ECOLOGICAL DYNAMICS OF POPULATIONS, COMMUNITIES AND DISEASE

OTTAR N. BJØRNSTAD, Assistant professor Entomology and Biology, Adjunct assistant professor Statistics

515 ASI Bldg (814) 863 2983 onb1@psu.edu

Ph.D., University of Oslo, Norway; Postdoctoral appointment, National Center for Ecological Analysis and Synthesis, UC Santa Barbara.

'Why do rodents exhibit regular cycles in abundance, while marine fish exhibit erratic patterns of variation?'

'How does predation of lynx on hare or parasitism of wasps on moth caterpillars affect dynamics of prey/hosts?'

'Why do measles undergo regular 2-year cycles in large cities and erratic unpredictable outbreaks in small communities?'

'Why are the outbreaks of lemmings synchronized across vast geographic regions, and what are the dynamical consequences of this?'

The importance of research on the natural and human influenced variability in abundance of animals is ever mounting. We increasingly recognize that human activities – in diverse forms such as harvesting, habitat destruction/modification and climate change – impose spatiotemporally varying challenges on populations and communities. Yet our understanding of how climatic variability and altered habitat heterogeneity translates into altered patterns of abundance is rudimentary. What has recently been coined the *new synthesis* is the effort to acknowledge that population fluctuations arise from the combined influences of environmental stochasticity, direct or indirect anthropogenic forcing, nonlinear dynamics, and their interaction.

The goal of my research program is to develop the theory for spatiotemporal fluctuations in the abundance of animals to the level where it can be used to predict outbreaks of disease or pest species and catastrophic declines of endangered species or species of economic importance. I seek general theories about the ecological factors that shape spatial and temporal variability in abundance by addressing specific questions pertaining to specific systems (such as the Q's above): To understand any system we need to understand its idiosyncrasies, to understand broad patterns we need to understand its generalities. I therefore see it as the ultimate challenge to theory to both accommodate and transgress the details of natural history.

My work has five interrelated themes:

(1) Population dynamics – how do the interactions between individuals and between individuals and the environment determine fluctuations in abundance?
(2) Interactions between species – how do competition, predation and parasitism affect dynamics?
(3) Spatial dynamics – what causes regional synchrony or asynchrony in fluctuations, and how does spatial patterns feed back on temporal dynamics?
(4) Ecology of infectious disease – how do host and pathogen characteristics affect incidence of disease?
Partly as an integral part of (1-4) and partly as a separate research area, I am also interested in the foundations of confronting theory with data. My fifth theme is
(5) Ecological statistics – how can we test the theories about spatiotemporal variation using abundance data?

CURRENT PROJECTS:

POPULATION DYNAMICS: CYCLES, CANNIBALISM AND ENVIRONMENTAL VARIABILITY In single species systems as diverse as fish and insects, interactions between individuals can give rise to population cycles. One project with collaborators at the University of Liverpool (UK) studies the spectacular cycles that arise from cannibalism in the Indian meal moth. Another project studies the fluctuations in abundance of Atlantic cod using a combination of nonlinear and stochastic models.

INTERACTIONS BETWEEN SPECIES: PREDATORS, PARASITES AND DELAYED REGULATION Predator-prey cycles arise because predation induces delays in regulation. One project, with collaborators in Canada and Norway, centers on cycles and lagged regulation in the Snowshoe hare and the Norwegian lemming. Since experimentation on these systems often require prohibitively large-scale, long-term manipulations, We use a protocol of comparative biogeography across areas with different predator fauna.

SPATIAL DYNAMICS: TRAVELLING WAVES AND SYNCHRONOUS OUTBREAKS Fluctuating populations – whether vertebrate or insect – are often synchronized across vast regions. I have developed statistical methods to analyze spatiotemporal dynamics. Current projects with collaborators in Cambridge (UK), the Center for Disease Control (Atlanta, GA), and the Forest Service in West Virginia are centered on the spatiotemporal dynamics of measles in school children, rabies in raccoons, and outbreaking forest pests in boreal forests.

ECOLOGY OF INFECTIOUS DISEASE: CYCLES, OUTBREAKS AND INTERVENTION I am currently involved in several collaborative efforts to answers questions about outbreaks and persistence of disease: (A) Outbreaks and cycles of measles. (B) The dramatic expansion of rabies in raccoons in east coast US. (C) Delays in the regulation of insect abundance by virus. (D) How can we optimize vaccination and veterinarian interventions to minimize ecological and economic costs.

SELECTED PUBLICATIONS:

Bjørnstad, O.N., Sait, S.M., Stenseth, N.C., Thompson, D.J. & Begon, M. 2001. Coupling and the impact of specialised enemies on the dimensionality of prey dynamics. Nature 401: 1001-1006.

Bjørnstad, O.N., Finkenstädt, B. & Grenfell, B.T. 2001. Endemic and epidemic dynamics of measles: estimating epidemiological scaling with a time series SIR model, in press.

Bjørnstad, O.N. 2000. Cycles and synchrony: two historical 'experiments' and one experience. Journal of Animal Ecology 69: 869-873.

Bjørnstad, O.N. and Bolker, B. 2000. Canonical functions for dispersal-induced synchrony. Proceedings of Royal Society London B 267: 1787-1794.

Bjørnstad, O. N., Ims, R. A. and Lambin, X. 1999. Spatial population dynamics: Causes and consequences of spatial synchrony in density fluctuations. Trends in Ecology and Evolution 14:427-431.

Bjørnstad, O. N., Fromentin, J.-M., Stenseth, N. C. and Gjøsæter, J. 1999. Cycles and trends in cod population. Proceedings of the National Academy of Science USA 96:5066-5071.

Bjørnstad, O.N., Stenseth, N. C. and Saitoh,T. 1999. Synchrony and scaling in dynamics of voles and mice in northern Japan. Ecology 80:622-637.