Evaluating trade-offs of a large, infrequent sediment diversion for restoration of a forested wetland in the Mississippi delta

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ABSTRACT

Flood control levees cut off the supply of sediment to Mississippi delta coastal wetlands, and contribute to putting much of the delta on a trajectory for continued submergence in the 21st century. River sediment diversions have been proposed as a method to provide a sustainable supply of sediment to the delta, but the frequency and magnitude of these diversions needs further assessment. Previous studies suggested operating river sediment diversions based on the size and frequency of natural crevasse events, which were large (>5000 m3/s) and infrequent (active < once a year) in the last naturally active delta. This study builds on these previous works by quantitatively assessing tradeoffs for a large, infrequent diversion into the forested wetlands of the Maurepas swamp. Land building was estimated for several diversion sizes and years inactive using a delta progradation model. A benefit-cost analysis (BCA) combined model land building results with an ecosystem service valuation and estimated costs. Results demonstrated that land building is proportional to diversion size and inversely proportional to years inactive. Because benefits were assumed to scale linearly with land gain, and costs increase with diversion size, there are disadvantages to operating large diversions less often, compared to smaller diversions more often for the immediate project area. Literature suggests that infrequent operation would provide additional gains (through increased benefits and reduced ecosystem service costs) to the broader Lake Maurepas-Pontchartrain-Borgne ecosystem. Future research should incorporate these additional effects into this type of BCA, to see if this changes the outcome for large, infrequent diversions.

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1. Introduction

During the 20th century, Louisiana lost about 25%, or 4800 km2, of coastal wetlands, due mainly to the effects of human activities.

(Couvillion et al., 2011). One of the major causes is leveeing of the Mississippi River (MR) and its distributaries, which has isolated deltaic wetlands from the MR, preventing overbank flooding and crevasse formation (Day et al., 2000, 2007, 2016a). Engineered sediment diversions, which divert sediment and nutrient laden freshwater from the MR to adjacent wetlands, have been identified as a critical tool in restoring the Mississippi river delta plain (MRDP) (Day et al., 2007, 2016a; Kim et al., 2009; Allison and Meselhe, 2010; Paola et al., 2011; CPRA, 2012, 2017a; Dean et al., 2014; Wang et al., 2014). Three operational river diversions were constructed for the purpose of restoration: the Caernarvon and Davis Pond diversions (99 and 302 m3/s, respectively) control salinity intrusion, and the West Bay diversion (566 m3/s) is designed to divert sediment to create and nourish wetlands near the mouth of the river. The Bonnet Carré spillway (operated at 3000–9000 m3/s, several weeks...
physical units are less intuitive. However, for policymakers and politicians, where in other studies benefits were limited to those

The “ecosystem services” framework has recently gained traction as a means for communicating the benefits of natural systems. Especially in the management of coastal systems, which provide a rich array of benefits under increasing stress from human development (Turner and Schaafisma, 2015). Ecosystem service valuation (ESV) offers a means to capture, in monetary terms, these benefits. ESV is especially useful in BCA, where benefits and costs can be expressed with a common unit, but there exist methodological challenges which make its application difficult. In the 2012 Comprehensive Master Plan (CMP), for example, the Coastal Protection and Restoration Authority (CPRA) avoided representation of ecosystem services in monetary terms, stating that “we did not include this economic aspect of ecosystem services in the master plan analysis [because] [m]odels to analyze this aspect were not readily available, and we did not have time to develop them ourselves” (the same approach is taken in the 2017 CMP). Recent examples of combined modelling and ESV exercises applied to ecosystem restoration exist in the MRDP and Florida Everglades (Mather Economics, 2010; Caffey et al., 2014; REC & EE, 2016).

This study explored a large, infrequent sediment diversion, of the sort described by Day et al. (2016a), into the Maurepas swamp (Fig. 1) (unless otherwise stated, by “diversion” we mean “sediment diversion”, a diversion intended to build land, versus a “freshwater diversion” which is intended to control salinity). Day et al. (2016a) suggested that large diversions operated infrequently are advantageous to small diversions operated continuously, but lack a quantitative assessment of the drawbacks of infrequent operation. In particular, what are the drawbacks of “curtailing” sediment delivery for one year or more compared to continuous operation? This paper addressed this question. By parameterizing a delta progradation model for the Maurepas swamp we were able to estimate land building for a number of diversion sizes, operation strategies (years inactive between operations), and SLR scenarios. First, we analyzed the relationship between years inactive, size, and land building in general, and assessed the potential to sustain land building. Second, we used the land building estimates to further assess large, infrequent diversions by performing a BCA, where ESV is applied to capture, in monetary terms, the benefits provided by the Maurepas swamp restoration. Based on the applied model, our estimates of ecosystem service benefits were limited to those
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