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How Successful Mangrove Forest Restoration Informs the Process of Successful General Wetland Restoration

This article is derived from a more specific paper just on mangrove forest restoration published by the Society of Wetland Scientists in 2009. The intent of this article is to utilize some basic principles of successful mangrove forest restoration as a starting point to describe the routine problem with a lack of successful wetland restoration for all wetland types. This subject has been described in a number of recent articles in the National Wetlands Newsletter.

By Roy R. "Robin" Lewis III

Mangrove forests are ecologically important coastal ecosystems composed of one or more of the 69 species of salt-tolerant plants. These ecosystems currently cover 146,530 square kilometers (km^2) of the tropical shorelines of the world, which represents a decline from 198,000 km^2 of mangroves in 1980, and 157,630 km^2 in 1990. Thus, loss of mangrove area has occurred at a rate of 1-2% per year during the past three decades. Achieving no net loss of mangrove forests would therefore require a minimum of 150,000 hectares (ha) 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 nonexistent. For example, a recent report from the Philippines (Samson & Rollon 2008) indicates that in spite of 20 years of efforts devoted to the restoration of 44,000 ha of mangroves in the Philippines, and the expenditure of $17.6 million, the plantings experienced high mortality and the few that survived "had dismally stunted growth." This failure was attributed to two erroneous assumptions: (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?

Figure 1 illustrates the restoration of a portion of a 500-ha mangrove forest restoration project in Hollywood, Florida, within the Anne Kolb Nature Park. The interesting part of the story is that none of the mangroves you see were planted! They are all what we call "volunteer" mangroves—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 seeds 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 in all mangrove forests and allow for the movement of fish and invertebrates into and out of the forest as tidal levels rise and fall. A recent symposium on "Mangroves as Fish Habitat" (Serafy & Araujo 2007) 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 (Lewis & Gilmore 2007).

Mangrove Restoration in the Hierarchy of Wetland Restoration in General

Figure 2 is a general hierarchy of types of wetlands and their likelihood of successful restoration. This sequence is derived from many years of research by the author and published work, such as the 1989 U.S. Environmental Protection Agency study of wetland creation and restoration edited by Jon Kusler and Mary Kentula (1990) and practical guides, such as Lewis et al. (1995) and Mitsch (2006). While all of the listed wetland types have been successfully created or restored, the success rate declines as one moves from those with relatively predictable and more easily replicated hydrology (intertidal wetlands) to those with more difficult and highly unpredictable (and therefore more difficult to replicate) hydrology due to a reliance on seasonal and interannual variations in freshwater delivery. Submerged aquatic vegetation, such as seagrass meadows, falls into a category of their own due to a vast myriad of biophysical factors, such as water quality, tidal currents, wave energy, etc., which make successful establishment very difficult (but see additional information at www.seagrassrestorationnow.com).

Mangrove forests are shown as one of those types that ought to be successfully restored most of the time, but repeated studies of real-world success, as cited before, show most mangrove restoration projects are unsuccessful in establishing persistent plant cover over many years. Mangrove forest

Figure 1: Time sequence over 78 months of a mangrove restoration project in Hollywood, Florida. No mangroves were planted. The mangrove vegetation resulted from volunteer seedling recruitment. Photos courtesy of Roy Lewis.

PROBABILITY OF SUCCESS

. . . high

- Estuarine Marshes
- Coastal Marches
- **Mangrove Forests**
- Freshwater Marshes
- Freshwater Forests
- Groundwater Seepage Slope Wetlands
- Seagrass Meadows

. . . low

Figure 2: General probability of successful restoration of various wetland types.

restoration often fails due to a lack of routine understanding of mangrove biology and hydrology, and an overreliance on planting either expensive nursery-grown mangroves or less-expensive direct installation of mangrove seeds on unvegetated mudflats.

Aside from 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."

Just as a fallow field will eventually become a forest if left alone, some damaged mangrove forests have the ability to revegetate without human intervention under some circumstances. Periodic freeze events or hurricanes, for example, can damage forests. The natural secondary succession process in damaged mangrove forests often begins with the appearance of a "nurse species," which is typically a herbaceous plant species, such as smooth cordgrass, *Spartina alterniflora*, and saltwort, *Batis maritima*. These species and others, such as *Portesia coarctata* in Bangladesh, India, and Southeast Asia, 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 facilitating physical trapping of floating mangrove seeds. Such knowledge is important in planning and conducting mangrove restoration projects, because mimicking the natural secondary succession will lead to a more successful restoration in the long run.

Other Wetland Types

These cautionary notes about mangrove restoration apply equally to other wetland types. Cypress trees (*Taxodium* spp), for example, are widely used in forested wetland restoration projects but all too often are subjected to incorrect hydrology and prolonged flooding resulting in early death or stunted growth. Again, an example of a failure to understand and design for the correct hydrology. It happens all too often.

Thus, while mangrove forest or cypress forest restoration should be routinely successful if a few basic ecological restoration principles are applied at the early planning stages, that knowledge, while readily available, is not understood, or simply not applied by many wetland restoration practitioners. In addition, permit reviewers are rarely trained to detect design errors during the permit review process, and, thus, the blind lead the blind, and design errors become construction errors.

Teaching Both Ecological Mangrove Restoration and General Wetland Restoration

Over the years, I have seen many mistakes made in attempting to restore many wetland types around the world. Some of these were my projects and were the direct result of my lack of experience in the early years of my self-training program. My professional training was as an ichthyologist, and back in the 1960s when I started restoring wetlands, there were no formal training courses in wetlands restoration. Now there are, but few professionals take advantage of them. After all, without the recognition and use of trained wetland professionals for this kind of work, just about anyone can list themselves as a "wetlands restoration expert," take a retainer, and start a project designed to fail. The historical lack of a strong wetland construction and mitigation compliance and enforcement policy by local, state, and federal government then leads to failed restoration or mitigation projects without any consequences. We can routinely do successful wetland restoration projects, but it is essential to teach "lessons learned" to younger practitioners of what the Society of Ecological Restoration International calls "ecological restoration."

Andy Clewell, in his book, *Ecological Restoration* (Clewell & Aronson 2007), 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 of the plant species; and all of the animal species. The emphasis on just planting a single wetland species, for example, is not ecological restoration, even if it works.

Thus, it has evolved into a living process of assembling the information, teaching it, usually in a 3-4 day course, with field trips to both successful and unsuccessful wetland restoration projects to show on the ground what common mistakes can be made and how to avoid them. Bill Mitsch and I take great pride in trying not to reveal too much about a site in advance of our field trips as part of our annual wetlands restoration course at the Olentangy River Wetlands Research Park at the Ohio State University in Columbus, Ohio. We wait until after all the sites are inspected, then invite each student to critique the sites and rate their "success." It has proven to be a very informative way of applying principles learned in the classroom.

With my colleagues overseas, I have developed an "Ecological Mangrove Restoration (EMR)" outline (Lewis 2005; Lewis 2009a) to clarify the steps toward successful mangrove restoration, but I believe it can generally be applied to just about any wetland type. This outline consists of six steps:

1. Understand both the autecology (individual species ecology) and the community ecology of the mangrove (or your wetland) species at a specific 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, successful establishment, and growth of targeted mangrove species.
3. Assess modifications to the wetland that prevent natural secondary succession.
4. Select a restoration site and restoration method applicable to the target species and your knowledge from steps 1-3.
5. Design the restoration program at appropriate sites selected in step 4 to initially restore the appropriate hydrology and utilize natural mangrove (or other wetland plant) propagule recruitment for plant establishment, unless it is otherwise determined unlikely to succeed. In many cases with freshwater wetland species, planting is essential for success and to limit competition from exotic or invasive species.
6. With mangroves, step 6 is to be cautious with plantings. Direct planting is not a substitute for proper appreciation of steps 1-5 above. With other species, this is usually determined from the careful design process preceding the other steps.

The critical step preceding all others is for the restoration team to include an experienced and well-qualified wetland professional. I would recommend looking for a professional wetland scientist (PWS) certified as such by the Society of Wetland Scientists Professional Certification Program (see listing at www.wetlandcert.org, under "SEARCH for a Wetland Scientist," enter a state, and view a list of PWSs). This is an essential step to avoid having an inexperienced or poorly trained individual designing what could be a very expensive failure.

Conclusion

I would close with a caution about accepting academic training alone as a substitute for hands-on restoration experience. In my opinion, a mentoring program is likely essential. Collectively, my colleagues and I have hundreds of man-years of on-the-ground experience in what works, and what does not. Academia is a good start, but as Bill Mitsch and I will tell you, you have to really design and implement and monitor your projects in order to learn from your mistakes to genuinely achieve a level of knowledge to do it right every time. We are not there yet, but the goal of no net loss of wetlands or, better yet, a net gain of wetlands, for the world demands we do a better job of training wetland professionals, wetland regulators, engineers, lawyers, and, yes, our volunteer partners, to accept nothing less than the best investment of public and private funds in well-designed and routinely successful wetland restoration projects. ■

Resources

The Society of Wetland Scientists Research Brief by Roy Lewis, *Mangrove Field of Dreams: If We Build It, Will They Come?*, is available at:

www.sws.org/researchbrief/

More information on mangrove restoration can be found at:

www.mangroverestoration.com
www.seagrassrestorationnow.com
www.mangroveactionproject.org

Information about wetland certification is available at:

www.wetlandcert.org

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