Resilience indicators support valuation of estuarine ecosystem restoration under climate change

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Abstract

Economic valuation of ecological restoration most often encompasses only the most tangible ecosystem service benefits, thereby omitting many difficult-to-measure benefits, including those derived from enhanced reliability of ecosystem services. Because climate change is likely to impose novel ecosystem stressors, a typical approach to valuing benefits may fail to capture the contribution of ecosystem resilience to sustaining long-term benefits. Unfortunately, we generally lack predictive probabilistic models that would enable measurement and valuation of resilience. Therefore, alternative measures are needed to complement monetary values and broaden understanding of restoration benefits. We use a case study of Chesapeake Bay restoration (total maximum daily load) to show that ecosystem service benefits that are typically monetized leave critical information gaps. To address these gaps, we review evidence for ecosystem services that can be quantified or described, including changes in harmful algal bloom risks. We further propose two integrative indicators of estuarine resilience—the extent of submerged aquatic vegetation and spatial distribution of fish. Submerged aquatic vegetation extent is indicative of qualities of ecosystems that promote positive feedbacks to water quality. Broadly distributed fish populations reduce risk by promoting diverse responses to spatially heterogeneous stresses. Our synthesis and new analyses for the Chesapeake Bay suggest that resilience metrics improve understanding of restoration benefits by demonstrating how nutrient and sediment load reductions will alleviate multiple sources of stress, thereby enhancing the system’s capacity to absorb or adapt to extreme events or novel stresses.

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