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Session 16: Future Scenarios for Agriculture and Environmental Outcomes in the Chesapeake Bay Watershed

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Co-developing future land use and management scenarios to explore resilience of agro-ecological systems under uncertainty

Scenarios are a useful tool for creating common understanding of socio-environmental issues, risk management options, and pathways to desirable futures. Researchers within the Thriving Ag project (https://thrivingag.org/) are involving diverse partners in developing future scenarios of how the Chesapeake Bay Watershed (CBW) might develop agricultural systems that sustain food production while supporting diverse ecosystem services and social goals. Diverse research methods were applied to first co-develop narrative scenarios of desirable futures through stakeholder engagement and then to convert those narratives into ranges of system drivers that are being modeled by research teams to measure socio-ecological outcome metrics to compare scenario performance. The narrative scenarios were business as usual, ecosystem services, anti-sprawl policies, enhanced local food, and plant-based meat. Choosing the scale and pattern of quantitative changes to embed within scenarios involved conducting horizon scanning, trend analysis, and other modeling. Some existing projections by Chesapeake Bay partners were used but many had to be extended to represent more distant changes to 2050 and 2100. Some changes that might not be well represented by current trends were explored such as an analysis that used downscaled climate projections to suggest shifts in agricultural production using analog areas that currently have the climate projected for the CBW and similar geophysical setting. This relatively straightforward analysis generated many questions about path-dependency of agricultural production by region and policy or social constraints to climate adaptation. This presentation will also explore the different uses for scenarios in a time of rapid and uncertain change to explore solutions that are robust to alternative futures.
Many researchers, in addition to the authors, have contributed to this work including: Darrell Bosch, Michael Gomez, Matt Ehrhart Caitlin Grady, Nate Hu, Marali Kalra, Jason Kaye, Paniz Mohammadpour, Nancy Nunn, Cibin Raj, Matt Royer, Asif Rasool, Wei Zhang, Zeya Zhang.

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Residents' Support for Varied Scenarios for Agricultural Systems in Urbanized Landscapes

Agriculture remains a significant land use activity within the Chesapeake Bay Watershed (CBW), playing a crucial role in the regional economy and food production. However, agriculture within the region is facing various challenges ranging from the loss of farmland to sprawling suburban development and nutrient pollution of various water bodies due to fertilizer runoff from farm fields. What the future of agriculture in CBW will look like is uncertain due to the potential loss of farmlands and regulations that are likely to be tightened. To help envision the desired futures for agricultural systems in urbanized landscapes over 25 years, we assess agricultural and non-agricultural residents' support for scenarios for alternative approaches to achieving long-term economic and environmental sustainability for agriculture in urbanized landscapes. The scenarios include business as usual – or maintaining current trends; 2) providing incentives (e.g., public funds) that help farmers engage in best management practices; 3) preserving farmland; 4) increasing farm profitability through enhanced local food efforts and strengthening rural and urban relationships and 5) encouraging a societal shift from consumption of meat to vegetable-based proteins. To do this we draw upon data collected from an online panel of 955 residents and a mail/online survey of 365 producers across the southern part of CBW (Maryland, Delaware, and Virginia) in 2021 and 2022, respectively. Preliminary descriptive results indicate that (77.49%) and (77.28%) of residents' mostly support and strongly support scenarios 4 and 3 respectively. Scenarios 2 and 3 were also mostly supported and strongly supported by producers as (84.70%) and (81.87%) indicated their support for these strategies. A chi-square result also suggests that residents' level of education, income, political identity, how close they live to a farm, their concerns about the loss of farmland, and their awareness about the loss of farmlands were related to their support of the most top-two supported scenarios. This result can help us understand the broader landscape of perceptions and help with state or regional planning efforts.

Kalra Marali, Raj Cibin

Impacts of cover cropping on soil and water ecosystem services in the Susquehanna River Basin

Cover cropping is a tried-and-true method for improving water quality, building soil fertility, and increasing the provisioning of other soil and water ecosystem services. Many of these benefits are unrealized in Pennsylvania, where cover cropping is currently practiced on only a fraction of cropland. Management practices such as harvesting cover crop biomass and sowing cover crops before cash crop termination could offer additional ecosystem services benefits. This study uses a Soil and Water Assessment Tool to investigate four possible changes to current cover cropping practices in the Susquehanna River Basin: planting grain vs. legume cover crop species; extending the cover crop season with earlier planting and later termination; harvesting cover crops vs. leaving biomass as soil cover; and increasing the percentage of agricultural area under cover crops. Results show water quality improvements, decreases in surface runoff, and decreases in soil erosion with increasing cover crop area, while extending the cover crop season leads to an increased "green manure" effect, where nutrients from cover crop biomass are mineralized and made available to cash crops. These findings show that cover cropping is a management tool with untapped potential for helping Pennsylvania progress toward its TMDL goals while providing additional benefits in water flow regulation, erosion regulation, and nutrient cycling ecosystem services.

Chenyang Hu, Darrell Bosch, Wei Zhang

Extensive vs. Intensive Margin Approach of N Load Reduction from Agriculture: Implications for Chesapeake Bay Watershed

Agricultural activity is the largest source of nitrogen (N) runoff to streams in Chesapeake Bay (2025 Watershed Implementation Plans (WIPS) - Chesapeake Progress, n.d.)). Federal and state governments have taken actions to protect and restore water quality, but progress is not satisfactory. Researchers have been evaluating cost effectiveness of choices to improve ecosystem services along extensive and intensive margins. The extensive margin refers to changes in cropland area while the intensive margin refers to changes in other production inputs. An intensive margin approach is Yield Reserve Program (Metcalfe et al., 2007), an innovative proposal made to reduce nutrient applications and nutrient pollution potential by compensating farmers to reduce their N applications below standard recommendations. An extensive margin approach is land retirement, such as the Conservation Reserve Program (Wu, 2000).

This study uses the Regional Environment and Agriculture Programming (REAP) model, which was developed by USDA's Economic Research Service to analyze the intersection of agriculture and the environment for policy applications. We examine the effects of a government budget-equivalent Yield Reserve Program and an expansion of land retirement program (CRP) on revenues, costs, output, and potential reductions in N loads from the U.S. agricultural sector. We simulate three scenarios of increasing subsidy payments of approximately $500 million, $750 million, and $1 billion to farmers to achieve N load reductions from all US croplands. The regional implications for Chesapeake Bay watershed are also analyzed.

References

2025 Watershed Implementation Plans (WIPs) - Chesapeake Progress. (n.d.). Chesapeake Progress. https://www.chesapeakeprogress.com/clean-water/watershed-implementation-plans

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Rashid Ansari

Enhanced Flood Adaptation and Nutrient Management: Integrated Modeling for Regional Sustainability

Increased Flood risks and nutrient contamination are major concerns in many watersheds with changing climate patterns and increased land development, especially in agricultural basins. Strategies aimed at flood management typically concentrate on direct water control but also support water quality improvement— a co-benefit that is frequently overlooked. To navigate the complex interplay between flood management and nutrient pollution effectively, our research introduces an integrative modeling framework to concurrently address these challenges. The framework merges the capabilities of the widely used ecohydrologic model, Soil Water Assessment Tool (SWAT), with the LISFLOOD-FP hydrodynamic model, augmented with precise spatial representations of crucial hydrological features and flood control infrastructures. This integrated approach provides an expansive outlook on watershed management, empowering more accurate 'what-if' scenario projections that are essential for informed decision-making and flood adaptation strategies. Our modeling framework highlights the symbiotic relationship between flood, sediment, and nutrient management and paves the way for advanced environmental planning and enhanced regional resilience.

Jesse Bash

Impact of decarbonization scenarios on atmospheric nitrogen deposition to the Chesapeake Bay

Combustion sources that emit carbon dioxide also co-emit reactive nitrogen species and other atmospheric pollutants. Thus, recent decarbonization targets at the national and state levels have the potential to reduce reactive nitrogen emissions and subsequent deposition. Atmospheric deposition of reactive nitrogen is one of the largest loadings of nitrogen to the Chesapeake Bay Watershed. Here we apply the Global Change Analysis Model with state-level resolution of the U.S. energy system (GCAM-USA) to project future emission scenarios that satisfy federal and state level decarbonization targets for 2035. The impact that these emissions changes have on atmospheric nitrogen deposition are evaluated using CMAQ v5.4. The Detailed Emissions Scaling, Isolation, and Diagnostic (DESID) module in the U.S. EPA's Community Multiscale Air Quality (CMAQ) model v5.4 is used to apply state, sector, and pollutant-specific scaling factors from GCAM-USA scenarios to the EPA's National Emissions Inventory. These sensitivities will be evaluated for nitrogen loading to the Chesapeake Bay Watershed using CMAQ's Surface Tiled Aerosol and Gaseous Exchange (STAGE) deposition option for detailed land use specific deposition estimates and to the tidal waters. CMAQ's Integrated Source Apportionment Model (ISAM) is used to characterize the reductions by emission sector, e.g. light-duty gasoline powered vehicles, electrical generation utilities, etc., and by oxidized and reduced forms of nitrogen.