Overarching Hypothesis
Climate-induced adaptive changes in agricultural practices and ecosystem processes will cause large indirect phenologic (seasonal and intra-annual) effects in riverine loading that will propagate through watersheds to the estuary and affect ecosystem health.

Project Overview: Impacts of Climate Change on the Phenology of Linked Agriculture-Water Systems
William P. Ball (1), Lisa Wainger (2a), Ciaran Harman (1), Damian Brady (3), Ariel Ortiz-Bobea (4), W. Michael Kemp (2b), Jeremy M. Testa (2a), Laura Murray (2b), Daniel Wilusz (1).
Johns Hopkins University, Dept. of Geography and Environmental Engineering; (2) University of Maryland Center for Environmental Sciences; (3) University of Maine, School of Marine Sciences; (4) Cornell University, School of Applied Economics and Management. Contact: Daniel Wilusz, dwilusz1@jhu.edu; William Ball, bball@jhu.edu

Chesapeake Bay System Study Site
• Deep central channel with seasonal (summer) stratification.
• Large watershed to estuarine surface area ratio (~15).
• Increasing agricultural yields and development during the last 60 years.
• 30-years of monitoring data and >30-years of intense modeling effort in watershed and estuary; US EPA enforced TMDL activity since 2010.

Figure 1. The Chesapeake Bay watershed and major tributaries (left) and estuary (right).

1. Farmer Adaptations to Climate Change.
How is farmer crop choice changing with climate?
• Discrete choice modeling using climatic, environmental, and economic factors.
• Analyzing climate change influences for double cropping systems.
• Developing methods for “big data” econometric analysis.
• Allowing for farm structural change.

2. Watershed Processes Affecting the Phenology of Connectivity.
How are farmers altering timing of activities to manage risk?
• Crop yield modeling with varying sensitivities to weather shocks throughout growing season.
• Simulating alternative planting decisions (and subsequent fertilization timing).
• Combining timing and crop choice decisions to predict changes in nutrient availability to run off.

How do changes in the timing and location of watershed inputs affect estuary physical and biological responses, including the severity of hypoxia?
• Analyzing 30-year Bay monitoring dataset for chlorophyll, dissolved oxygen, and nutrients to understand shifts in the seasonal cycles.

Identify policy-relevant leading indicators of environmental harm.
• Finding combinations of human actions and biophysical system responses that generate economic harms.
• Identifying the type, timing and scale of nutrient reduction interventions that avoid adverse conditions, e.g.: 
  – Post-drought actions to capture unused nutrients
  – Payments for changes in tillage management contingent upon outside policies

Key science questions
How do changes in climate and land use affect the timing and magnitude of water, N, P and SS loads reaching the Bay?

Variable source areas
• Using TOPSWAT to simulate the influence of VSAs on inter- and intra-annual variability of nutrient transport.

Climate Change and Land Use (CC/LU) Scenarios
• Forcing scenarios with a common set of climate and land use scenarios representing plausible conditions up to 2100.
• Deriving climate scenarios from downscaled and bias-corrected CMIP global circulation models.
• Land use scenarios being made by partners using the Chesapeake Bay Land Change Model.

Close Integration with Bay Management Activities
• Working closely with Chesapeake Bay Program Office (USEPA, USGS, NOAA) in support of Chesapeake Bay Program partnerships.
• Helping improve the Chesapeake Bay Modeling System (toward 2017 and 2022 TMDL, USEPA deadlines).
• Running workshops and symposia in collaboration with the Chesapeake Research Consortium.

Educational Outreach
Hosting a school teacher to develop an educational module for the Teach Ocean Website. (www.teachoceanscience.net).

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