“Integral Projection Models: Scalability and Multivariate Extensions”

Souparno Ghosh

Department of Mathematics and Statistics
Texas Tech University

Abstract:

Historically, matrix projection models (MPMs) have been employed to study population dynamics with regard to size, age, or structure. To work with continuous traits, integral projection models (IPMs) have been proposed. Currently, IPMs are handled first with a fitting stage, then with a projection stage. Model fitting has, so far, been done only with individual-level transition data to estimate the demographic functions (survival, growth, fecundity) that comprise the kernel of the IPM specification. The estimated kernel is then iterated from an initial trait distribution to obtain what is interpreted as steady state population behavior. Such projection results in inference that does not align with observed temporal distributions. This might be expected; a model for population level projection should be fitted with population level transitions.

Ghosh et al. (2012) offer a remedy by viewing the observed size distribution at a given time as a point pattern over a bounded interval, driven by an operating intensity. They propose a three-stage hierarchical model. At the deepest level, demography is driven by an unknown deterministic IPM. The operating intensities are allowed to vary around this deterministic specification. Further uncertainty arises in the realization of the point pattern given the operating intensities. Such dynamic modeling, optimized by fitting data observed over time, is better suited to projection.

Here, we address scaling of population IPM modeling, with the objective of moving from projection at plot level to projection at the scale of the eastern U.S. Such scaling is needed to capture climate effects, which operate at a broader geographic scale, and therefore, anticipated demographic response to climate change at larger scales. We work with the Forest Inventory Analysis (FIA) dataset, the only dataset currently available to enable us to attempt such scaling. We
illustrate our methodology with a simulation as well as with an analysis a tree species. We further discuss the possibility of extending the population level IPM to handle multiple traits.