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ECOSYSTEM STATUS AND TRENDS IN THE GULF OF CALIFORNIA



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First edition: December 2014

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University of California, Riverside  
900 University Ave., 3324 Olmsted Hall  
Riverside, CA 92521-0147  
ucmexus.ucr.edu

© Secretaría de Medio Ambiente y Recursos Naturales (Semarnat)  
Blvd. Adolfo Ruiz Cortines 4209. Col. Jardines en la Montaña  
c.p. 14210. Delegación Tlalpan, Mexico City  
semarnat.gob.mx

Instituto Nacional de Ecología y Cambio Climático (INECC-SEMARNAT)  
Periférico Sur 5000. Col. Insurgentes Cuicuilco  
c.p. 04530. Delegación Coyoacán, Mexico City  
inecc.gob.mx

Cover photos: © Octavio Aburto-Oropeza

Editorial coordination and design: Ana Ezcurra & Amanda González Moreno

ISBN: 978-1-4951-2222-4

Printed and made in Mexico

This book is dedicated to the memory of  
Laura Arriaga Cabrera, Salvador Contreras-Balderas,  
and Daniel Lluch Belda, caring colleagues,  
great scientists, and exceptional human beings  
to whom Baja California and the Gulf of California  
owe so much.

Dedicamos este libro a la memoria  
Laura Arriaga Cabrera, Salvador Contreras-Balderas y  
Daniel Lluch Belda, colegas comprometidos,  
grandes científicos, y seres humanos excepcionales,  
a quienes Baja California y el Golfo de California  
tanto les deben.

# BAJA CALIFORNIA OASES: A HISTORICAL DESCRIPTION ABOUT THEIR LAND USE AND NATURAL RESOURCES

Andrea Martínez-Ballesté<sup>1,2</sup>

Since the arrival of the Jesuits to the Baja California Peninsula in 1697, the historical process of colonization has produced important changes on the land use and the natural environment. The scarcity of water and rain pulses has been the most important limitation for Baja California colonization and has set the pace in desert ecosystem's land use. The oases, with springs or permanent water availability were the best places for the foundation of new missions, but the construction of reservoirs and channels for water management produced important transformations on the environment at this times. Subsistence agriculture; commercial crops like date palms, olives, sugar cane and livestock, have been the more important economic activities in the oases. Mainly in the south, people are still living in the missions founded by the Jesuits; however, in the last century, touristic activities have changed the use of natural resources in some oases. By using a collection of ground photograph taken at the beginning of the twentieth century and their repetition in 2008, the historical land use changes have being analyzed. A high demand on water resource because tourism and population growth have diminished agricultural activities. Nowadays, date and native palms occupied the agricultural landscape; and more trees and palms grow in the backyards of the houses. The biodiversity of Baja California inhabited oases is the result of more than three centuries of human activities and have been the drivers of the historical land use changes.

## 1. JESUIT PERIOD (1697–1768): THE FOUNDATION AND CONSTRUCTION OF THE ECOSYSTEM

### 1.1. Foundation

The scarcity of water, the harsh environment, and the difficulties to find appropriate locations for founding the missionary work was a common characteristic recounted in most of missionary documents (Kirchhoff 1942, Burrus 1966, León-Portilla 1990). These inconveniences were experienced in both peninsular territories, however compared with the northern region (still unexplored approximately until the 1746 exploratory trip by Fernando Consag), the southern parts of the Peninsula presents a more hospitable landscape, with springs of permanent surface water, where the first missions were established (Zavala-Abascal 1964, León-Portilla 1990, Minnich and Franco-Vizcaíno 1998, Lazcano-Sahagún 2000, Wehncke et al. 2009). Seventeen missions were founded in the southern part of Baja California during the Jesuitical period (1697–1768), however, although the better environmental conditions of the south, the missions founded in this region were never were completely self-sustaining. The organization of an economical support network by the Jesuit missionaries was the corner stone for the maintenance of the missions in these hard conditions (Piñera-Ramírez 1991, Crosby 1994, Del Río 2003). The scarcity of water and the difficulty to obtain enough food by agricultural practices, forced the Jesuits to maintain a close relationship with the missions founded by them in the other side of the California Gulf. With the unique purpose of the evangelization, the missionaries were the only authority on the mission who took decisions on the land management. Once they found a good place, the church was constructed and the californios were attracted to live in the missions. The arrival of foreign people to live in Baja California Peninsula was always rejected by the Jesuit fathers. Inspired on the Tomas Moro utopia, they tried to construct a communal society where the feelings of brotherhood and mutual aid would not give capacity to the greed that the Spaniard civilians could bring to the missions. This fact delayed the establishment of the other kind of property and the development of other economic activities that were not agriculture and cattle ranch.

### 1.2. Construction: water and cultivable land

The construction of reservoirs and channels for water obtaining produced new environmental conditions on the oases that could have consequences on the biodiversity of the ecosystems. Sometimes water was available in the place where the mission was established, that was the case of Santa Rosalía de Mulegé, San Ignacio, La Purísima,

and Santa Gertrudis, but in other missions water was brought from other places. The labor to obtain water was described by father Baegert showing us how hard it was to obtain water for the maintenance of the missions and the degree of transformations that the Jesuits did on the environment.

*Water was taken wherever and however it was found. The site for a new mission was determined, if possible, by the availability of at least some water which could be used to irrigate the land, either at the mission, or in a place several miles away. No effort was spared. In some places, water was brought half an hour's distance over irregular terrain through narrow channels or troughs carved out of the rock. At other locations, water was collected from six or twelve places—a handful from each source—and conducted into a single basin. Some swamps were filled with twenty thousand loads of stones and as many loads of earth. And sometimes just as many stones had to be cleared away to make this or that piece of land tillable. Nearly everywhere it was necessary to surround the water as well as the soil with retaining walls or bulwarks, and to erect dams, partly to keep the small amount of water from leaking out, and partly to keep the soil from being washed away by the torrents of rain. Even so, all the work was often useless. At best one had to patch and to repair every year, and sometimes it was necessary to start all over again (Baegert 1979).*

### 1.3. Elements of the construction: known plant and animal species

The main concerns of Jesuit fathers were the production of enough food for the maintenance of few soldiers and a small group of native people living there. Through the economical support of the *Fondo Piadoso* foundation and the always difficult work to have ships in good conditions to cross the Sea of Cortés (Crosby 1994), the missionaries brought to the oases in Baja California many new exotic plants that were adapted to growth under this environment. On relation with the introduction of new species on Baja California, father Baegert said.

*Of European and German fruits, there were none in California except a few peach trees. From them, two rather small and stale peaches were once sent to me from a place thirty hours away (Baegert 1979).*

Corn and wheat were the most important crops in all the missions, nevertheless in some of them also olives, grapes, figs and dates were cultivated. There are also

references about crops of beans, chick-pea, watermelon, melon, pumpkin, cotton, sugar cane, peach tree, banana, pomegranates, orange, lemon and other vegetables. The father Piccolo brought from Sinaloa roses and quinces, and sowed and harvested some rice (Del Barco 1973, Baegert 1979).

Cows, goats, horses, pigs, sheeps, and other domestic animals were introduced to supply food products that could not be obtained by the agriculture. The cattle were also used for the manufacture of candles and soap, ships and boats, shoes, saddles and bags. In the following sixty years, after the Loreto mission foundation, the *visitador* Ignacio Lizassoáin in 1761 reported 1500 to 4000 cows per mission and between 1000 to 4000 goats and sheeps (Del Río 2003). The harsh environment in the Peninsula made cattle growing difficult to practice into the missions; most of the livestock were left in freedom to find their own food in the desert. Baegert said about this, *The cattle had free passage and were permitted to wander fifteen and more hours in every direction to find their feed*. Even after the expulsion of the Jesuits, the amount of cattle that lived on wild was very high. The Franciscan Juan Ramos de Lora in 1768 said *if the cattle living in wild had been gathered, the problems of food, during the Jesuit period, had been resolved* (Del Río 1974).

Due to the absence of grass, the cattle introduced in Baja California fed itself mainly on the legumes and succulent plants of the desert. Baegert described the behavior of the cattle as follows, *They ate thorns, two inches long, together with stems, as though they were the tastiest of grasses*. The great amount of cattle introduced by the Jesuits and the lack of control on it brought a new ecological condition for the desert environment, the introduction of herbivore pressure exerted by large animals. Although there are no references about the impact of this condition, livestock could have significant effects on the ecosystem, changing the abundance and distribution of the species that they usually ate.

During the Jesuit period, the introduction of new plants, the water management, and the agricultural and cattle practices brought by the missionaries were the most important drivers for the colonization and the transformation of the Baja California Oases in the first forms of productive systems of the Peninsula. By the economical support of the southern missions in Baja California and the mission's ones in the continent, the Jesuits had time and some resources to explore new lands in the north. The information gathered along these explorations was very valuable for the knowledge of the natural resources of the Baja California Peninsula and for the colonization process to the north.

## 2. AFTER JESUITS PERIOD (1768–1900): DECLINE AND CHANGE

### 2.1. Property land changes after the missionary period

After the expulsion of the Jesuits from Baja California, the colonization and land management ran by civilian authorities and not by the religious order. In 1768, the Gálvez Instructions promoted the creation of new towns in the ancient missions (Piñera-Ramírez 1991). The Franciscan, who occupied the place of the Jesuits, continued having the control of the churches but the mission system disappeared and the cultivable lands around the churches were slowly distributed among the civilian population, the Californios and the Franciscans. The land was divided in small yards and the people could take decisions on the land use, however, land property was uncertain delaying the colonization process and the development of the economical activities in the ancient missions.

It was until 1830 when the missionary organization finished and the land tenure of the oases passed to be property of the nation (Piñera-Ramírez 1991), that process permitted the authorities to give little more security on the land possession and the new settlers of the oases, mainly mestizos and descendants of Spaniards, began to raise cattle and to seed these lands of the oases in Baja California Sur.

Several missions were recognized like as towns in 1858 (San José del Cabo, Santiago, Miraflores, San Antonio, San Bartolo, El Rosario, Comondú, Loreto, San Javier, La Purísima, Mulegé, San Ignacio and Santo Tomás) and settlers began a new form of land tenure organization, in the *ejidos* (Piñera-Ramírez 1991). This communal form of land possession was used to take decisions on cattle management and some agricultural activities.

At the end of nineteenth century, 60% of the population lived in the south portion of the Peninsula (Deasy and Gerhard 1944) and the agriculture and cattle raising activity was more concentrated in this region. Besides the growing of vegetables, Mediterranean products like fig, grapevine, date and olive trees, as well as sugar cane were the most important crops in the villages of the southern region of Baja California Peninsula. Comondú and Mulegé were very important for its wine production whereas in San José del Cabo and La Paz it took place for the great amounts of sugar cane. In 1853, Rafael Espinosa and Francisco Xavier, published in the *Boletín de la Sociedad Mexicana de Geografía y Estadística* a description about the economy of the region. From southern Baja Californian, products like grapes, onions, potatoes, sweet potatoes and pitahayas were exported to Mazatlán and Guaymas, while, from

the northern part, were obtained grapes, figs, dates, olives and wine, being the best, the wine that produced in San Ignacio. However, Baja California Peninsula followed continued not being non self-sufficient and products like flour, corn, beans, rice, chick-pea, lentil, sugar and others like clothes and materials for construction were brought by the ships coming from other parts of Mexico (Piñera-Ramírez 1991).

### 3. TWENTY CENTURY: OASES TRANSFORMATION CONTINUES

#### 3.1. A comparative approach about land use changes

At the beginning of twentieth century, the Peninsula of Baja California was still, an inaccessible place that awakened curiosity on many explorers. Some of them left evidence by means of photographs that portray the landscape of the missions and the towns the Jesuits founded from the end of the 17th to the middle of the 18th century. In 2008, during my postdoctoral stay in the University of California in Riverside with Dr. Ezcurra, I saw the first time some of these photographs. We compared between the old and recently plates photographs taken in the same oasis, and were amazed about the land use changes that happened during the last century. It was for this reason that I devoted myself during that year to increase the photograph collection to be able to repeat it and to describe the land use changes that had happened on the last one hundred years.

Through the contributions of some collaborators—Exequiel Ezcurra, San Diego Natural History Museum (SDNHM) and University of California, Riverside; Stephen, Bullock, Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE); Juanita Ames and Jacobo Rousseau, settlers of San Ignacio, Baja California Sur; Javier Aguiar Zuñiga and Noe, settlers of Mulegé, Baja California Sur; and Nestor Agundez Martínez, Culture House Director in Todos Santos, Baja California Sur—and by means of the search in libraries, historical archives and Web pages—Fototeca de Monumentos Históricos, Mexico; Fototeca Nacional, Mexico; Library of SDNHM; San Diego Historical Society; San Diego Museum of Man; CalPhotos, Berkeley; Orpheus University of California San Diego; and US Geological Survey Photographic Library—I acquired a suite of 70 photographs of nine oases of Baja California Sur taken between *ca.* 1900 and 1970.

The repeated ground-based photographs technique was used for the first time in 1888 to describe landscape changes in glaciers (Turner *et al.* 2003). For the evaluation of vegetation changes, one of the most important research studies that used repeated photographs was published with the name of *The Changing Mile* in 1965, and then, with the name of *The Changing Mile revisited* between the late 1800s and the late

90s of the twenty century, were Raymond M. Turner and collaborators continued its long term commitment for the study of the landscape changes at the Desert Laboratory in Tucson, Arizona. The interpretation of matching pair photographs has been an excellent tool for the evaluation of vegetation changes (Bullock *et al.* 2005). Other recent tools like aerial photographs and satellite imagery have some advantages, such as, the large spatial coverage, however, the identification of the species composition is limited to only to the dominant ones. On the other hand, the first aerial photographs became available at the late 1920s and satellite imagery until at the early 1970s so, ground photographs are considered a better tool if long-term (longer than 100 years) studies are being planned.

On March 2008, I traveled with a group of collaborators to the oases of Santa Gertrudis, San Ignacio, Mulegé, Todos Santos, El Pescadero, La Purísima, San Isidro, Comondú, and San Javier; where we repeated the photographs that different photographers had obtained, sometimes, more than a hundred years ago. For a good match of the photographs, it was necessary to find exactly the place from which the photographers took them. Then, using the ArcGis 9.2 hardware, I have being compared the repeated ground photographs in order to define the land use categories in both of them, and estimated the changes in land cover.

#### 3.2. Some tendencies on land use changes in the last century on Baja California Sur oases

In Baja California Sur, many people live in the oases where Jesuits founded the old missions. Like in the past, agriculture and cattle rising are still being important activities, but in some oases like San Ignacio, Mulegé and Todos Santos, the tourism become became and important industry at the end of the last century. This situation has incremented the pressure to obtain water and in some cases, the agricultural production has diminished due to the scarcity of this resource that is now used, preferably, for the touristic activities. Agricultural diversity that surprised travelers at the beginning of twenty century (Martínez 1947, Jordán 1951) has disappeared in the oases where tourist or other activities have developed, and instead of this agricultural landscape, *Washingtonia* palm, which surely grew in these oases before the arrival of the first settlers, is returning to occupy its place in the homegardens of the old missions. However, in some oases, the agricultural activity is still important. In the oases of Santa Gertrudis, Pescadero and San Javier, people are growing vegetables that sometimes, are selling in markets of organic products. The isolation of the oases of Comondú, La Purísima, and San Isidro, has promoted the abandonment of the towns. The production of grapevine, date and olive trees, that was very important in

the past have disappeared. The sale of leaves and individual palm trees of *Washingtonia robusta* for touristic places is, nowadays, one of the most important activities in Comondú oases.

In general, the photographs of the oases in 2008 show more vegetation cover for two reasons; first, because agricultural lands diminished and water becomes a limited resource (based on the opinions of the settlements), people began to grow more plants in their home backyards. In the photographs of 2008 there are more trees and palms (*Phoenix dactylifera* and *Washingtonia robusta*) growing in the backyards areas of the houses than in the old photographs. Second, the old agricultural areas that were abandoned and were not occupied with houses nowadays are places where the native palm, *W. robusta* is growing. In particular from the comparative analysis of the photographs of Mulegé (see Figure 1), I found a positive growth rate of the urbanized area. Nowadays, the number of roads and houses has grown and occupy the area that was used for agriculture. From 1900 to 1959, the average area in the photographs of Mulegé that showed agricultural and agroforestry landscape was of 13.69%, but in 2008, the areas with polyculture agriculture have being reduced to only 1.88% of the photograph, whereas, monoculture agriculture have completely disappeared.

The harvest and sale of date fruits was a very important economical activity in the oases of San Ignacio, Mulegé and Comondú. However, the 2008 photographs of Mulegé, although do not show a reduction in the average cover area of date palms, the number of patches with *W. robusta* have been increased forming mixed palm trees. These are growing in those areas where only *P. dactylifera* grew in the past. The trade of dates has been reduced in the last years and replaced by other economical activities. In Mulegé it is probably that many people came to work for the tourist industry and thus, they abandoned their agricultural parcels.

Other vegetation areas that were modified in the second half of the twenty century in Mulegé were the desert areas that surrounded the towns, the river, and the mangroves. The 39.10% of the desert area in average estimated in the old photographs, in 2008 reduced to 25.45%. The towns in all the oases that I visited have grown in the last decades, and the areas of desert were occupied with houses and the home backyard vegetation. In 1913, 1931 and 1959, in the photographs of San Ignacio and Mulegé, big floods were registered. Probably, latter, these events were responsible of changes of the form of the rivers. At present the river of Mulegé has reduced their width and more sand banks are now exposed. The Mangroves have being reduced dramatically from 1.18% in the past to a cover area of 0.60% in 2008, and most of it have disappeared because of the construction of new roads.

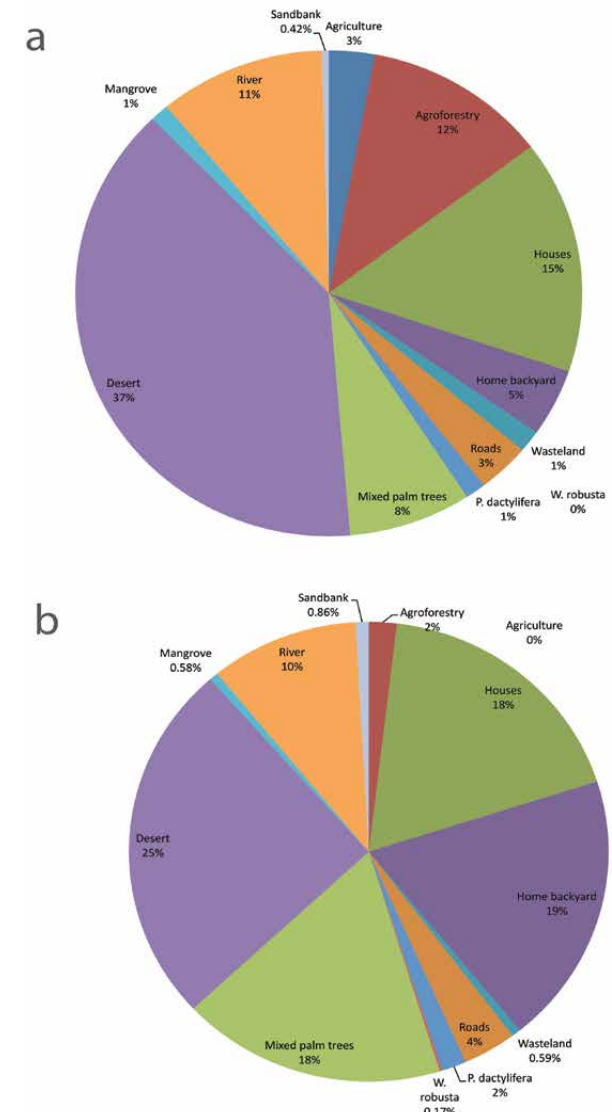


FIGURE 1. Historical land use changes in the oasis of Mulegé. (a) Past cover land use categories (%) from the area obtained in average from photographs taken in 1900, 1910, 1937, 1956, 1957 and 1959; (b) Present cover land use categories (%) from the repeated photographs taken in 2008. Land use categories were defined as; agriculture, agroforestry, houses, home backyard vegetation (trees, of *Washingtonia robusta* palms and *Phoenix dactylifera* palms), wasteland, roads, *P. dactylifera* palm trees, *W. robusta* palm trees, mixed palm trees (*W. robusta* and *P. dactylifera*), arid areas of desert, mangroves, river areas and sandbanks.





1910



2008



1900



2008

Pair photographs of Mulegé that show changes on the river and mangroves (above), and agricultural places replaced with mixed palm trees (bottom). The photograph of 1910 was taken by anonymous photographer and that of 1900, by Juan José Rousseau, a settler of San Ignacio, BCS. Carlos Martorell in collaboration with Pedro P. Garcillán and the author took the repeated photographs in 2008.

Although, before the conquest, these were important places for the survival of the ancient *Californios*, was until the Jesuits arrived when these oases becomes the first permanent inhabited places. The agricultural and cattle rising practices inherited from Jesuits defined the land use changes that nowadays we observed in the oases where they founded their missions. The biological diversity in the inhabited oases of Baja California is the result of several centuries of human activities in this region but one aspect of particular importance for the establishment in these places has been the presence of water and the management of this resource. The historical changes of the land use in the inhabited oases of Baja California can only be understood at the light of the human activities and also through the limitations that the environment has imposed to them in these places. We can say that these have been the drivers of the land use change in the oases of Baja California.



1957



2008



1959



2008

Pair photographs of Mulegé showing changes in agricultural land use, an increment in home backyard vegetation, and the size of the town (above). The impact of the 1959 flooding on the palm trees of Mulegé (bottom). The photograph of 1957 was taken by Dario Ruiz, a settler of Mulegé and that of 1959 by an anonymous photographer. Carlos Martorell in collaboration with Pedro P. Garcillán and the author took the repeated photographs in 2008.

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Exploring Mexico's northwest, the Baja California Peninsula, its surrounding oceans, its islands, its rugged mountains, and rich seamounds, one feels diminished by the vastness and the greatness of the landscape while consumed by a sense of curiosity and awe. In a great natural paradox, we see the region's harsh arid nature molded by water through deep time, and we feel that its unique lifeforms have been linked to this desert and sea for thousands of years, as they are now.

These landscapes of fantasy and adventure, this territory of surprising, often bizarre growth-forms and of immense natural beauty, has inspired a wide array of research for over two centuries and continues to inspire the search for a deeper knowledge on the functioning, trends, and conservation status of these ecosystems in both land and ocean.

This book offers a compilation of research efforts aimed at understanding this extraordinary region and preserving its complex richness. It is a synthesis of work done by some exceptional researchers, mostly from Mexico, who indefatigably explore, record, and analyze these deserts and these seas to understand their ecological processes and the role of humans in their ever-changing dynamics.

Elisabet V. Wehncke



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