Integrated Modeling to Provide Policy Insight: Gulf of Mexico Hypoxia and CEAP Modeling Effort

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Mississippi River Basin and its Major Subbasins





What is hypoxia?



Common definitions (Steckbauer et al., 2011):

oxygen levels < 2mg/L organisms exhibit stress

oxygen levels < 0.5 mg/L mass mortality

Normal levels > 3 mg/L

What abatement options exist? Examples from U.S. Agriculture

- In field Management Practices
 - Reduced (no) tillage
 - Manure, fertilizer management/reduction
 - Cover crops, rotation changes
 - Land retirement
- Structural Practices
 - Buffers
 - Grassed Waterways
 - Denitrification, controlled drainage
 - Wetland restoration



Conservation practices









Land Retirement





Panoramic view of gamma grass-big blue stem planting http://www.fsa.usda.gov/Internet/FSA_Image/ia_767_15.jpg

Wetlands Restoration





Photo courtesy Missouri NRCS



CEAP Modeling Approach

Data from 12308 farm fields sampled in the drainage area:

- 3 years of detailed farm management
- Conservation district office conservation plan records
- National Resource Inventory and Soil Survey data
- 47 years of daily weather
- Detailed biophysical model of cultivated cropland with APEX model used as edge-of-field loads in SWAT
- Modeled other land types and point sources using SWAT



Scenario Details

- ECA and ECC (Erosion Control)
 - Infield mitigation: terraces on high slopes, contour or strip cropping on all
 - Edge-of-field mitigation: fields near a waterway received a riparian buffer, filter strips elsewhere
- ENMA and ENMC (Nutrient Management)
 - Adjusted rate, form, timing, and method of application to be most efficient



Hypoxic Zone Model (Initial Stage of development)

 $\begin{aligned} HypoxicZone_t &= \beta_{intercept} + \beta_{hurricane} Hurricane_t + \beta_{current} Current_t \\ (-) & (-) \end{aligned}$

 $+ \beta_{hurrN} Hurricane_t * N_t + \beta_{hurrP} Hurricane_t * P_t + \beta_N N_t$ $(+) \qquad (-) \qquad (+)$

$$+\sum_{i=0}^{5}\beta_{i,P}P_{t-i} + \sum_{i=0}^{5}\beta_{i,NP}N_{t-i}P_{t-i} + \varepsilon_{t}$$

where $N_t = log 10$ (N load at time t) and $P_t = log 10$ (TP load at time t).



Model performance





Using CEAP input data





Model-predicted size of hypoxic zone, CEAP scenarios





Average Hypoxic Zone Prediction Under Scenarios





Research Needs and Future Directions

- Valuing Damage to Ecosystem when:
 - Large areas impacted, SR mortality, alterations to food web, habitat, reproductive effects
 - but thus far, not major effects in aggregate
 - Uncertainty: LR effects, thresholds, irreversibilites, biodiversity effects...?
- Policy Design:
 - nonpoint source pollution, can voluntary (US) programs work?

