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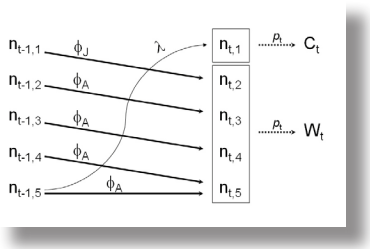
Patuxent Wildlife Research Center

Hierarchical Models for Estimation of Population Parameters



The Challenge: Much of wildlife research consists of the description of variation in data. Some of the variation results from spatial and temporal change in populations, while some results from biologically irrelevant sampling variation induced by the process of data collection. Distinguishing relevant from irrelevant variation is the first task of statistical analysis, but the job does not end there. Even if the true values of population parameters were known, without the contamination of sampling variation, the investigation of population processes would require an evaluation of pattern among parameters.

The Science: Hierarchical models treat unknown population parameters as random variables, with probability distributions governed by hyperparameters. Knowledge of these stochastic relationships is fundamental to the understanding of demographic processes.

The analysis of hierarchical models has been facilitated by recent advances in Bayesian analysis, and computationally intensive techniques such as Markov Chain Monte Carlo. This study has been undertaken with the goal of promoting and developing hierarchical modeling solutions for demographic analysis.

For example, the demographic buffering hypothesis states that natural selection favors low temporal variability in population sensitive demographic parameters. An evaluation of this hypothesis using a 30-year mark-recapture data set for Weddell seals (*Leptonychotes weddellii*) required estimation not only of survival and recruitment rates, but also estimation of temporal variation and covariation among the rates.

The Future: Model selection and model criticism are important problems in statistical inference, and have been widely studied for simple models. These problems are more difficult for hierarchical models. Bayesian p-values and model weighting are tools for these tasks, but there is a need for further development of methods.

A study in progress applies hierarchical models in modeling life history data for Trumpeter swans (*Cygnus buccinators*) based on annual counts of cygnets (gray) and older birds (white). An age structured population model is a latent feature of these data, and can be uncovered using hierarchical models. Ongoing work will address selection among alternative models of the age structuring, and temporal change in demographic parameters.

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