Intermediate MARK Workshop

Background + Format

How many are there? What is the survival probability? What is recruitment probability? What is the extent and pattern of movement? All of these questions are fundamental to ecological analysis and management, whether it be question-driven 'conceptual research', or practical application 'in the real world'. The intermediate workshop will explore the conceptual and quantitative methods for addressing these questions, using **Program MARK**. The workshop will focus on the analysis of data from marked individuals, exploring the theory and application of a variety of statistical techniques in the study of population dynamics. A mixture of lectures and laboratory exercises will be provided. Participants will learn the basics of parameter estimation with likelihood theory, model selection with Akaike's Information Criterion (AIC), and the binomial and multinomial distributions as fundamental conceptual building blocks. We will then introduce the use of modern methods in capture-recapture and recovery analysis to estimate survival probability, abundance (and density), immigration, emigration, and population growth and sensitivity analysis using open and closed population models. The Cormack-Jolly-Seber (CJS) mark-recapture, band (tag or ring) recovery models (both Brownie and Seber), known fate, and closed captures models will be covered in detail. More advanced models combining both open and closed population models (including occupancy modelling) will be described so that participants will understand the benefits of these models, but those models would not be covered extensively (although which models are covered beyond 'core, fundamental' models is somewhat at the discretion of participants).

The clientele for this intermediate workshop are (typically) biologists with some prior experience in the analysis of data from marked animals. The content is aimed at providing the participants with a solid background in the philosophy, theory, and analysis of data from marked animals. This is not a workshop for complete beginners to this subject.

Format of the workshop will be a combination of lectures and computer lab exercises, proceeding over (typically) 4-5 days. The workshop would start on the morning of the first day, and (typically) end at noon on the final day (with some time during the final afternoon to address specific user questions). Evening sessions would be provided by the instructor for any individual who would like to take advantage of the opportunity to pursue concepts and techniques further, beyond what is covered during the daily sessions. Attendees are encouraged to bring their own data for analysis to the workshop, but should recognize that a thorough analysis will not be

completed at the workshop. Given the amount of material to be covered, attendees likely would not be able to begin analysis of their own data until Thursday afternoon.

The following 'schedule' is a (very) broad – and somewhat 'fluid' - overview of the subjects typically covered, in what sequence, and when (day, time). Depending on how quickly we move through things (or not), and the interests of participants, the timings and subjects covered might change somewhat (especially on day 4-5), but the following presents the typical coverage general sequencing and subjects covered in an intermediate workshop.

Day	Time	Subject	Example data set
Day 1	AM	introduction	
		estimation background (ML)	
		model selection + multi-model inference	
		overview of program MARK	`ed_males.inp`
		PIMs + basic parameterization concepts	`ed_males.inp`
	PM	handling multiple groups	`AA.inp`
		age (TSM) models	`age.inp, age_ya.inp`
Day 2	AM	linear models	`ed_male.inp, AA.inp`
	PM	individual covariates	`indcov1.inp`
		multi-state models	`deer + ms_csj.inp`
		clam kill experiment	`clams.inp`
Day 3	AM	closed population abundance estimation	`simple_closed1.inp`
	PM	open population models: JS/Pradel	`moth-example.inp`
		Pollock's 'robust design'	`rd_simple.inp`
Day 4	AM	occupancy models	`TBA`
	PM	dead recovery models	`brownadt + brownie.inp`
		joint live encounter-dead recovery models	`ld1.inp`
Day 5	AM	simulations in MARK	
	PM	open	

About the Instructor

Evan G. Cooch is a professor of applied and theoretical ecology at Cornell University in Ithaca, New York, USA. His primary applied research is focused on a series of themes; all focused on the general question of making optimal resource management decisions under uncertainty. Each of the themes addresses one particular area of uncertainty: (i) structural (research on modeling population dynamics), (ii) observation (research on estimation of model parameters), (iii) controllability (estimation on harvest management of structured populations, from both technical and human dimensions perspective), and (iv) optimal decision theory for state-dependent management strategies. His conceptual research is directed at 2 primary questions: (i) assessment of methods for direct and indirect assessment of spatial structuring and coupling in populations, and (ii) analysis of evidence for phenotypic life-history trade-offs, using advanced statistical methodologies.

An overarching theme for much of his work is based on the premise that robust testing of evolutionary and ecological theory is ultimately limited by our ability to robustly estimate various parameters using empirical data, and deriving 'reasonable' models for complex system. I am involved in a number of areas of research on areas of mark-recapture estimation, matrix modelling, and some newer areas of the application of Bayesian inference to estimate 'difficult' parameters.

He is co-author along with Gary White (developer of MARK) of the 1100+ book '*Program MARK – A Gentle Introduction*'. He has taught many workshops using MARK, and still believes that an 1100+ page book can be regarded as a 'gentle introduction'.