Context Document: Mangrove Restoration Ecosystem Service Logic Model for the Gulf of Mexico

Project: GEMS
http://bit.ly/NI-GEMS

Ecosystem Service Logic Models (ESLMs) are conceptual models that summarize the effects of an intervention, such as a habitat restoration project, on the ecological and social systems. Each model links changes in biophysical systems caused by an intervention to measurable socioeconomic, human well-being, and ecological outcomes. ESLMs assume that the restoration is successful and include all potentially significant outcomes for the intervention; not all outcomes will be relevant to each individual project, depending on location and environmental conditions.

The direction of an outcome (whether the restoration will have a positive or negative influence) often depends on the specific situation or is unclear due to multiple links (arrows) leading into an outcome that may have opposite effects. Thus, language like "increased" or "decreased" is not included in the models. These models are often used to consider management with or without an intervention or to compare different interventions.

This context document includes additional information about the restoration approach and details about some of the relationships in the mangrove restoration ESLM created for the Gulf of Mexico. The model was adapted from a mangrove ESLM built for southwestern Florida. This document also includes a list of the references used to develop the ESLM and names of experts with whom we spoke to refine the model.

Mangrove Restoration Description and Use in the Gulf of Mexico

Of the five Gulf states, southern Florida contains the largest expanses of mangrove habitat. However, mangroves do appear across the Gulf and will likely increase their range in this region as climate change makes more northern Gulf areas suitable habitat (Comeaux et al. 2020, Cavanaugh et al. 2019). Specific techniques for mangrove restoration vary in terms of the process used, but primarily consist of restoring site conditions to those that are conducive to mangrove growth and waiting for mangrove propagules to colonize the site. These restoration activities include: hydrological restoration (to restore proper tidal flow, freshwater inputs, and salinity levels) and restoring sediment elevation. In some areas of the Gulf mangrove site creation, rather than restoration, is being performed (i.e., creating site conditions conducive to mangrove recruitment in an area where mangroves didn't exist before). Restoration in this region very rarely involves planting seedlings.

External Factors That Influence Restoration Success

A number of factors, including environmental factors (salinity, sedimentation) and social factors (institutional constraints), can affect the success of a mangrove restoration project but are outside of the project's control. The following external factors affecting project success have been indicated as significant to mangrove restoration by the experts we consulted: storms and hurricane damage to mangroves, human development direct and indirect effects, water pollution (e.g., agricultural runoff, stormwater being directed into mangrove areas), sea level rise, invasive species, and ocean acidification.

Model Notes and Clarifications

Water Quality Outcomes: There was significant discussion between experts as to the effect of a single restoration site on water quality, specifically algae bloom frequency and associated downstream effects. The nutrient filtration capacity of mangroves is seen as significant, but participants noted uncertainty about the potential influence of a single restoration site on localized or regional algae blooms due to the multitude of factors that determine when and where algae blooms occur. Therefore, we have not included effects on algae bloom frequency or intensity in the generalized mangrove model. If someone using this model is examining restoration on a large scale or for multiple sites in a single estuary, they may want to consider adding these effects back into the model.

Beekeepers and Mangroves: We have heard mentions about commercial beekeepers using Florida's mangrove forests as a resting place for bees during part of the year. It is unlikely that a single mangrove restoration site would alter the delivery of this service. This service was not considered significant enough to include in the model at this time, but further investigation (or future changes in demand for commercial bee colonies) might indicate that this service should be incorporated into the model.

Odor: Dead or dying mangroves can release a unique (and unpleasant) odor, therefore mangrove restoration has the potential to remove or lessen this smell. Experts emphasized that this was a significant linkage to include in specific cases, especially if the dead or dying mangroves are nearby residential or commercial properties. However, this outcome will not be relevant everywhere. We have left it out of this model because of its limited applicability and importance, but it should be considered, and added into a model where this linkage is significant.

Aesthetics: The aesthetic value of mangroves is relative. In some cases, mangrove restoration improves aesthetic value due to the beneficial appearance of live vs. dead mangroves, or vegetation where there had previously been none. But in some cases, mangrove growth can block views of the water, and in these cases, they can be considered to have a negative aesthetic influence.

Nutrient Retention and Nutrient Credits: Mangroves do retain nutrients and restoration sites could potentially generate nutrient credits, but due to a lack of current nutrient credit programs and markets, this was removed from the model.

Adjacent Habitats: Mangrove restoration can have effects on other types of habitat close to the project site. Changes to these habitats will have their own suite of ecological and socioeconomic effects. In the ESLM, these are referred to under the heading, "Outcomes related to adjacent habitat." If a project is expected to have substantial effects on other habitat types, we recommend referring to the separate ESLM for that habitat type.

Context Is Essential: In some locations, mangroves are considered undesirable. For example, in some parts of the Gulf they are encroaching into salt marsh habitat and there is concern that they could displace or otherwise negatively affect salt marsh-dependent species (Kelleway et al. 2017, Smee et al. 2017). ESLMs are designed to show system change; they describe how a system will change given a particular management intervention or external stressor in comparison to some baseline. Invasive or encroaching mangroves could be considered an external stressor, and an ESLM adapted for this context could compare mangrove encroachment to a baseline of the habitat in its previous state. In these cases, the mangrove model provided here could be used to show relative change in service amounts compared to what they were in a previous habitat state.

Mosquitoes: The outcomes related to mosquitoes will differ depending on the type of mosquitoes breeding in mangrove habitats. For example, in southwestern Florida the primary mosquito species breeding in mangrove sites are Aedes taeniorhynchus and Culex nigripalpus, with A. taeniorhynchus being the most common. These mosquitoes are mainly pests; their primary impact is annoyance to humans, but C. nigripalpus has been known to carry West Nile and other diseases.

Nutrition for Communities: This as an expected socioeconomic outcome of restoration projects can come from two sources: changes in fish and shellfish harvesting, and changes in land-based hunting on restoration areas. For this model, the source of nutrition is mainly from changes in fish and shellfish harvesting.

Disruption from Flooding: Mangroves reduce flood height and extent, therefore diminishing the social and economic disruption that flooding causes. Flooding events can cause social disruption by closing schools, grocery stores, and other community infrastructure; prevent local businesses from opening due to damage and access issues; and create stress and anxiety among the affected population. Three links in the model from the flood height/extent node capture these effects: the link leading to social disruption from project or flooding, the link leading to economic activity of local businesses, and the link leading to mental health and psychological well-being.

Disruption from Construction: Construction activities related to the project can also cause social and economic disruption by changing traffic flows. This occurs when mangrove restoration projects include the installation of culverts or other alterations to infrastructure to restore hydrologic connectivity and make conditions more suitable for mangroves. Not all projects will have this effect. The model links leading from the construction disruption node represent these potential effects. When it occurs, construction-related disruption is temporary.

Experts Consulted

Kathy Worley, Conservancy of SW Florida

Jeff Carter, Rookery Bay NERR

Laura Flynn, Coastal Resources Group

Chad Washburn, Naples Botanical Garden

Marissa Kelley, Rookery Bay NERR

Stephanie Molloy, City of Naples

Brita Jessen, Rookery Bay NERR

Jessica McIntosh, Rookery Bay NERR

Ken Krauss, U.S. Geological Survey

Michael Osland, U.S. Geological Survey

Eric Millbrandt, Sanibel Captiva Conservation Foundation

Keira Lucas, Collier Mosquito Control District

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