres serenely, with the same fresh green color and the same abundant sap, as ever

The cardón is almost endemic to the peninsula of Baja California. Small stands do exist elsewhere on most of the islands in the Gulf of California and also on the Sonoran coast of mainland Mexico, but large stands are unique to the Baja California peninsula. Together with the Brazilian tree-shaped cactus, *Cereus jamacaru*, it is perhaps the largest species of the cactus family. An average mature cardón may reach a height of ten meters, but individuals as tall as eighteen meters are known; the trunk diameter often exceeds 1 meter. Most adult cardón have several side branches that may be as massive as the trunk. The resulting tree may attain a weight of 25 tons, out-weighting the gray whale that visits the shores of Baja in wintertime. Such large cardón specimens can be found in the fertile lands of San Juan de Los Planes, about 40 km east of La Paz, and on the remote Isla Catalina, far ashore southeast of Loreto. The former population is severely threatened by clear-cutting for agriculture, however, the latter is protected by the remoteness of its location and occasional heavy seas.

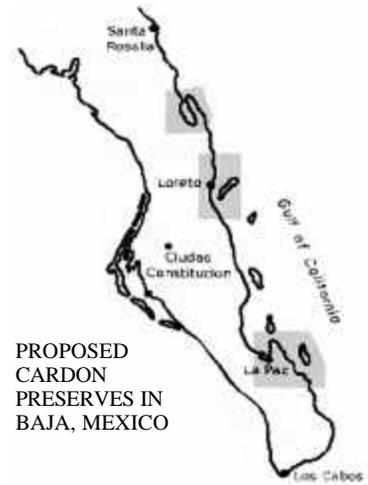
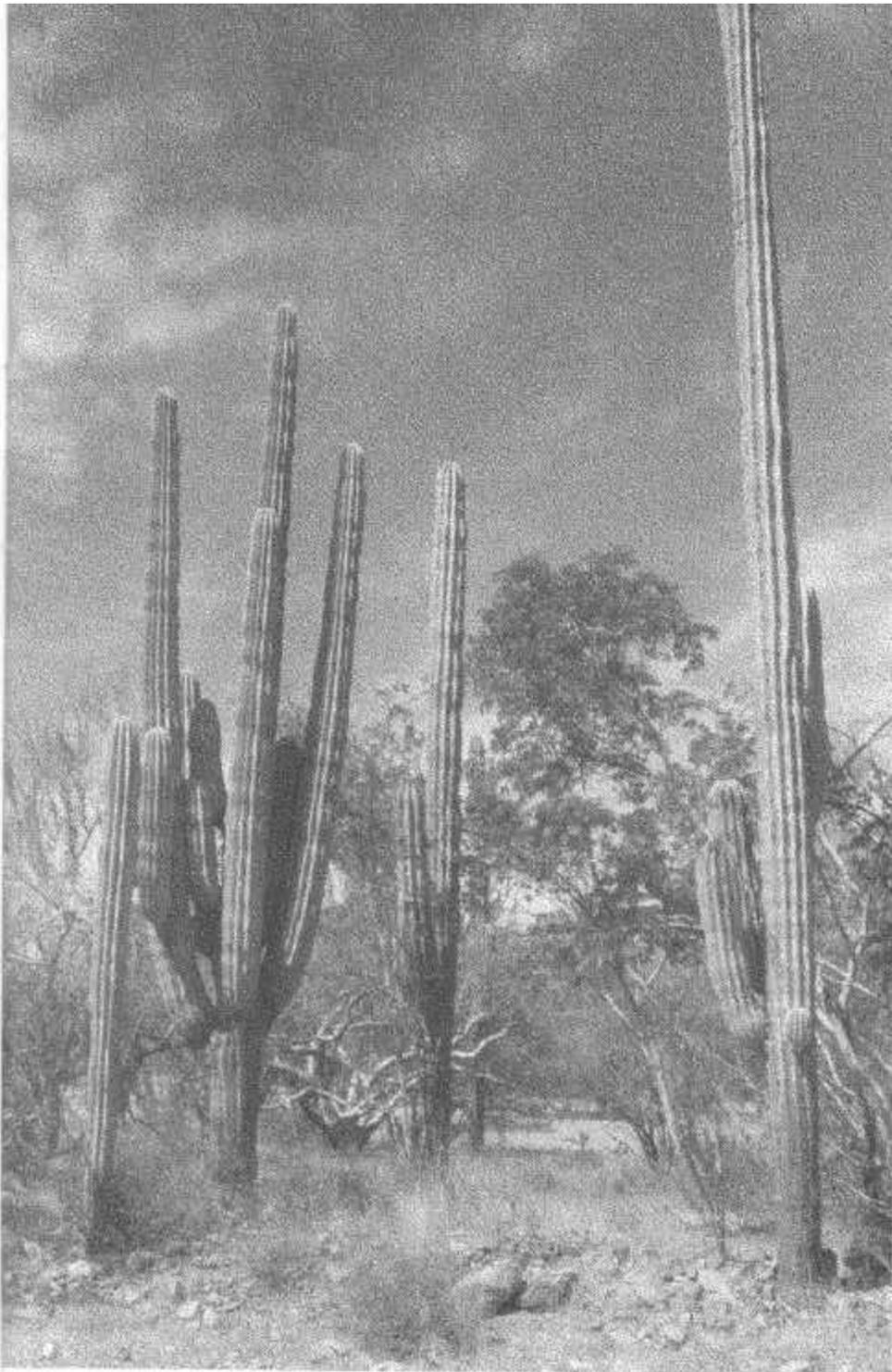
The highly nutritious and succulent fruits of the cardón, available in abundance during the desert dry season when other food sources are scarce, were enjoyed by the native Seri Indians of the Sonora desert, and are a major source of nutrients for many desert birds in the Baja California peninsula. The lesser long-nosed bats *Leptonycteris curasoae* of the mainland Sonoran coast are major pollinators of the night-blooming flowers of the cardón and depend on the fruit for survival. The birds are very efficient at feeding on cardón fruits. For years we have observed in our garden located on the edge of a fence-protected natural reserve that almost none of the fruits fell to the ground before being completely eaten.

Many residents of La Paz, including the gardening department of the municipality, believe that a large green cardón in front of their porch or in traffic islands in the city will decorate the place with a desert flavor. But the cardón is uncooperative. Almost none of these transplanted cardóns attain full size or are as beautiful as in the wilderness. A mature cardón is almost impossible to transfer unless you devote a fortune for the packaging of the giant plant and usually the transplant dies. A branch will not root, even with the aid of the growth hormone supplements commonly applied to many vegetatively-propagated cacti. From a gardening point of view, its rate of growth is discouragingly slow, to say the least, and is a lesson in patience. One or two cm per year is a typical reward for the patient gardener. In rainy years, or if irrigation is used as I frequently do in my garden, a record growth of 5-10 cm is achievable but no more. With a life span measured in hundreds of years and its slow growth, this plant will never make the gardener's or landscaper's "favorites list". This "gardening handicap" does not reduce the immense ecological importance of the cardón or its impact on the well-being and health of the local population. To the casual visitor driving from the US and Canada, Baja California seems a pristine environment hardly touched by civilization; a gigantic, untouched and unspoiled park. This is deceiving. Underlying this apparently idyllic setting, is a grim ecological reality. When naturally vege-

tated deserts are cleared to produce marginal agricultural land that is later abandoned (a process often called desertification) or to build urban neighborhoods lacking paved roads, nothing remains to hold the topsoil against wind-caused erosion. The result is severe soil erosion and subsequent dust pollution. The latter indirectly but significantly increases chronic respiratory illnesses. Official reports of the Ministry of Health of Mexico characterize about 30% of the state's population, mainly children, as having chronic respiratory illnesses. This phenomenon has been increasing throughout the developing world and in North America it is predominant in the semiarid areas of northern Mexico. Prevention of soil erosion and dust pollution in urban, low income, desert communities in Mexico are difficult for a variety of reasons: (i) Local municipalities are poor and can only afford to pave some roads. Thus, the unpaved roads yield heavy dust pollution caused by auto and truck traffic and strong desert winds. In our city of La Paz, for example, of the total 450 km of streets, over 40% are unpaved, and we are in the best shape in the state. (ii) Deforestation of large tracts of the tropical dry forest is considered to be necessary for the survival of small communal agricultural communities having large land holdings. (iii) Overgrazing by free-roaming cattle and goats is widespread and traditional since the Jesuit missionaries imported these animals in the 17th century. (iv) Fresh water is scarce and cannot be used to irrigate non-crop plants that might hold the topsoil. Much of the available water is used for priority tourist projects such as the huge tourist resort of Los Cabos and the green golf courses which provide a sharp contrast to the otherwise



Destroyed cardón



dry landscape. (v) State governments and municipalities lack financial resources to enforce existing laws against woodcutting. (vi) Desert trees, which ordinarily prevent erosion, such as mesquite and ironwood that grow with the cardon in the dry forests of Baja California, are valued for charcoal production everywhere.

How can our native desert plant, the cardon, help to remedy this ecological disaster? The giant cardon stands out for its ability to stabilize disturbed arid soils.

It has a widespread, branched, shallow root system capable of responding to rare rainfall by rapid growth. The roots, dispersed in a 30 m diameter around the tree, trap the topsoil that is essential for plant growth. Even during hurricanes, areas populated by cardon are dust-free. I still have a vivid memory of traveling to Ciudad Constitucion (an agricultural center 200 km north of La Paz) during a strong sandstorm. We passed, extremely slowly, through this city of 40,000 inhabitants by the main boulevard,

without seeing the numerous shops lining the street 15 meters to the side. This town, that years ago cleared all cardon cacti to make room for agriculture, is currently in economic ruin.

If the cardon is such a great topsoil stabilizer, why not cultivate it on a large scale? The catch is that it has a very low establishment rate on transplant, even as relatively young plants, and subsequent slow development when transferred from natural habitats or from nurseries to eroded urban soil. Numerous dying, or barely surviving cardons can be seen on traffic islands and in city gardens, replaced periodically with other cactus species. These are a testimony to the "uncooperative" nature of the cardon.

Perhaps something can be done to increase the survival of transplanted cardons?. Some years ago, we realized that the key to success may be to reestablish the microenvironment surrounding the cardon plants, especially the microorganisms living in their roots. We observed in our research center that the survival of small seedlings and the growth of cardon cacti can be significantly enhanced in its initial stages by treating the seeds with plant growth-promoting bacteria such as *Azospirillum* sp. These bacteria are known to promote the growth of numerous agricultural crops and are one of the microbial groups on which the future "fertilizer-free" agriculture is based. Transplanted cardons treated with the bacteria survived well (over 70% of the plants) compared to the untreated plants, none of which grew. When grown with the bacteria, five-year-old plants had an appearance of over 50-year-old plants

and this is encouraging. These microorganisms must be included in any transplantation program otherwise all efforts will be futile.

Cardon plants, despite their abundance, are not simply growing everywhere. Adult cardons are adapted to the harsh climate of the Baja California peninsula, which is characterized by drought and extremely high temperatures, but as seedlings and juveniles they depend for survival on nurse plants, such as legume trees mesquite *Prosopis articulata* and iron wood *Olneya tesota*. Only under the canopy of these trees, can an abundance of young cardons and other cacti grow. The cardon's life span is far longer than that of the mesquite, and eventually it will grow without the nurse tree. One obvious advantage provided by a nurse tree is shade in the desert to prevent heat shock, desiccation and death of the young plants. In addition, our studies of the biological and non-biological components under the shade of the nurse plant revealed that, in contrast to the surrounding barren desert soil, the soil under the nurse tree is finer, has higher water capacity, greater organic matter and nutrient content, and contains an abundance of mycorrhizal fungi. **We have evidence that these beneficial parasitic fungi, living in the roots of most plant species, serve as a below-ground network for transferring nutrients from the nurse plant to the nurselings.** The technology to apply all of this accumulated knowledge in a large-scale reforestation program to revegetate the desert is, unfortunately, years away.

A few years ago, during an expedition to the deep desert of the Sierra La Gigante and Sierra de Guadalupe, perhaps the only true wilderness of Baja, we discovered another amazing feature of the cardon. This area is composed of ancient lava flows, about 20 million years old, most of them barren moonscape even today. Yet, in numerous areas some plants, mainly cardons but also a few other cactus species such as Pitaya dulce *Stenocereus thurberi*, *Mammillaria* spp., and cimarron fig trees *Ficus palmeri*, were growing in sheer rock and cliffs without any trace of soil for hundreds of meters around. Some cardons were growing on a pile of stones-only 10 meters high. It occurred to us that these plants have an unknown ability to dissolve the basalt



rocks and to extract the nutrients essential for growth. Water availability is also a difficult problem; for example in the 1999 summer "wet season", the area had only 14 mm of rain, which is close to nothing as far as plant growth is concerned. Yet, the entire flora looked green, though not flourishing, but at least alive.

Opening basalt rocks with chisel and hammer when the air temperature is above 40°C and the rock temperature exceeds 60°C is no one's favorite pastime. But, we were curious. When the rock was opened, the entire root system of the

young cardon was revealed in a small cavity that the plant had apparently dissolved in the rock. The roots were completely devoid of soil and were suspended in the air in aeroponic conditions. Small roots were strongly attached to the rocks. Later Dr. Vladimir Lebsky, our electron microscopy specialist, and Esther Puente, a graduate student, discovered **an abundance of bacteria, fungi, and diatoms (small silica-coated microalgae) heavily colonizing the root system. Some of these microorganisms are capable of dissolving the**

rock, some can solubilize phosphate minerals that otherwise are not available to the plant, and others can fix atmospheric nitrogen. Together they are fulfilling the nutritional requirements of a plant determined to grow in a very inhospitable environment. It seems that life will find a way to survive.

How does this outstanding ability of the carbon-microorganism team assist nature? The natural degradation of these lava rocks by the elements alone takes millions of years. Rock-degrading plants, like the carbon, even though they are slow growers, accomplish as much in our lifetime. **They create soil, in geological terms, at accelerated speed.** This soil is



A carbon growing in a rock, without any soil and (middle) between two trees. This mesquite tree serves as a nurse tree for baby cardons.

eventually washed away from the rock cavities by the occasional rains and accumulates in lower areas of the lava flow, allowing other, non-rock dissolving, plants to grow. The desert gets greener. Not fast, but definitely greener.

It is possible to visit these ancient lava flows. However, heed a word of advice: Do not attempt to travel to this area without a 4x4 vehicle in excellent mechanical shape and without the physical and mental ability to survive in the wilderness if stranded for a short period of time. The 60-70 km of dirt roads between the Pacific and the Gulf of California, sometimes used by off-road racers, may take 4-15 hours to drive, unless of course, you are a Baja 1000 off-road competitor. In case of accident, help is perhaps a hundred km away over these rugged lands. Minimal

Spanish fluency might help as the ranchers are extremely friendly and helpful but cannot repair a computer chip in your engine. Also do not forget to take the rancher's kids wishing to visit the nearby town. They are waiting in the middle of nowhere for hours and sometimes for days for the ride.

If the carbon is so resilient and lives for hundreds of years, does this mean that there are no natural threats to its population? Like any living organism, the carbon has its share of natural maladies, although these do not significantly impact on its population size. In 1993, while surveying the desert, Dr. Gerardo Toledo (then my graduate student) and I observed that in some areas such as the Pacific coast 70 km from La Paz, enormous stands of carbon were degenerating. Most of the plants

looked as if a giant had chopped off their heads with a huge chain saw. We referred to this phenomenon in the scientific literature as "Flat-top-decay syndrome", which was the main feature of the affliction. Large numbers of these old-growth carbon were dying without any apparent reason. A referee in a scientific journal, criticizing our findings, claimed that bored ranchers as a possible pastime produced these abnormalities. Yet, the large extent of the damage and the height where the cuts were located (3-10 meters above ground) discounted the possibility of human vandalism. Fortunately our birds of prey that use the carbon as an observation deck, do not carry machetes as yet. The exact cause of this phenomenon awaits scientific investigation. Is anyone interested in joining the hunt?

Most cardon stands are still intact, yet the continued survival of this one of a kind plant is uncertain. Because the cardon is so widely distributed throughout the Baja California peninsula, it is not considered endangered, but exemplary stands are rare and increasingly threatened. The huge specimens of cardon that grow in some areas appear unusually vigorous and healthy, and represent the best germplasm of the species. These stands are scenically spectacular and accessible for the enjoyment of tourists and are suitable for study by scientists. **We recommend that these exceptional stands of cardon be protected as a national natural heritage for future generations as has been done for the saguaro *Carnegiea gigantea* cactus, organ pipe *Stenocereus thurberi* and Joshua trees *Yucca brevifolia* in Arizona and California.**

You do not have to own a special rugged vehicle to enjoy some of these magnificent stands. A good high clearance pickup or a common SUV will suffice. A starting point for one of these stands is the oasis village of Mulege on Mexico's Highway #1, one of the few villages in Baja located on a river. Drive south of the village and avoid the crowds of mainly North Americans on the beaches of spectacular Bahia Concepcion. Access to the cardon stand is at km 81 north of the town of Loreto (26°33' N and 111°51' W; sea level) on Highway #1 by way of a minor, very stony, dirt road. The site, at the southern end of Bahia Concepcion, is a mesa of about 5000 hectares. The cardons here are abundant and large (5-15m high) with few branches per plant (3-6 on average), a characteristic unique to this population as cardons growing in other parts of Baja California have numerous side branches and are much more massive in appearance.

Another accessible site that contains perhaps the largest cactus plants in the world is located a short drive from La Paz near the village of San Juan de Los Planes. Access to this site is from the paved secondary road that leads eastward from the city of La Paz to San Juan de Los Planes in the District of La Paz. Just before entering San Juan de Los Planes, one makes a right turn on a very dusty, powdery, dirt road that runs alongside the village football field. Follow this dirt

road for 3 km to where the site begins (from 23° 56.92' N and 109° 56.58' W; to 23° 54.90' N and 109° 57.43' W, a distance of 5 km). This area has large dense stands of mostly massive cardons, certainly some of the biggest in Baja California and we believe **some of the largest cacti in the world.** Plants 10 to 15m high and higher, with many massive branches, are very common here. The cardons at this site are associated with mesquite trees *Prosopis articulata* and low, dense, vegetatively-propagated, choya cactus *Opuntia cholla*, which make passage through the stand somewhat of a hassle. Encroachment by intensive agricultural development and cattle ranching threatens these cardons. Three large sections (over 20 ha each) were clear-cut by the local inhabitants as recently as January 1999 to create fields of asparagus for export. Because water is available here, and because the land is private and the population is relatively poor but rapidly growing, there is a possibility that the agricultural fields will eventually take over the place of the cacti and we are, perhaps, the last generation to see these giants of the desert.

The state of Baja California Sur is a tourist area with much of its income coming from international tourism, mainly Americans and Canadians attracted by its unspoiled marine and terrestrial beauty. Conservation, and later limited development, of exceptional cardon sites will add major ecotourism attractions and therefore income to the local population, which is accustomed to and accepting of tourism needs. Laws and conservation mechanisms in Mexico are already in place. The Mexican Federal government through its ecological ministry has already declared two large areas of Baja California Sur as natural reserves (the Vizcaino Desert and the Sierra de La Laguna mountain range) and has the administrative mechanism to protect any new conserved areas. Thus, we are hopeful that our plea for the conservation of these exceptional stands of cardons will be heard. Future generations of Mexicans and tourists should have the opportunity to see these plants alive and not just as pictures in an encyclopedia.

ADDITIONAL LITERATURE

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www.cibnor.org/conserv/cardon/icardon.html

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