Freshly caught crabs, Chesapeake Bay, USA
© Jason Houston

Chesapeake Bay Watershed
Foodscape

Restore natural habitats to enhance success of nutrient reductions

UNITED STATES

LOCATION: Mid-Atlantic, United States
AREA: 18 million hectares

SYNOPSIS

As its name indicates, the Chesapeake Bay Watershed foodscape spans terrestrial and marine environments and highlights the connections between the two. The Chesapeake foodscape helps frame the cause-and-effect relationship between upstream food producers and downstream consumers, but with a bit of a twist. In this foodscape, many downstream consumers are also food producers (seafood such as oysters and blue crabs) and their quality of life and their livelihoods are doubly threatened by excess nutrients flowing into the bay.

Looking at solutions to such a distributed problem from a foodscape perspective shows how new integrated approaches, including nature-based solutions such as oyster reef restoration, could significantly contribute to improving water quality by removing excess nutrients directly from the waters of the Chesapeake Bay and its tributaries.

CHESAPEAKE BAY

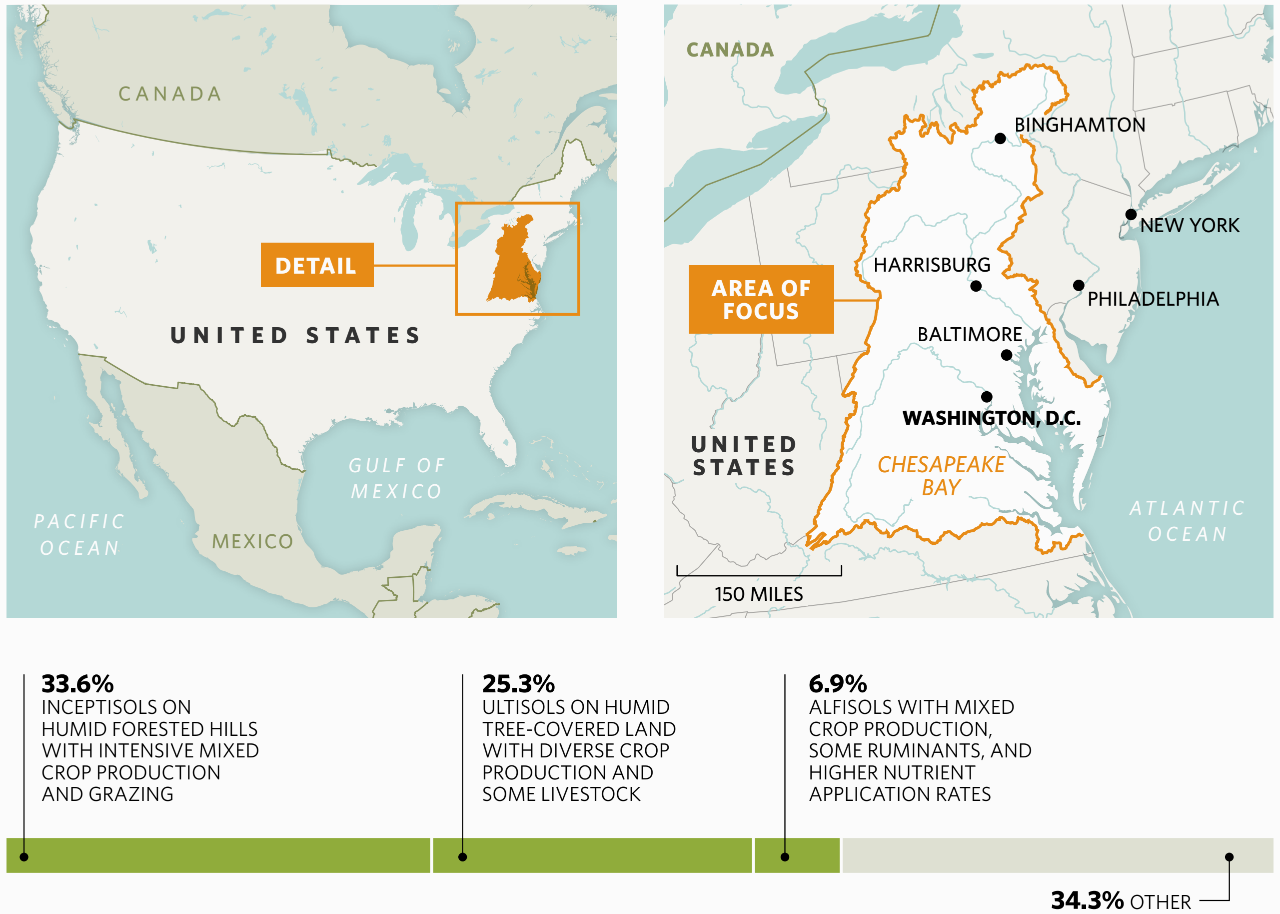

FIGURE 1. Map of Chesapeake Bay Watershed foodscape. The bars represent the most extensive foodscape classes within the foodscape. The color of bars indicates the intensity groups corresponding to those classes: mixed mosaic food cultivation (light green). The other category includes the classes that each made up <5% of the foodscape area.

Oysters are nature's water filter, and a single healthy adult can filter as much as 50 gallons of water a day. Still, as powerful as they are, restoring oyster reefs alone will not be enough for bay states to meet nutrient-reduction targets set by the federal government. Fortunately, the establishment of the Chesapeake Bay Watershed Agreement, a multi-state and multi-organizational partnership, created a unique framework for interstate action toward reaching those environmental goals. And the bay's health is improving.

Promising improvements in water quality to date are largely due to three factors: strong investment in science and the development of quantitative nutrient targets; several decades of action and investment, even before formal nutrient reduction targets were established; and political support and buy-in from the population of the watershed. Overlaying where enabling conditions and successful nutrient-reduction programs are in place across the foodscape could help decision makers pinpoint areas of maximum need and potential for meeting nutrient-reduction targets.

Ultimately, success in the Chesapeake will depend on a combination of regulations, public and private investment to support nature-based and other solutions, including environmental restoration, as well as the adoption of regenerative agriculture practices, and support from the broader supply chain to incentivize sustainable practices.

DESCRIPTION OF FOODSCAPE

The Chesapeake Bay Watershed foodscape is a complex system that provides a clear example of the need for multi-use planning and cooperation. Part of what makes the foodscape complex is its scale: it spans the states of Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia (FIGURE 1).

The area is home to more than 18 million people in some of the East Coast's most densely populated areas. In fact, only 20% of the watershed is made up of agricultural land. That agricultural land itself is varied, ranging from smallholder Amish dairies in Pennsylvania and New York to larger-scale poultry and feed-grain operations on the Delmarva Peninsula.

In Delaware and Maryland, more than three-quarters of agricultural land is under row crops, whereas only one-third of the Chesapeake's agricultural land in Virginia and New York is under row crops. Terrestrial food production revolves around the poultry industry, dairy, silage and feed production for the poultry and dairy industries, and a smaller amount of vegetable and fruit production and cow-calf operations for beef.

The Chesapeake Bay itself is an important food producing landscape. Perhaps best known for the blue crab, the bay has also been an important commercial fishery for striped bass, oysters, shad, and menhaden. This rich marine foodscape is characterized by the relationship among several species along the food chain.

Underwater grasses that grow in the shallower areas of the bay provide habitat for young crabs, menhaden, and shad as well as vulnerable molting blue crabs. These younger fish are important components in the food chain for larger taxa such as striped bass in deeper parts of the bay. Thus, impacts on shallower, coastal zones have cascading effects on the broader health of the bay. Coastal wetlands and oyster reefs are also crucial for wildlife through the provisioning of habitat and the ability to filter sediment and runoff.

CHALLENGES

Excess runoff of nutrients (both nitrogen and phosphorus) and sediment is the defining challenge of the Chesapeake Bay Watershed foodscape. Agriculture in the watershed is the greatest source of nitrogen. Despite making up only 20% of the area of the Chesapeake Bay Watershed, agriculture contributes more nitrogen to the bay than any other sector.

When nutrients and sediment enter the bay, they fertilize algae that block sunlight from reaching underwater grasses and create low-oxygen conditions harmful to marine life. Because of the interdependence of the broader bay ecosystem on coastal zones, the suppression of life in the littoral zone cascades to the broader bay. In the past, dams along the Chesapeake Bay's largest tributary, the Susquehanna River, captured some of the sediment entering the bay. Those dams are now full, making nutrient and sediment management upstream even more important to meet water quality goals in the bay.

A farm using optimal nutrient management practices, Cordova, Maryland, USA
© Isaac Shaw

Though agriculture is the greatest source of nutrients and sediments, the impacts of urban and suburban areas on water quality are also significant, and they are the only nutrient source in the bay that is increasing. In the past, the greatest reductions in nutrient loading to the watershed have come through management of wastewater treatment.

Cities such as Washington, D.C., established standards on clean water that comprised nearly two-thirds of the total nutrient reductions in the bay between the mid-1980s and 2018 (the other third came from the agriculture sector). Future urban expansion has the potential to affect the foodscape in direct and indirect ways.

Directly, the expansion of impervious surfaces associated with urbanization is increasing runoff quantity, which increases nutrient losses. Also, nitrogen deposition from fossil fuel combustion – such as cars – is an important source of nitrogen throughout the watershed; these nutrients run off into water from all land use types. Indirectly, urbanization is increasing the value of land, which increases the likelihood of conversion of agricultural land to suburban and exurban development. Although the net effect of this conversion on nutrient balance is uncertain, it poses a threat to the foodscape in terms of maintaining a viable farming economy that also provides environmental benefits.

Although nutrient loading is the major driver of changes in the Chesapeake Bay, fisheries and marine life have also been strongly affected by habitat loss. Coastal wetlands in particular have been threatened by shoreline development, invasive species, and sea-level rise. The loss of these wetlands, similar to the loss of underwater grasses due to hypoxia, threatens the

Oyster farmer in the Chesapeake Bay, White Stone, Virginia, USA © Robert Clark

broader health of the bay. Throughout the watershed, 600,000 hectares of nontidal wetlands have been lost. These noncoastal wetlands are crucial to coastal functioning because they filter water running off the land into bay tributaries.

Oysters, an iconic bivalve in the Chesapeake, have also experienced major declines, and today they are at a tiny fraction of their historical population due to overfishing, disease, and poor water quality. Oysters and their reefs provide essential ecosystem services such as water filtration and critical habitat for other species; their reductions have meant the loss of these services in many parts of the bay. Successful restoration of large-scale reefs over the past decade and the emergence of aquaculture as a sustainable fishery provide hope for the future for this keystone species.

Blue crabs also represent an iconic species in the Chesapeake and are essential to the region's economy and ecology. The population of blue crabs in the Chesapeake for the past two decades has been below average, and management actions have attempted to address areas of vulnerability, including harvest pressure, pollution, and habitat loss.

Overfishing has also led to losses of key species and declines in the viability of fishing livelihoods. Striped bass, one of the most important species commercially and recreationally, declined sharply in the 1970s and underwent strong regulation until it was considered recovered in the mid-1990s. Though the population is considered recovered, striped bass are an apex predator in the bay and therefore are susceptible to ongoing fishing pressure and changes throughout the food chain. A less rosy story is that of shad, which was both an important fishery and an important source of food for wildlife. The shad population has been significantly affected by dams and associated habitat loss as well as overfishing.

BENEFITS AND VALUE OF NATURE-BASED SOLUTIONS IN THE CHESAPEAKE BAY WATERSHED FOODSCAPE

Although regional activities, including voluntary nutrient reduction targets, had existed here for years, the 2014 Chesapeake Bay Watershed Agreement, a multi-stakeholder collaborative partnership, was created after the U.S. Environmental Protection Agency set regulatory nutrient-reduction goals for the bay in 2010. The agreement is a holistic watershed management strategy that incorporates goals for fisheries, habitat, water quality, climate resiliency, and community engagement.

While significant progress has been made over the past 30 years, the region is not currently on track to meet 2025 nutrient reduction targets, largely due to funding constraints in key states and sectors. Changing farm management practices, for example, can offer potential opportunities for using nature to help remove nutrients at the source. Livestock operations could introduce silvopasture paddocks in pasture areas, expand cover crops to cereal fields, and add edge-of-field vegetation strips to filter nutrients before they reach nearby streams and rivers.

Such practices could provide a revenue increase of $49,000 per year for a farm of about 100 ha, or about a 50% increase in net profit (Supplementary Material,[1] Archetype A). Combining cover cropped cereals with nontidal wetland restoration and perennials could also increase net profit by about 15% (Supplementary Material,[1] Archetype B).

Incorporating edge-of-field habitats, developing nature-based stormwater management systems, and creating a manure market for poultry farms could increase net revenue by 1%, which is the equivalent of about $13,000 per year for a 4 ha farm (Supplementary Material,[1] Chesapeake – Archetype C).

Finally, combining the nature-based solutions of silvopasture, cover crops, and edge-of-field restoration across the entire Chesapeake Bay Watershed foodscape could increase net farm benefits by $206 million per year and provide $29 million per year in public benefits (FIGURE 2).

The increased adoption of both in-field and edge-of-field practices is essential to achieving nutrient reductions in the Chesapeake Bay watershed. Cover crop use has increased from nearly zero ha in the mid-1980s to close to 400,000 ha at present. Nutrient management and many edge-of-field practices, however, remain low. On the agricultural side, working with farmers' trusted advisors as well as traditional technical assistance providers, such as university extension and soil conservation districts, to ensure that farmers have access to information and technical support will be critical to adoption and continued use of new practices.

Planning at the foodscape level, may illuminate ways the broader supply chain could create incentives by sourcing commodities produced with practices that minimize nutrient losses and provide other ecosystem services, or by investing in farms within their supply chain to implement conservation practices. Agribusiness, such as fertilizer and seed retailers, provides important technical services to farms and could be an important contributor to increased adoption of nature-based and other nutrient-reduction practices.

Because water quality in the bay is so dependent on the health of its coastal habitats, restoration, the original nature-based solution, also has a critical role to play in reducing nutrients, erosion, and sedimentation. Across the Chesapeake Bay Watershed foodscape, there are immediate opportunities for restoring both tidal and nontidal wetlands under the Chesapeake Bay Watershed Agreement. RRight now, the agreement calls for reestablishing and restoring 55,000 ha of wetlands and 75,000 ha of underwater grasses.

Habitat restoration also extends to restoration of marine habitat. An emerging body of science has demonstrated the clear nutrient reduction benefits associated with oyster reef restoration.[34] Restoration of oyster reefs in the Chesapeake over the past decade has been the largest shellfish reef restoration on the planet, and this has delivered ecological and economic benefits through additional nutrient removal and enhanced production of fish and crabs that depend on these reefs for at least part of their life cycles.

Under the terms of the Watershed Agreement, oyster reef restoration will be included as an approved strategy for achieving nutrient reduction targets within the bay. This type of approach also demonstrates a nature-based solution that creates environmental benefits while also supporting a growing aquaculture industry within the foodscape.

AGGREGATION OF ARCHETYPES TO THE FOODSCAPE LEVEL

FIGURE 2. Summary of economic analysis of nature-based solutions in the Chesapeake Bay Watershed foodscape. **Disaggregated costs & benefits toward $114 million net benefits from several farm archetypes:** Starting with baseline current farm profits (grey, far left), the diagram shows proposed future on farm benefits and costs (dark blue), totaling farm net benefits of $US 206 million (light blue, middle). Additional public off farm benefits and costs (light green) added to and subtracted from farm net benefits equals $US 114 million total net benefits (light blue, far right). Other impacts are qualitative assessments of other ecosystem service benefits, except for soil erosion and nutrient runoff, which were quantified. The change in area of nature-based solutions associated with the farm archetypes is represented in the boxes. See Supplementary Material for a description of methods.[1]

[34] Kellogg, M., Cornwell, J., Owens, M. & Paynter, K. Denitrification and nutrient assimilation on a restored oyster reef. *Mar. Ecol. Prog. Ser.* **480**, 1–19 (2013).

This is a case study excerpted from the report *Foodscapes: Toward Food System Transition*. Please access the entire global report at nature.org/foodscapes.

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