Context Document: Beach and Dune Restoration Ecosystem Service Logic Model for the Gulf of Mexico

Project: GEMS
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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 beach and dune restoration ESLM created for the Gulf of Mexico. 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.

Beach and Dune Restoration Description and Use in the Gulf of Mexico

Beach restoration in the Gulf of Mexico aims to replace sand that erodes from a beach. It is usually completed by dredging offshore sand and adding it onto the beach. Finding a similar grain size to the sand that is already in the beach/dune system is the most important consideration when adding sand dredged from offshore because the wrong sized sand grains can be easily redispersed due to wave action specific to an area (Hanley et al. 2013). Beach restoration, beach replenishment, beach nourishment, and beach renourishment are all terms used to refer to this action.

Dune restoration also aims to offset sand erosion but may also include increasing dune size and resilience. There are three major types of dune stabilization techniques: importing dredged sand from offshore to build up the dune, planting grasses or other plants to secure the sand, and installing fencing along the dune on both the seaward and landward sides of the dune. Planting and fencing projects are often referred to as dune stabilization practices, but all three techniques fall under the umbrella of dune restoration. Uniola paniculata and Panicum amarum are the vegetation species most often used to stabilize foredunes (dunes facing the side of the sea) in the Gulf of Mexico (Hester et al. 1994). Planting and fencing projects are often less expensive than building up the dune. The most successful restoration projects use all three techniques to add redundancy. Restored dunes are often smaller, more linear, and are characterized by fewer plant species than natural dune systems (Godfrey and Godfrey 1974, Nordstrom et al. 2000). Therefore, the relationships displayed in the model may be less impactful than they would be from a natural dune system.

Dune restoration is frequently used in Florida, Louisiana, and Texas, which all have larger amounts of coastline than Mississippi and Alabama, but all five Gulf states do beach restoration on small and large scales. Mississippi, Alabama, and Louisiana most often do beach and dune restoration as part of barrier island restoration, which is more relevant in their coastal zones.

External Factors That Influence Restoration Success

Beach and dune erosion is caused by wave action and aeolian processes (wind) and is exacerbated by large storm events, which are increasing due to global climate change (Godfrey and Godfrey 1974). Because of this, dune stabilization and beach nourishment are often viewed as short-term solutions that require regular maintenance, monitoring, and upkeep (Speybroeck et al. 2006).

Using different fencing patterns and shapes may be more or less effective at preventing erosion or burying plants (Charbonneau & Wnek 2016). Additionally, different plants have been shown to have different effects on the erosion rate, and planting later successional species may be a better way to stabilize the dune (Charbonneau et al. 2015). It may be important for various restoration projects to look into local wind patterns and plant species to determine the best course of action.

Model Notes and Clarifications

Restoration Group: To simplify the model, arrows stemming from the beach and dune restoration box apply for both beach nourishment and dune stabilization techniques. Arrows coming specifically from one or the other only imply relationships for that type of restoration project and do not apply to the other.

Dune Vegetation and Erosion: Dune vegetation reduces erosion rates by stabilizing sand (Charbonneau et al. 2015). Many dune plants have a symbiotic relationship with an arbuscular mycorrhizal fungus, which provides nutrients for faster growth rates for the plants post-stabilization (Corkidi and Rincon 1997, Gemma and Koske 1996). Plants are usually already inoculated with the fungi when planted as part of a restoration, and the fungi cannot grow without plants (Charbonneau et al. 2015, Gemma and Koske 1996). The effects of this relationship are captured in the arrow from dune vegetation to erosion rate.

Property Value: It is unknown whether dune stabilization has an overall positive or negative effect on property value. There is a lack of empirical evidence to explain this, however there are numerous lawsuits from property owners contesting dune building because it blocks beach views. In addition, evidence demonstrates that higher dunes protect landward ecosystems, reducing the risk of property damage (Komar and Allen 2010). The chain of dune height & width → Beach Aesthetics → Property Value indicates the idea that higher dunes can alter ocean views, a negative effect. The chain of erosion rate → shoreline and property protection → property value indicates that protection from wave and wind action can be a positive effect.

Potential for Hazards: The uncertain link in the model describes the hypothesis that beach nourishment alters beach morphology in ways that may increase the likelihood of rip currents and other hazardous conditions, leading to an increase in drownings and other beach accidents or injuries (Fletemeyer et al. 2018). However, more research must be done to establish the link.

Adjacent Habitats: Dune stabilization has effects on adjacent ecosystems such as salt marshes, mangroves, and seagrass by acting as a buffer from storms and sea level rise (see salt marsh, mangrove, or seagrass ESLM). Barrier island restoration practices are particularly overlapped with dune restoration and beach nourishment because all three aim to reduce the rate of erosion, and barrier islands are usually made up of beach and dune systems at the foredune and marsh systems behind the dunes (Mendelssohn et al. 1991). To get a better idea of the effects of barrier island restoration, it may be helpful to examine the beach restoration model and the salt marsh restoration model together.

Disruption from Flooding: Dunes protect the areas behind them from flooding, therefore reducing 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 likelihood of coastal flood events reaching shoreline development 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 closing community amenities (such as beaches used for recreation), reducing local business revenue due to fewer tourists or access issues, and limiting opportunities for people to engage in recreational activities that promote well-being. The model links leading from the construction disruption node represent these effects. Construction-related disruption is temporary and can sometimes be mitigated by planning construction activities for the off-season, when fewer people are in the area and using the recreational resources.

Experts Consulted

Bianca Charbonneau, U.S. Army Corps of Engineers

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