Ecological Engineering 65 (2014) 9–14

Contents lists available at ScienceDirect

Ecological Engineering

journal homepage: www.elsevier.com/locate/ecoleng

When will ecologists learn engineering and engineers learn ecology?

William J. Mitsch (Editor-in-Chief)[a,b,*]

[a] Everglades Wetland Research Park, Juliet C. Sproul Chair for Southwest Florida Habitat Restoration and Management, 110 Kapnick Center, Florida Gulf Coast University, 4940 Bayshore Drive, Naples, FL 34112, USA
[b] Professor Emeritus, The Ohio State University, Columbus, OH 43210, USA

ARTICLE INFO

Article history:
Received 5 October 2013
Accepted 6 October 2013
Available online 9 November 2013

Keywords:
Ecological engineering
Self-design
Indian Ocean tsunami
Delaware Bay marshes
Louisiana Delta
Mississipi–Ohio–Missouri River Basin
Mesopotamian Marshlands
Florida Everglades

ABSTRACT

Six large-scale wetland restoration case studies are presented here, three of which relate to ecological engineering of coastlines, and three of which relate to large-scale watershed improvements that in turn lead to improvement of downstream aquatic ecosystems. All of these case studies suggest that there is much more to restoration than returning a system to what it was before, particularly given the drastic changes to the physical and chemical environment.

1. Introduction

The fields of ecological restoration and ecological engineering are intertwined and considered by some to be redundant or duplicative. But are they the same or are there distinct differences? Perhaps the more important question is whether either paradigm will be the right approach as we enter an age of more environmental issues now complicated by climatic shifts, more populated and more dense urban complexes, and a good possibility that we are running out of conventional energy resources that we have depended on in the past to buy our way out of ecological problems.

Ecological restoration has been defined as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (SER, 2004) or as "the return of an ecosystem to a close approximation of its condition prior to disturbance" (NRC, 1992). Ecological engineering is defined as the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both (Mitsch, 1993, 2012; Mitsch and Jørgensen, 2004). The goals of ecological engineering are two-fold: (1) the restoration of ecosystems that have been substantially disturbed by human activities such as environmental pollution or land disturbance, and (2) the development of new sustainable ecosystems that have both human and ecological value (Mitsch and Jørgensen, 2004). The "development of new sustainable ecosystems" goal separates the two fields and makes ecological engineering broader. Restoration should be and is for the most part the "heart and soul" of ecological engineering (Mitsch, 2012). Ecosystem restoration was described by noted British restoration ecologist Tony Bradshaw (1997) as "ecological engineering of the best kind," and this makes a great deal of sense. The best kind of ecosystems we can create or restore are the ones that were there before.

There are many situations where ecological engineering/restoration is needed on a large scale to provide ecosystem services on a large scale. In fact, billions of US$ have been spent around the world in the name of ecosystem restoration. In reality, that restoration is all ecological engineering because it is rare if not impossible to restore ecosystems back to where they were. In all cases, the examples presented below are described as returning ecosystems to their prior conditions or assisting in their recovery. But in almost all cases, these examples include much more than "putting back" ecosystems that were there before. They also involve creating new, hopefully sustainable, ecosystems to assist in those recoveries, either by minimizing downstream pollution or providing coastal protection from storms and tsunamis. Six case studies are

* Correspondence to: Everglades Wetland Research Park, 110 Kapnick Center, Florida Gulf Coast University, 4940 Bayshore Drive, Naples, FL 34112, USA.
Tel.: +1 614 946 6715; fax: +1 239 732 7043.
E-mail addresses: ecoeng@fgcu.edu, wmitsch@fgcu.edu

0925-8574/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.ecoleng.2013.10.002

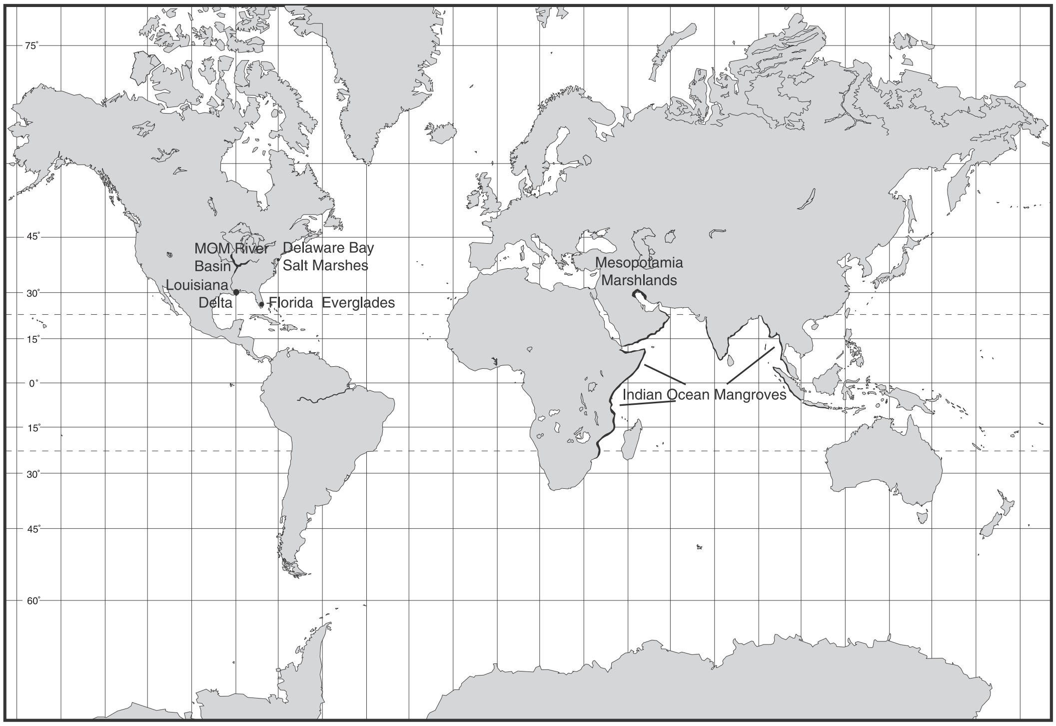

Fig. 1. Location of six large-scale wetland restorations discussed in this paper.

presented here (Fig. 1), three of which relate to ecological engineering of coastlines, and three of which relate to large-scale watershed improvements that in turn lead to improvement of downstream aquatic ecosystems. All of these case studies suggest that there is much more to restoration than returning a system to what it was before, particularly given the drastic changes to the physical and chemical environment.

2. Ecological engineering for protecting coastlines

2.1. Indian Ocean mangrove restoration

An estimated 230,000 people were killed in late December 2004 as a result of a massive tsunami around the Indian Ocean caused by an earthquake off the coast of Sumatra, Indonesia. Waves as high as 30 m were reported. This Boxing Day Tsunami has been called "one of the deadliest natural disasters in recorded history" (http://en.wikipedia.org/wiki/2004_Indian_Ocean_earthquake). Since most of the destruction and loss of life occurred on the tropical coastlines of the Indian Ocean, destruction of mangrove swamps for shrimp farms and tourist meccas bears some of the responsibility for the carnage. In the areas hardest hit, 26% of mangrove wetlands, or 1.5 million ha, had been destroyed from 1980 to 2000 (FAO, 2003). In the aftermath, Danielsen et al. (2005) reported that in an area of southeast India, there was significantly less damage caused by the tsunami where mangroves had been protected.

The 2004 Indian Ocean tsunami initially caused great interest in restoring mangrove and other coastal ecosystems to replace areas stricken by the tsunami as well as to provide coastal protection in the event of future tsunamis or other tidal surges. Simulation models illustrated that a wide (100 m) belt of dense mangrove trees (referred to as a "greenbelt") on the coastline could reduce a tsunami pressure flow by more than 90% (Hiraishi and Harada, 2003). In the wake of the tsunami, the governments of Malaysia, India, and Indonesia alone promised a total of US$ 55 million to replant mangrove forests along their respective coastlands. However, Check (2005) reported that despite many local mangrove "replantings" and massive public assistance provided by international organizations such as the United Nations, many tropical coastline regions are returning to their old way of destroying mangrove forests for short-time profitable shrimp farms, making the regions even more susceptible than before to tropical storms and tsunamis. Furthermore, because mangrove restoration is really ecological engineering, many of the restored mangrove forests could fail because the plantings may have occurred in regions where the tidal and hydrologic conditions are not proper (Lewis, 2005, 2010). In fact, Lewis (2010) declares that there is little evidence that mangroves have ever been restored on a large scale. He attributes this to two misguided assumptions regarding mangrove restoration: "(1) mangroves can only be restored by planting, and (2) sub-tidal mud flats are suitable for planting mangroves, when in fact they likely never supported a mangrove forest in the first place."

2.2. Louisiana Delta restoration

Louisiana is one of the most wetland-rich regions of the world with 3.6 million ha of marshes, swamps, and shallow lakes. The Mississippi River delta and coastline in Louisiana in south-central USA are disappearing into the sea with rates of coastal wetland loss of between 6600 and 10,000 ha per year (Day et al., 2005). This represents a loss of 2% of its vast wetlands per decade. This loss is usually attributed to natural causes (land subsidence) combined with human actions (river levee construction, oil and gas exploration, urban development, sediment diversion, and possibly climate change). For the past 25 years there has been great interest not only in reversing this loss of wetlands but even regaining coastal areas, particularly freshwater marshes and salt marshes. An ambitious ecological engineering project, called the Louisiana Coastal Area (LCA) project, was proposed in the middle part of the 1990s to re-engineer the coastline to curtail the land loss. This