Modeling the presence and spread of aquatic invasive species using an integrated-network model

Several challenges arise when developing species distribution models, particularly for invasives. Most species distribution models focus on environmental conditions (e.g., temperature, pH) and species-level tolerances. Yet, the distribution of invasive species depends heavily on colonization dynamics and vectors of spread, such as boater traffic in aquatic systems. Other challenges include imperfect detection and spatially varying sampling biases associated with areas that are easy to access or close to human population centers. We develop a network model that addresses these challenges by integrating multiple data sets to inform parameters that quantify propagule pressure and establishment probabilities while also adjusting for imperfect detection and spatially-varying-sampling biases. We fit the model to 11 years of Eurasian watermilfoil (Myriophyllum spicatum) data collected using both opportunistic and systematic surveys in Minnesota between 2007 and 2018. We show how the model can be used to estimate prevalence rates, identify lakes likely to have invasives that are not yet detected, and to forecast transition probabilities. Lastly, we discuss how a similar model structure could be adapted to other species distribution models, allowing researchers to quantify dynamics near the edge of current species ranges.