Appendix S1

The Wetland Morphology Model

To mitigate the loss of wetland and associated ecosystem services across the coast, the State of Louisiana has developed its Coastal Master Plan and updated it every five years to guide coastal protection and restoration efforts. A series of coastwide predictive models were developed to predict changes in multiple ecological and socio-economic components of the Louisiana coastal system in support of Louisiana's 2012 Coastal Master Plan (Fig. S1). The Eco-Hydrology model predicts the salinity, stage, sediment, and other selected water quality constituents of the open water bodies including channels and bayous along coastal Louisiana (Meselhe et al. 2013). In the model, a mass-balance approach was used to estimate the exchanges of solids and chemicals due to advection and dispersion through the landscape represented by conveyance links and storage cells. The Wetland Morphology model tracks the changes in wetland area and elevation over time including the loss of existing wetlands, the creation of wetlands by both natural and artificial process, and the fate of those newly created wetlands (Couvillion et al. 2013). The Barrier Shoreline Morphology model is driven by analysis of historical shorelines and tracks changes in both Gulf and bay sides of islands along shoreline segments to estimate changes in island shape and migration (Hughes et al. 2012). The Vegetation model predicts spatial and temporal changes in vegetation type and the spatial extent of 19 plant communities of emergent vegetation and submerged aquatic vegetation based on environmental drivers, such as salinity and water level change (Visser et al. 2013). The Ecosystem Services model predicts how well Louisiana's future coast would provide habitat for commercially and recreationally important coastal species, habitats for other key species, and key services for coastal communities (Nyman et al. 2013). The Storm Surge and Wave model uses the widely adopted Advanced Circulation (ADCIRC) large-domain storm surge model, coupled with the unstructured Simulation Waves Nearshore (UnSWAN) wave model to provide flood stage and wave time series at select locations for use by the Risk Assessment model (Cobell et al. 2013). The Risk Assessment model uses an asset inventory based on 2010 census estimates to estimate residual economic damages from storm surge flooding due to surge and waves from hurricanes and storms (Johnson et al. 2013). Each of the spatially-explicit predictive models provides inputs to other models, produces outputs, or both at a 5-year interval for simulations of 50 years (2010-

2060) to estimate how the landscape might change, as well as how restoration projects might perform on the landscape over time (Figure S1).

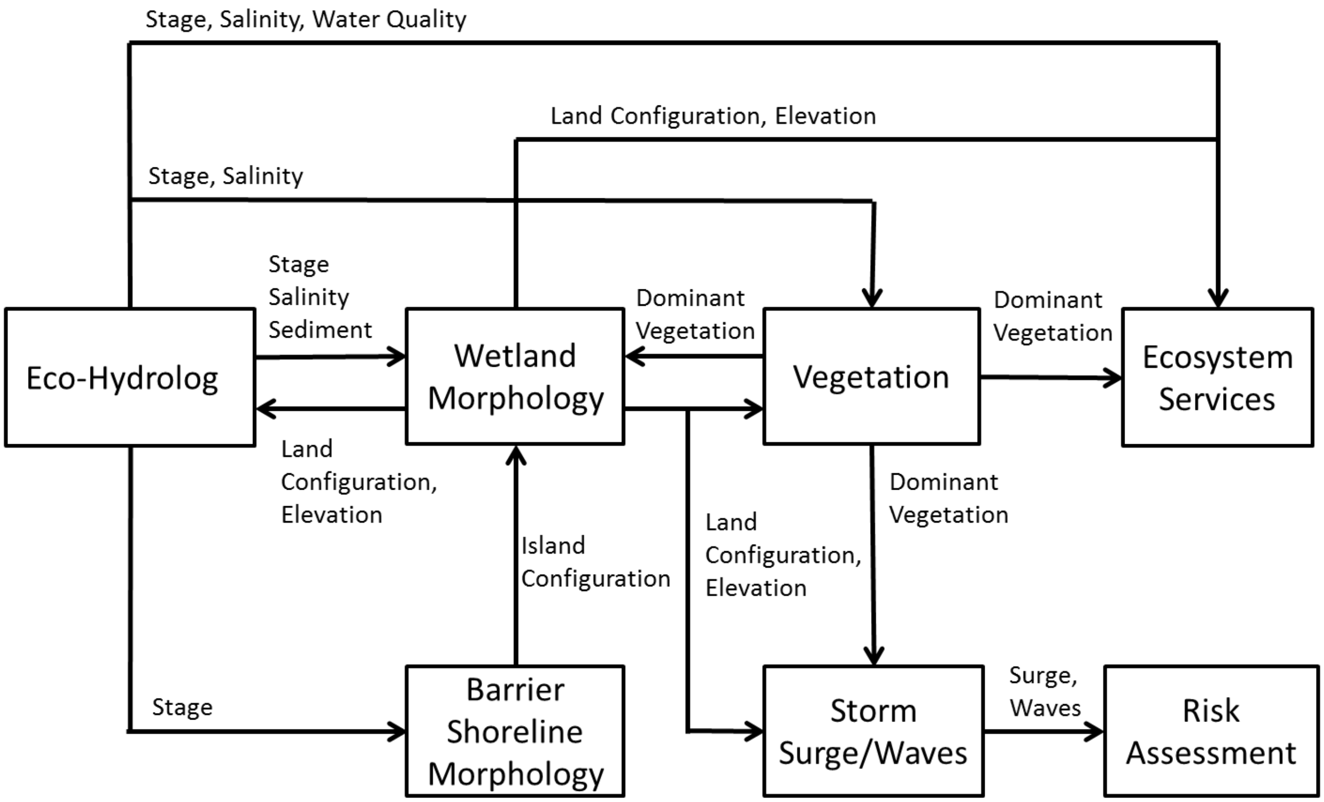

Figure S1. Flow diagram of the integrated modeling framework for the 2012 Louisiana Coastal Master Plan. The simulated landscape SOC sequestration rates were estimated based on simulated landscape configuration and vertical accretion under MR diversions and future environmental scenarios using the Wetland Morphology model (modified from Peyronnin et al. 2013).

We used the simulation results of the Wetland Morphology model to assess and predict the landscape effects of Mississippi River (MR) diversion on soil organic carbon (SOC) sequestration under future environmental conditions. The Wetland Morphology model tracks elevation changes as a result of subsidence, and then updates landscape topography and bathymetry according to Equation S1:

$$E_{yr2} = E_{yr1} + 0.01 \times (H - S) \quad \text{(S1)}$$

Where E_{yr2} is adjusted surface elevation at Year 2 (m NAVD 88); E_{yr1} is surface elevation at Year 1 (m NAVD 88); H is vertical accretion rate (cm yr^{-1}); S is subsidence rate (cm yr^{-1}); and 0.01 is a conversion (cm to m) factor. The model translates those vertical changes into changes to the horizontal composition of the landscape (land/water area). The translation of elevation changes into landscape-configuration changes is done primarily by the use of inundation depth-based marsh-collapse thresholds (Table S1) as described in detail by Couvillion and Beck (2013).

Table S1. The marsh collapse thresholds for different vegetation types across coastal Louisiana

Marsh Type	**Salinity (ppt)***	**Inundation depth (cm)**
Fresh	6-8	
Intermediate		30.7 - 38.0
Brackish		20.0 – 25.6
Saline		16.0 – 23.5

* Eight-week average growing season.

Vertical accretion (H) is estimated by examining the roles of both organic matter and mineral sediments on wetland vertical accretion and surface elevation:

$$H = \frac{Q_{sed}+Q_{org}}{10{,}000*BD} \qquad \text{(S2)}$$

Where Q_{sed} is mineral sediment accumulation rates (g m^{-2} yr^{-1}), which is provided by the Eco-Hydrology model (Meselhe et al. 2013); Q_{org} is organic matter (OM) accumulation rate (g m^{-2} yr^{-1}); BD is soil bulk density (g cm^{-3}) and the constant 10,000 is a conversion factor from m^2 to cm^2. This equation assumes that vertical accretion can be described by both mineral and OM accumulation, and soil bulk density at equilibrium when BD does not change with depth (if equilibrium cannot be reached, then average BD values are derived from a calibration process) (Steyer et al. 2012).

Organic matter accumulation rate (Q_{org}, g m^{-2} yr^{-1}) is estimated as:

$$Q_{org} = Q_{sed} * \frac{F_{org}}{F_{min}} \qquad \text{(S3)}$$

Where F_{org} is the fraction of OM mass in total soil mass, which is equivalent to OM content (OM%) divided by 100; and F_{min} is the fraction of inorganic matter mass in total soil mass ($1 - F_{org}$) at equilibrium. This method assumes that site specific OM accumulation can be derived from the relationship between long-term mineral matter accumulation and OM accumulation at equilibrium in the sediment (where bulk density stops changing with depth), and that OM accumulation does not occur when mineral material accumulation is zero.

The Wetland Morphology model is sensitive to hydrological basin and vegetation type determined soil bulk density and OM content. Therefore, BD and OM content were calibrated for each basin/vegetation group in coastal Louisiana (refer to Couvillion et al. 2013 for details on the calibration). The simulated vertical accretion could be larger than observed accretion rates (e.g., feldspar marker methods). Consequently, a maximum vertical accretion based on historical observed rate (2.26 cm yr-1) was applied in the model to produce reasonable vertical accretion (Steyer et al. 2012). The model was validated by long-term sediment accumulation and vertical accretion rates at 79 sites in the Coastwide Reference Monitoring System (CRMS) (Steyer et al. 2012, Couvillion et al. 2013). The model tends to underestimate observed accretion rates by approximately 22% (Couvillion et al., 2013). Vertical accretion rates could be underestimated in areas of low mineral sedimentation, but there is high organic accumulation due to significant contribution of vegetative growth to accretion (Nyman et al., 2006).

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