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## Mangrove Field of Dreams: If We Build It, Will They Come?

### Background

Mangrove forests are ecologically important coastal ecosystems composed of one or more of the 69 species of salt tolerant trees and shrubs. These ecosystems currently cover 146,530 square kilometers (1 km<sup>2</sup> = 247 acres) of the tropical shorelines of the world, which represents a decline from 198,000 km<sup>2</sup> of mangroves in 1980 to 157,630 km<sup>2</sup> in 1990. Thus, loss of mangrove area has occurred at a rate of 1 to 2 percent per year during the past three decades. Achieving no-net-loss of mangrove forests would therefore require a minimum of 150,000 hectares (1 ha = 2.47 acres) of successful mangrove forest restoration per year at the current rate of loss.

The evidence for successful restoration of mangroves on any large scale, however, is nearly non-existent. For example, a recent report indicates that in spite of twenty years of efforts devoted to the restoration of 44,000 ha of mangroves in the Philippines, and the expenditure of \$USD 17.6 million, the plantings experienced high mortality, and the few that survived “had dismally stunted growth.”

This failure was attributed to two assumptions regarding restoration: 1) Mangroves can only be restored by planting and 2) Sub-tidal mud flats are suitable for planting, when in fact they likely never supported a mangrove forest in the first place.

### What works?

The three images in Figure 1 illustrate the restoration of a portion of a 500 ha (1236 acres) mangrove forest restoration project in Hollywood, Florida, USA, within the Anne Kolb Nature Park.



Figure 1. Example of a mangrove restoration project in Florida, USA.

The interesting part of the story is that none of the mangroves you see were planted! They are all what we call “volunteer” mangroves (Fig. 2)—ones that colonized the site on their own after appropriate biophysical conditions were established.

Such conditions include appropriate tidal hydrology to support natural colonization by the millions of floating “propagules” (seeds or seedlings) of mangroves naturally produced in this area every year.

A three year pilot project prior to this major restoration effort had established the target topographic elevation that would facilitate natural recruitment of mangroves. The construction of a tidal creek in the center of the project was essential to replicate the natural tidal creeks found in all mangrove forests and to allow for the movement of fish and invertebrates into and out of the forest as tidal levels rose and fell. A recent symposium on “Mangroves as Fish Habitat” documented the need for such waterways and the successful establishment of fish populations equivalent to control sites for this project area within five years of construction.



Figure 2. “Volunteer” seedlings of red mangrove growing with a “nurse species”, *Sesuvium portulacastrum*. Natural recruitment of seedlings can revegetate a restoration site. (Photo courtesy of K. L. McKee)

## “MANGROVE FOREST RESTORATION OFTEN FAILS DUE TO A LACK OF UNDERSTANDING OF MANGROVE HYDROLOGY”

### Fish and Mangroves

Two of the more important ecological functions of mangroves are the provision of direct food resources via a detrital food web and habitat for a wide variety of fish and invertebrates, which in turn are food resources for numerous species of wading and seabirds, reptiles (crocodiles), and mammals, including the rare Bengal tiger. Both commercial and recreationally important fish and invertebrate species may use mangrove forests both as juveniles and adults. Access to the flooded forest floor is provided by tidal channels and creeks, and these same creeks provide refuge on low tides or concentrate prey species for consumption by predators.

Managing and restoring mangroves is thus not only about the vegetation, but also about the open water tidal creeks, ponds, mud flats, and salt flats, which are often not obviously vegetated. These are critical components of the mangrove forest ecosystem, and protection of mangrove forests should include adjacent creeks, flats and upland edge.

Mangrove loss been accompanied by declines in fish and invertebrate harvests and associated declines in the larger animal species. Unfortunately, attempts at mangrove forest restoration often fail due to a lack of understanding of mangrove hydrology. Even if mangrove vegetation is established, habitat use by fish and invertebrates is not optimized due a lack of tidal creek design as part of the project.



Figure 3. View of the sub-tidal portion of a mangrove forest along a tidal creek.

### Understanding Natural Recovery

In addition to the need to understand the existing hydrology as it relates to topography of an adjacent mangrove forest reference area, it is also important to understand the natural recovery processes in damaged mangrove forest areas, also known as “secondary succession.”



Figure 4. Freeze-damaged mangroves in Tampa Bay, Florida, USA.

Just as a fallow field will eventually become a forest if left alone, damaged mangrove forests have the ability to revegetate under some circumstances. For example, periodic freeze events (Fig. 4) or hurricanes can damage forests. The natural secondary succession process in damaged mangrove forests often begins with the appearance of a “nurse species” (Fig. 2), which is typically herbaceous plant species such as Smooth Cordgrass, *Spartina alterniflora*, or Saltwort, *Batis maritima*. These species, which are associated with mangrove forests around the world, appear to facilitate the recolonization and eventual natural restoration of damaged mangrove areas. Although not well studied, facilitation may work by reducing stressful soil conditions and/or physical trapping of floating mangrove seeds. Such knowledge is important in planning and conducting mangrove restoration projects, because mimicking the natural secondary succession may lead to a more successful restoration in the long-run.

### When Extra Help is Needed

At restoration sites prone to erosion after mangrove damage or loss, the use of a rapidly colonizing species like Smooth

Cordgrass (Fig. 5) may quickly stabilize exposed sediments that might otherwise oxidize or erode away leaving the topography too low to support natural colonization by volunteer mangrove propagules.



Figure 5. Herbaceous species can be used to stabilize soils and to promote mangrove recolonization.

Some damaged mangrove forests may not have the natural ability to heal themselves. Several reports on hurricane damage in Florida and Honduras have noted that the natural secondary succession processes appear stalled. One of the explanations for this could be that older forests with mature trees can tolerate gradual sea level rise, but new seedlings find it difficult to deal with more frequent flooding on lower lying exposed soils.

There is also the phenomenon of “propagule limitation”. Large areas of disturbance, such as the herbicide destruction of mangroves in Viet Nam, resulted in a lack of sufficient mangrove seed sources locally to provide for natural recolonization. As a result, local citizens were organized to plant seeds of *Rhizophora apiculata* collected from adjacent undamaged or naturally recovering forests within the Can Gio Mangrove Biosphere Reserve near Ho Chi Minh City. Concentrating on only one species of mangrove when 20-30 are common in these forests was a limiting factor in the success of this project, but natural recruitment of other species has occurred.

Thus, successful mangrove forest restoration should be routinely successful if a few basic ecological restoration principles are applied at the early planning stages.



# Ecological Restoration

Ecological Mangrove Restoration (EMR) is a proven six step methodology for designing and building a successful mangrove restoration project

## Teaching Ecological Mangrove Restoration

Over the years I have seen many mistakes made in attempting to restore mangrove forests. Some of these were my projects and were the direct result of a lack of experience. Now that I can achieve routine success in restoring mangroves, I have felt it important to pass the principles I learned to younger practitioners of what we call "ecological restoration". Andy Clewell in his new book, "Ecological Restoration", defines the term as meaning "the process of assisting the recovery of an impaired ecosystem". I would add that my definition emphasizes the restoration of all the components of the ecosystem: hydrology, soils, water quality, all the plant species and all the animal species. The emphasis on just planting a single mangrove species, for example, is not ecological restoration, even if it works.

Thus has evolved a living process of assembling the information, teaching it, usually in a three day course, and asking students and other professionals to critique the proposed "Ecological Mangrove Restoration" process.

My colleagues and I are now in our 53rd version of the teaching materials, largely PowerPoint images, and have distilled this information into a six step process. These steps are:

1. Understand both the autecology (individual species ecology) and the community ecology of the mangrove species at a particular location, in particular the patterns of reproduction, propagule (seeds and seedlings) distribution, and successful seedling establishment.
2. Understand the normal hydrologic patterns that control the distribution and successful establishment and growth of targeted mangrove species.
3. Work together with local communities to assess the modifications of the previous mangrove environment that occurred and that may prevent natural secondary succession.
4. Select appropriate mangrove restoration sites through application of steps 1-3 above that are both likely to succeed in restoring a sustainable mangrove forest ecosystem and are cost effective, given the available funds and labor.
5. Design the restoration program at appropriate sites selected in Step 4 to initially restore the appropriate hydrology and utilize natural recruitment of propagules or seeds for plant establishment unless otherwise determined likely not to succeed.
6. Only utilize actual planting of propagules, collected seedlings, or cultivated seedlings after determining through steps 1-5 that natural recruitment will not provide the quantity of mangroves desired (or the desired rate of stabilization or growth of seedlings) established as quantitative goals for the project.

Our courses always include a field component during which we inspect and often gather data about existing mangrove restoration projects and proposed sites for restoration. This is an essential part of our training courses, during which many of the "lessons learned" in class are applied in the field.

These courses have been taught in the United States, Cuba, Nigeria, Thailand, India and Sri Lanka over the last decade and have received good acceptance by students and critical reviews that have been applied to improving the teaching content and the restoration process.



## Additional Information

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Web Resources: [www.mangroverestoration.com](http://www.mangroverestoration.com); [www.mangroveactionproject.org](http://www.mangroveactionproject.org)



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