Schreiber Exam

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(a) A patch is a sink under the Pulliam definition if it is a net importer of individuals, $I_i > E_i$. It is sometimes useful to think of sinks instead as patches in which persistence is possible, but we will stick to Pulliam's definition.

(b) Sinks are ecologically important for a variety of reasons. One important reason comes from temporal heterogeneity, where a sink today may be a source tomorrow.

Under the Pulliam definition, a sink can still have a positive growth rate, and be a net importer of individuals. We might imagine newly colonized or restored habitat to draw in more individuals than are leaving it, in which case immigration into this sink would be advantageous. Since we assume all patches must exhibit regulation (negative density dependence at high densities) this would not be an equilibrium in a temporally homogeneous world. If patches are being annihilated by disaster and regularly recolonized, as in the Levins patch model (and many others), then this situation would occur regularly, and dispersal into these net importing sinks would be evolutionarily advantageous.

Dispersal into a sink habitat will be an ESS whenever the population can achieve a greater growth rate than those that don't. If individuals moving to a Pulliam sink can achieve greater fitness than they would get if they stayed (even if that fitness is less than 1), than some dispersal to sinks will be favored.

(c) Populations B and C both exhibit balanced dispersal, since their immigration rates are equal to their emigration rates.

3

(a)

Negative density dependence means that the per capita growth rate $R(N)$ decreases with increasing population density, while positive density dependence means the per capita growth rate increases with increasing population density. Positive density dependence is most likely to occur at very low population densities, where it is known as an Alee effect. At very low densities, increasing density can have a synergestic effect, such as helping individuals find mates, or allowing them to form packs or herds of an appropriate size to experience decreased predation. Meanwhile, negative density dependence is most often seen at much higher population densities, and is usually thought to be the result of increased competition for resources among individuals, though can also result from increased disease, etc. Models of negative density dependence are quite common, such as the logistic, Beverton-Holt, and Ricker forms. Positive density dependence is less often incorperated in models, though it can easily be done, for instance, by a logistic-like equation with a positive quadratic term. It is possible to combine the two form of density dependence, usually allowing the positive one to dominate at low densities and the negative to dominate at high densities.

(b) Pollard describes a permutation test method for testing for density dependence. Consider a time series abundance data set, and consider (many) permutations of the time ordering of the series. Ask what is the probability of getting that particular ordering by chance. This lets you distinguish between a time series produced by drawing independent random numbers, where any ordering is equally probable, from a time series exhibiting density dependence, where the real ordering is more likely to show population abundance decreasing when above the mean and increasing when below the mean.

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(a) Very small, about 5 individuals per acre.

(b) much larger, about 95 individuals per acre.

(c) The system considered here exhibits alternate stable states. The population began in the basin of attraction of the higher density stable state. However, the harvesting shifted it into the basin of attraction of the lower stable state before it had time to reach the high equilibrium in part (a). In part (b), the system was allowed to reach the higher state. This system exhibits hysteresis, since once it has been forced to the lower stable state, as in (a), stopping the harvesting will not be sufficient to return it to the high equilibrium. This has obvious consequences for resource management.

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