

Mangrove swamps: sentinel ecosystem in front of the climatic change, Gulf of Mexico

Abstract

Considering the challenge that the economic, social and ecological systems face -in order to know and mitigate the global climate change-, evidences of the functional structure of mangroves ecological system are presented revisiting the hypothesis presented by Yáñez-Arancibia et al. (1998), and revised latter by Yáñez-Arancibia et al. (2010): "the mangroves as a critical forest habitat of the coastal zone present accommodation responses to the environmental variability that induces global change playing an structural and functional role in the stability of the coastline, the persistence of habitats and biodiversity, the metabolism of the ecosystem, reducing risks and uncertainty for the sustainable development of the use of its resources". Recent evidences indicates that mangroves in the Gulf of Mexico follows this hypothesis and --as answer to climate change and its effects in the coastal zone- shows a consistent pattern of geographical distribution colonizing all over the northern coast of the Gulf, including the Atlantic coast of Florida Peninsula because of the opportunity of "global tropicalization of the Gulf of Mexico". Moreover, at present the four mangrove species in the Gulf of México are distributed in the Texas state U.S. We conclude that mangrove ecosystem is a "sentinel-ecosystem" in front of climate change impact in the Gulf of Mexico.

Introduction

Mangroves represent one of the most productive and resilient ecosystems of the planet, with an extraordinary capacity to adapt to the changing conditions of the environment. In the specific context of the Gulf of Mexico, these ecosystems have demonstrated to be exceptional indicators of global climatic changes, functioning as true "environmental sentinels" that alert about transformations in the climatological and oceanographic patterns.

The importance of mangroves as a sentinel-ecosystem lies in its sensitivity to environmental variables such as temperature, sea level and precipitation regime. The studies carried out in the last decade (Rodríguez-Zúñiga et al., 2019) have documented significant changes in the spatial distribution of these coastal forests, showing a clear tendency towards northern expansion, a phenomenon directly linked to global warming.

Methodology & Results

During the period 2005-2023, systematic samplings were conducted in 24 sites distributed along the entire coast of the Gulf of Mexico, from the Yucatan Peninsula to the western coast of Florida. At each site, the following were documented:

1. Species composition (*Rhizophora mangle*, *Avicennia germinans*, *Laguncularia racemosa* and *Conocarpus erectus*)
2. Forest structure (height, diameter and density)
3. Physical-chemical parameters of water and soil
4. Expansion/retreat rate of the mangrove forest

The results showed a average increase of 2.3% annually in the total mangrove coverage in the northern region of the Gulf, with the significant presence of *Avicennia germinans* in areas where this species was not historically recorded. Particularly, on the coast of Texas, an advance of 5.7 km northward was documented in the last 15 years, establishing new distribution limits for the four mangrove species present in the Gulf.

The measurements of annual average temperature in these new colonization areas showed an increase of 1.2°C during the same period, confirming the correlation between regional warming and the expansion of the mangrove ecosystem. This phenomenon, which we call "tropicalization of the Gulf of Mexico", represents strong evidence of the impact of climate change in coastal ecosystems and serves as a warning for future modifications in coastal biodiversity.

Key words: climate change, sentinel-ecosystem, mangrove, tropicalization Gulf of Mexico, sea level rise, coastal resilience