Lecture 9. Role of immigration and emigration in populations.

Reading:

Sinclair, A. R. E. 1992. Do large mammals disperse like small mammals? Pages 229-242 *in* Stenseth, N. C., and W. Z. Lidicker, Jr. Eds. Animal dispersal small mammals as a model. Chapman and Hall, New York, New York, USA. 365 pp.

Optional:

Greenwood, P. J. 1983. Chapter 7. Mating systems and the evolutionary consequences of dispersal. Pages 116-131 *in* I. R. Swingland and P. J. Greenwood, eds. The ecology of animal movement. Clarendon Press, Oxford, England.

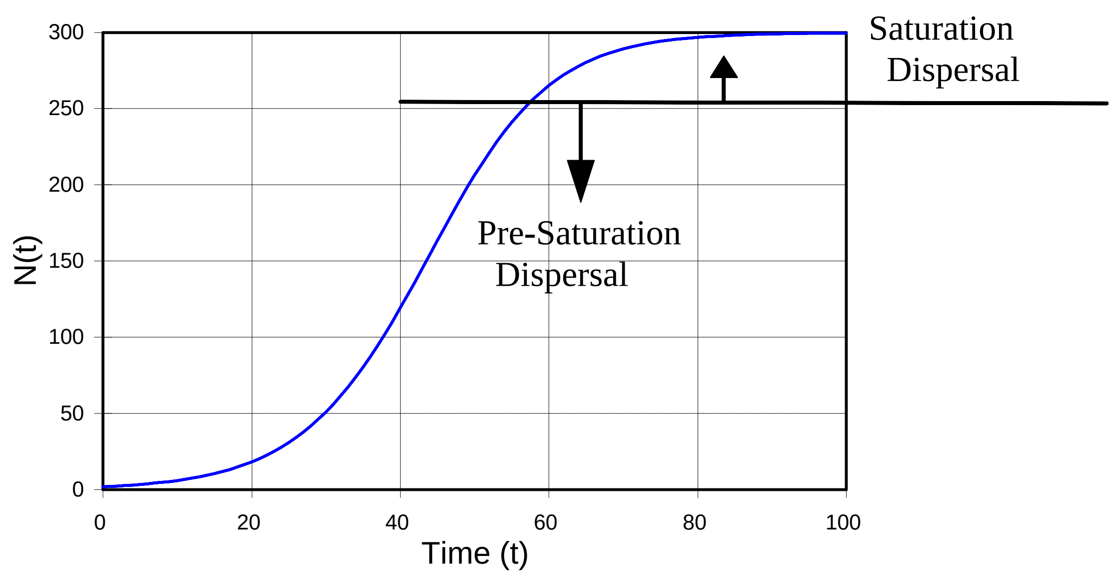
Stenseth, N. C. 1983. Chapter 5. Causes and consequences of dispersal in small mammals. Pages 63-101 *in* I. R. Swingland and P. J. Greenwood, eds. The ecology of animal movement. Clarendon Press, Oxford, England.

Dispersal -- “waif of population ecology” (Ricklefs 1990:373).

- Important, but difficult to measure. Dispersal is defined as the one-way permanent movement away from an established home range or natal area. In contrast, migration is the two-way movement between 2 areas. Philopatry is the fidelity or tenacity to an area or home range. Immigration can be thought of as dispersing animals that are leaving the area of interest, whereas emigration is the arrival of dispersing animals onto the area of interest.

Two types of dispersal (Lidicker 1975)

- Saturation dispersal, population crowded with respect to resources and aggressive individuals force others to leave.
- Presaturation dispersal, individuals with an innate predisposition to wander and leave. Dispersers leave their current place of residency before the patch's carrying capacity is reached.



Proximate causes of dispersal: competition for mates, avoidance of inbreeding (Bollinger et al. 1993), and competition for resources. Boolinger et al. (1993) found that meadow voles (*Microtus pennsylvanicus*) released into experimental grassland plots with siblings were more likely to disperse from these plots than were voles released into similar plots with nonsiblings. Furthermore, voles that dispersed from sibling groups did so sooner than dispersing voles from nonsibling groups.

Dispersal, how the mechanism evolved (see Emlen 1984, Chapter 13)

- Evolve a genotype that leaves an area where population is close to carrying capacity.
- This genotype would be deleterious at low densities, but beneficial at high densities (assuming areas away where fitness is increased)

Role in population regulation

- Keeps population from getting too high in one area
  - Evidence for population regulation provided by "fence effect" (Krebs 1992)
- Buffers population over several subpopulations
- Maintains genetic structure

Maximum dispersal takes place at MSY when there are the most juveniles available to disperse, at least according to common perceptions. However, this perception has not held up with experimental work. Andreassen and Ims (2001), in an experimental study with 12 enclosed, patchy populations, found that dispersal in root voles (*Microtus oeconomus*) was strongly density-dependent, and most so for subadult animals. However, high-density patches had low emigration rates. Root voles immigrated onto patches with a smaller number of individuals, especially of their own sex and reproductive state, than were present in the patch they left. Most shifts between patches took place from patches with relatively low density to patches with even lower density. Small patches had higher spatiotemporal variability in density, and demographic composition than large patches, and this probably caused most of the demographic turnover in small patches. In particular, emigration was the main demographic parameter behind declining numbers and patch extinction in small patches with few individuals. The kind of density-dependent emigration-immigration dynamics found by Andreassen and Ims (2001) does not match the common perception that dispersal works primarily to reduce extinction probabilities through rescue effects. In particular, the impact of emigration as a factor that may increase the extinction probability of small, isolated patches with few individuals is an important aspect of metapopulations.

Dispersers should be either young animals which have not yet attained maximal reproductive value (and which have not yet established a breeding site), or much older individuals whose prospects for future reproductive output is low (but still greater than zero) (Morris 1982). Examples of older individuals leaving are male lions from pride, or 10+ year old African buffalo males leave the breeding herds (Sinclair 1992).

Applications of dispersal theory in applied ecology (Hansson 1992). Generally immigration is more pertinent than emigration.

- Pest control -- removal of pest and time to re-colonization
- Pest outbreaks (jack rabbits, house mice)
- Settling in human habitations (annual fall mouse trapping episodes)
- Disease transmission, both within the species and to other species, e.g., livestock, humans.
- Re-colonization of areas with extinct populations (Yellowstone wolf -- is it necessary to transplant individuals)

Dispersal distances -- how to measure? (Porter and Dooley 1993).

Most studies get a biased view of dispersal distances because of distance-weighted sampling procedures. Radios provide the best method for estimating dispersal distances, but even new technology can be flawed if the animals move far enough. Dispersal distances are important in metapopulation models because distance (along with frequency) determines time to re-colonization of a vacant patch and gene flow frequencies. Good example of a study with radios to measure dispersal is Larsen and Boutin (1994) on 250 red squirrels (*Tamiasciurus hudsonicus*) in Alberta, Canada. Foray distance was not related to age or size of the offspring. Offspring that settled relatively farther away from their natal territory were more likely to obtain larger territories, with traditional hoarding and overwintering sites (middens). These offspring also had higher overwinter survival, suggesting that the costs of making forays off the natal territory may be balanced by the advantages of locating a superior territory.

Modeling dispersal and population dynamics -- Hastings (1993). Dispersal stabilizes chaotic discrete logistic models.

> "A study of one of the simplest systems incorporating both dispersal and local dynamics, coupling two discrete time logistic equations, demonstrates several surprising features. Passive dispersal can cause chaotic dynamics to be replaced by simple periodic dynamics. Thus passive movement can be stabilizing, even in a deterministic model without underlying spatial variation in the dynamics. The boundary between initial conditions leading to qualitatively different dynamics can be a fractal, so it is essentially impossible to specify the asymptotic behavior in terms of the initial conditions. In accord with several recent studies of arthropods and earlier theoretical work, density dependence may only be detectable at a small enough spatial scale, so efforts to uncover density dependence must include investigations of movement."

Again, a superficially simple model suggests a hypothesis about real populations that will be difficult to test.

Literature Cited

Andreassen, H. P., and R. A. Ims. 2001. Dispersal in patchy vole populations: role of patch configuration, density dependence, and demography. Ecology 82:2911-2926.

Bollinger, E. K., S. J. Harper, and G. W. Barrett. 1993. Inbreeding avoidance increases dispersal movements of the meadow vole. Ecology 74:1153-1156.

Hansson, L. 1992. Small mammal dispersal in pest management and conservation. Pages 181-198 *in* Stenseth, N. C. and W. Z. Lidicker, Jr. Animal dispersal small mammals as a model. Chapman and Hall, New York, New York, USA.

Hastings, A. 1993. Complex interactions between dispersal and dynamics: lessons from coupled logistic equations. Ecology 74:1362-1372.

Krebs, C. J. 1992. The role of dispersal in cyclic rodent populations. Pages 160-175 *in* Stenseth, N. C. and W. Z. Lidicker, Jr. Animal dispersal small mammals as a model. Chapman and Hall, New York, New York, USA.

Larsen, K. W. and S. Boutin. 1994. Movements, survival, and settlement of red squirrel

(*Tamiasciurus hudsonicus*) offspring. Ecology 75:214-223.

Lidicker, W. Z. 1975. The role of dispersal in the demography of small mammals. Pages 103-128 *in* F. B. Golley, K. Petrusewicz, and L. Ryszkowski (eds.). Small Mammals: Their Productivity and Population Dynamics. Cambridge University Press, Cambridge, United Kingdom.

Morris, D. W. 1982. Age-specific dispersal strategies in iteroparous species: who leaves when? Evolutionary Theory 6:53-65.

Porter, J. H. and J. L. Dooley, Jr. 1993. Animal dispersal patterns: a reassessment of simple mathematical models. Ecology 74:2436-2443.

Ricklefs, R. E. 1990. Ecology. 3rd Edition. Freeman, New York, New York, USA. 896 pp.

Sinclair, A. R. E. 1992. Do large mammals disperse like small mammals? Pages 229-242 *in* Stenseth, N. C. and W. Z. Lidicker, Jr. Animal dispersal small mammals as a model. Chapman and Hall, New York, New York, USA.