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World Atlas of  
**Mangroves**



### Box 11.1 Mangrove restoration encouraged by plant–microbe interactions in the arid environment of Baja California Sur, Mexico

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Around 1991 to 1992, two sections of the mangrove forest at Balandra Lagoon in the Baja California Peninsula of Mexico were illegally clear-cut, leaving bare areas with tree stumps (see Figure 11.1). Natural re-vegetation of mangroves in arid climates is a very slow process that can take many years if not supported by artificial reforestation of plants propagated in greenhouses. In 1995, the area was still bare, with very few naturally grown small mangrove shrubs and large expanses of the saltmarsh halophyte *Salicornia bigelovii*. Conventional reforestation of the entire destroyed area was impractical, given the lack of sufficient resources and lack of government interest in restoration of mangroves at that time. Therefore, we decided upon an innovative approach.



**Figure 11.1** Clear-cut area of arid zone mangroves at Laguna de Balandra, Baja California Sur, Mexico, circa 1994

Source: Yoav Bashan

A nursery was established in September 1994 using sand culture pots irrigated with seawater and planted with *Avicennia germinans* seeds. Some of the plants were inoculated with the nitrogen-fixing cyanobacterium *Microcoleus* sp. This is believed to assist in the establishment and growth of the seedlings (Bashan et al, 1998) and is one of a group of plant growth-promoting bacteria (PGPB), which recycle scarce nutrients, such as nitrogen and phosphorus, within mangrove ecosystems (Holguin et al, 2001).

After four months, 500 seedlings were transplanted to shallow secondary channels that connect the clear-cut area to the central lagoon section with its intact mangrove forest. No special treatment

was given to the area other than annual weeding of competing *Salicornia* shrubs, which was performed for three years (Toledo et al, 2001).

In 2007, the restored mangrove area was flourishing, only distinguishable from the primary natural forest by smaller trees (see Figure 11.2). In 2005, a survey showed that crab populations in the restored area had not completely recovered to the level of the intact mangrove stand. Perhaps more time is needed for this fauna. However, the microbial nitrogen-cycle activities within the clear-cut area had completely recovered by early 2007.



**Figure 11.2** After restoration, the same area in Laguna de Balandra, Baja California Sur, Mexico, in 2007

Source: Yoav Bashan

A surprising outcome was that local visitors appreciated the 'new look' of their beautiful green mangrove forest in the middle of the dry desert. In 2006, when a developer proposed converting the Balandra shore into another golf course resort, the public outcry was so loud that the 'development' was delayed. In 2008, the area was declared a Ramsar protected wetland. We wish to believe that our restoration success contributed to this conservation attitude.

Another recent case of successful restoration of a hurricane-damaged mangrove at Punta del Mogote, Baja California Sur, Mexico (Holguin et al, 2006) is described in detail at [www.bashanfoundation.org/conservation2.html](http://www.bashanfoundation.org/conservation2.html).

upon adjacent mangrove areas, while on the Pacific Coast the Escalera Náutica (Nautical Staircase) project has begun a long-term plan to enlarge or build 24 ports and marinas, together with numerous airports, hotels, roads and golf courses across the region to encourage a massive increase in tourism and in

recreational boating (Escalera-Nautica, 2007). There will inevitably be considerable pressures on coastal ecosystems such as mangroves from direct destruction, hydrological alteration, pollution and the impacts of freshwater abstraction.

The legal protection provided to mangrove species