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Annotated Bibliography: Matrix Effects on Dispersal

Baum, K. A., K. J. Haynes, F. P. Dilleuth and J. T. Cronin. The matrix enhances the effectiveness of corridors and stepping stones. *Ecology* 85: 2671-2676.

The title of this paper basically sums up their findings. It is unusual in that it is a synthesis of corridor studies and matrix studies, although the conclusions seem intuitive. Stepping stones were found to work in low-resistance matrix but have no effect in high-resistance matrix, and stepping stones and corridors in low-resistance matrix increased numbers of colonists threefold compared to a matrix only landscape.

Gustafson, E. J., and R. H. Gardner. 1996. The effect of landscape heterogeneity on the probability of patch colonization. *Ecology* 77: 94-107.

An early modeling paper which concludes that most (89%) of the variability in dispersal success can be explained by differences in the size and isolation of patches, and not the quality of the intervening matrix. An interesting finding was the frequent occurrence of asymmetric immigration/emigration rates between patches. Strangely, this concept that the rate of transfer from Patch A to Patch B might not be the same as the rate of transfer from Patch B to Patch A seems to have been overlooked by many subsequent matrix dispersal studies.

Hanski, I. 1998. Metapopulation dynamics. *Nature* 396: 41-49.

This paper develops the Incidence Function Model (IFM), which it is argued can be used to predict the effects of habitat destruction on patch occupancy. A good example of how the quality of the matrix is accounted for by modification of the distance parameter, a technique frequently employed in studies of connectivity.

Haynes, K. J. and J. T. Cronin. 2003. Matrix composition affects the spatial ecology of a prairie planthopper. *Ecology* 84: 2856-2866.

A worthwhile paper to look at since they attempted to control for inherent patch variation, which is not often done in studies of patches embedded in different types of matrix. They found that the quality of patches (as measured by leaf nitrogen levels) differed in mudflat and in nonhost grass matrices, and that plant quality was variable within the patch, from interior to edge.

Haynes, K. J. and J. T. Cronin. 2004. Confounding of patch quality and matrix effects in herbivore movement studies. *Landscape Ecology* 19: 119-124.

A review article that raises the question: Are researchers adequately isolating effects of the matrix from patch quality effects? Although only a small number of papers was

examined (11), more than half of these did not adequately isolate these effects. They argue convincingly for the need to investigate the covariance of patch quality and matrix composition in dispersal studies.

Henein, K. and G. Merriam. 1990. The elements of connectivity where corridor quality is variable. *Landscape Ecology* 4: 157-170.

An early paper that uses published demographic data on a small rodent (white-footed mouse) to construct deterministic models of a metapopulation, where corridor quality is varied. The model is somewhat simplistic, but serves well to highlight the potential importance of geographic isolation of patches on the potential for local extinction. While it does not deal explicitly with the matrix, corridors within the matrix are a subsection of dispersal research.

Jonsen, I. D., R. S. Bouchier and J. Roland. 2001. The influence of matrix habitat on *Aphthona* flea beetle immigration to leafy spurge patches. *Oecologia* 127: 287-294.

Interesting analysis of a weed biocontrol system involving an introduced beetle and the invasive plant, leafy spurge. Researchers looked at the ability of 2 related species of beetle to move through either shrub or grass-dominated matrix, when released at various distances from a patch of leafy spurge. Findings were intriguing in that not only did the species respond differently, but males and females of the same species differed in their ability to move through the matrix. It would have been interesting if the researchers had also sampled around the target patch to try to find out where the beetles that didn't make it to the patch were ending up.

Manning, A. D., D. B. Lindenmayer and H. A. Nix. 2004. Continua and umwelt: novel perspectives on viewing landscapes. *Oikos* 104:621-628

While this paper does not explicitly discuss dispersal through the matrix, it is interesting and relevant for its argument that the heterogeneity of landscapes needs to be taken into account. In addition, the manner in which individual organisms perceive and respond to the landscape around them is important, as evidenced in the Schooley and Wiens (2003) paper.

Moilanen, A. and I. Hanski. 1998. Metapopulation dynamics: effects of habitat quality and landscape structure. *Ecology* 79: 2503-2515.

This paper attempts to look at the potential of several variables to explain variation in a metapopulation model, using data from the Glanville fritillary butterfly. Its conclusions are in the minority of matrix research, in that they found that patch area and isolation alone were sufficient to include in the model, and the addition of variables representing patch quality and matrix structure did not significantly help the model. Perhaps the most helpful part of this paper is their discussion of various assumptions made, problems with those assumptions, and what ideal data collection would look like.

Revilla, E., T. Wiegand, F. Palomares, P. Ferreras and M. Delibes. 2004. Effects of matrix heterogeneity on animal dispersal: from individual behavior to metapopulation-level parameters. *The American Naturalist* 164: E130-E153.

I have included this paper simply because it is one of the very few papers I came across that has a vertebrate (Iberian lynx) as the study organism.

Ricketts, T. H. 2001. The matrix matters: effective isolation in fragmented landscapes. *The American Naturalist* 158: 87-99.

A frequently cited paper that demonstrates how equations predicting movement can be modified to account for different matrix types. This is accomplished by incorporating a “resistance parameter” which modifies the distance term of the equation, and is different for each matrix type. Empirical data is also presented for several species of butterfly, and as in the Jonsen et al. flea beetle paper, closely related species responded differently to the matrix. Ricketts suggests an interesting practical application of his findings, which is that the matrix can be actively managed as a means of increasing connectivity between patches, rather than simply focusing on the management of isolated habitat patches.

Schooley, R. L. and J. A. Wiens. 2003. Finding habitat patches and directional connectivity. *Oikos* 102: 559-570.

One of a few papers that I found that illustrates what seems to be a new level of complexity in matrix dispersal research – directional connectivity. Researchers looked at cactus bugs and patches of *Opuntia* cactus, and found that there was a significant effect of wind direction on the orientation behavior of the cactus bugs. This seems to point strongly to the possibility that olfaction is an important factor in movement decisions made by the cactus bug, and highlights the importance of understanding thoroughly one's study organism.

Schooley, R. L. and J. A. Wiens. 2004. Movement of cactus bugs: patch transfers, matrix resistance, and edge permeability. *Landscape Ecology* 19: 801-810.

Another cactus bug paper, but one that does not seem to break new ground. Basically, it was demonstrated that dispersal distances were greatly reduced by a matrix with high vegetation structure as opposed to one with lower vegetation structure.

Vandermeer, J., B. Hoffman, S. L. Krantz-Ryan, U. Wijayratne, J. Buff and V. Franciscus. 2000. Effect of habitat fragmentation on gypsy moth (*Lymantria dispar* L.) dispersal: the quality of the matrix. *American Midland Naturalist* 145: 188-193.

This paper approaches the challenge of measuring dispersal in an interesting manner; by looking at the abundance of egg masses as a proxy for the presence of individuals, rather than marking and trying to recapture individuals. The researchers found that the abundance of gypsy moth egg masses was significantly higher in forest fragments embedded in swamp matrix than in forest fragments embedded in old field matrix. However, the number of egg masses was no different in continuous forest than in forest

fragments embedded in old field matrix.