

EDGE EFFECTS

Reviews and Meta-Analyses

Cadenasso, M. L., S. T. A. Pickett, K. C. Weathers, and C. G. Jones. 2003. A framework for a theory of ecological boundaries. *BioScience* 53:750-758.

Cadenasso *et al.*'s focus is on looking at edges across a range of environments and a range of scales. They develop a conceptual model, and then test the model in an experimental study of forest-field boundary function. The paper provides thorough definitions of both patches and edges (here, referred to as boundaries). They review (1) the type of flow across boundaries (flow of materials, energy, organisms, and information), (2) patch contrast, and (3) boundary structure. However, the framework that they propose does not seem to offer much new to the theory of edge effects and is not all that interesting.

Murcia, C. 1995. Edge effects in fragmented forests: implications for conservation. *Trends in Ecology and Evolution* 10:58-62.

Great review and an easy read. Murcia gives a nice background about how edges can affect organisms in fragments (abiotic, direct biological, and indirect biological). Then she moves on to talk about why there is little consensus in the results of edge effect studies. She lays out several problems with study design that obscure any patterns: (1) lack of replication, pseudoreplication, or inadequate replication; which result in a lack of power to detect effects, (2) confounding fragment size with edge effects, (3) confounding treatments with replicates, and (4) confounding other co-occurring topographic lines or soil discontinuities with edge effects. She also discussed how edge effects don't vary consistently with distance from the edge and that different species perceive edges at different scales: few studies use a fine enough scale of measurement to detect precise estimates of edge response (e.g., insects) while other studies should look over hundreds of meters (e.g., nest predation in territorial birds). All in all a good starting point, even a must read, for those interested in edges.

Ries, L., R. J. Fletcher, J. Battin, and T. D. Sisk. 2004. Ecological responses to habitat edges: mechanisms, models and variability explained. *Annual Review in Ecology, Evolution, and Systematics* 35:491-522.

This paper starts with a nice review of the history of edge effect research. Then, the researchers developed a model in attempts to explain the variable and apparent idiosyncratic species' responses to edges. The model is a nice attempt to explain what is happening by examining whether the edge is between two pieces of habitat (and further divide those habitats as providing supplementary or complementary resources), between habitat and non-habitat (and again divide responses between those that have supplementary and complementary resources), and areas with resources concentrated along the edge. However, then they conduct a meta-analysis of other's research to see if their model correctly predicts a species response. They compared predicted versus observed responses across four taxa (birds, butterflies, mammals, and plants). While at first glance, the model seems to predict responses, there were several problems. First, they considered that the model correctly predicted a species response even when it did not (e.g., a neutral observed/predicted responses). Second, they selected studies for their meta-analysis by a frequently-criticized method called "vote-counting." This method weights all studies equally, independent of the power or effect size of the studies looked at. In summary, this is a nice review, the model provides an explanation for some of the variability in species' responses, but the test of the model is weak. It does have a great literature cited section.

Mammals

Clark, T. P., and F. F. Gilbert. 1982. Ecotones as a measure of deer habitat quality in central Ontario. *Journal of Applied Ecology* 19:751-758.

An empirical study of the importance of edge environments to the white-tailed deer. Study was done in response to previous research that called edges "ecological traps." Seems like the researchers may have had some problems with replication and possibly with their methods (using pellet plot counts to estimate habitat use). However, they did find that deer appeared to increase only marginally along edges. Short read, and gives insight into earlier work on edges.

Lidicker, W. Z. 1999. Responses of mammals to habitat edges: an overview. *Landscape Ecology* 14:333-343.

This is a review paper, focused on how mammals respond to edges. It gives a brief review of the history of edges, defines edges, defines edge effects, and attempts to separate the effect of an edge from the matrix effect. It also points out that there are varied responses, even how different species respond differently to the same edge. Finally, he discusses the relationship between the use of corridors and response to habitat edges (species that avoid edges are unlikely to use corridors).

Manson, R. H., R. S. Ostfeld, and C. D. Canham. 1999. Responses of a small mammal community to heterogeneity along forest-old-field edges. *Landscape Ecology* 14:355-367.

In this empirical study, Manson *et al.* compared the responses of three small mammals to forest-field edges. They found varied responses – voles were captured more frequently in old field zones distant from the forest edge, whereas mice were more abundant at the forest edge, and shrews did not show a strong association. They also found that the mice response differed depending on the density of voles, suggesting possible competitive displacement. In addition, they examined mice and vole spatial patterns and compared them to tree seed and seedling survivorship, yielding insights for plant/animal interactions. Overall, this is an interesting paper.

Communities

Cadenasso, M. L., and S. T. A. Pickett. 2001. Effect of edge structure on the flux of species into forest interiors. *Conservation Biology* 15:91-97.

An interesting look at how the spread of exotic species is affected by edge structure. They used an experimental approach – by altering vegetation structure at edges (within 20 m of edge) into two categories (thinned and intact). Then they measured seed dispersal across the edge (5m) and into the interior (50m was the furthest measurement). Not surprisingly, they found that the thinned treatment had higher dispersal rates and seeds dispersed further into the interior. Unfortunately, it seems like the study has problems with replication (they only had one thinned and one intact plot, in which, they sampled extensively). Also, this seems to only be relevant to wind-dispersed plants.

Fagan, W. F., R. S. Cantrell, and C. Cosner. 1999. How habitat edges change species interactions. *The American Naturalist* 153:165-182.

This is an examination on the effects of edges on population dynamics and species interactions. It is a review of both theoretical and empirical studies. They summarize the effects (using a mathematical approach) into four mechanistic classes: (1) edges as dispersal barriers (filters), (2) edge influence on mortality, (3) edge involvement in spatial subsidies (similar to source-sink dynamics), and (4) edge-generated novel interactions. The math was a bit heavy (lots of partial differential equations) but its synthesis into classes of edge-related species interactions is useful and their review in each category thorough. It does seem that they over-emphasize the importance of edge effects on community structure.

Fletcher, R. J. 2005. Multiple edge effects and their implication in fragmented landscapes. *Journal of Animal Ecology* 74:342-352.

Fletcher examines how the presence of multiple edges in a single patch affects the spatial distribution of a songbird. While a few models have been developed to look at the effects of multiple edges, this is one of the first empirical studies. He compared bobolink occurrence in single edge plots, double edge plots, and interior plots, and found that multiple edges increased the magnitude and extent of edge effects on bobolinks (single-edge effects were twice that of interior plots, double-edge effects were four times that of interior plots). Although this is an interesting pattern, it does not get at the processes that underlie the pattern (e.g., changes in habitat structure, food availability, nesting success, or species interactions). He also developed models to attempt to extrapolate edge effects to fragmented landscapes. I found the models hard to follow, but the result was (1) lower levels of occurrence were only predicted in highly fragmented landscapes and (2) patch size affected the outcome of the model. Finally, it is important to realize that by "multiple edges" the author is only referring to single-edges versus double-edges.

Patch Shape

Blouin, M. S., and E. F. Connor. 1985. Is there a best shape for nature reserves? *Biological Conservation* 32:277-288.

While not a discussion of edge effects, edge effects and patch shape are related (long linear patches would presumably have increased edge effects). Blouin and Connor explore the relationship between species richness and island shape across 33 datasets and five taxa (plants, birds, insects, mammals, and amphibia and reptiles). They found that, despite popular belief that reserves should be as round as possible, patch shape did not explain a significant amount of the residual variation (using multiple regression and after accounting for island area). They give several explanations for their results including that island shape simply does not affect species number. They also suggest that shape could be important, but that the variables chosen to represent mechanisms were not appropriate (unlikely). Finally, other sources of variation may have obscured any potential effect (also unlikely). Therefore, it is unlikely that shape is a major concern for reserve design.

Game, M. 1980. Best shape for nature reserves. *Nature* 287:630-632.

This is a short and interesting examination of one of Diamond's rules in establishing nature reserves: that reserves should be as round as possible. Game suggests that if immigration is important in maintaining richness, then round reserves might not be the best shape. This is because in the eyes of a disperser, a long linear patch will appear larger. The increased immigration rate may offset any potential increase extinction rate. Quick read.

Orrock, J. L., and B. J. Danielson. 2005. Patch shape, connectivity, and foraging by oldfield mice (*Peromyscus polionotus*). *Journal of Mammalogy* 86:569-575.

This is a study of corridors and patch shape. Orrock and Danielson compared mouse foraging patterns in three types of patches: (1) a patch connected to another patch via a corridor, (2) a patch that is not connected but has corridor-like extensions, and (3) a patch of equal area but without any linear extensions. They found that patch shape (not corridors) affected foraging activity but not mouse abundance. Further, edges and corridors appeared to be risky places for mice with respect to predation risk. Not particularly interesting, but it's at least a recent empirical study relating to patch shape.

Seed Rain

Cubina, A., and T. M. Aide. 2001. The effect of distance from forest edge on seed rain and soil seed bank in a tropical pasture. *Biotropica* 33:260-267.

Another empirical study of edge effects, but this one is interesting because (1) it is looking at plants and (2) it has important management implications for forest regeneration. Cubina and Aide found a strong effect of distance from the forest edge on the abundance and diversity of woody species in the seed rain and seed bank of an active pasture. Specifically, they demonstrated that few seeds disperse into pastures adjacent to forests. Even when a rare dispersal event occurs, species do not accumulate because of short-term seed viability and, possibly, high seed predation. The study suggests that only a small subset of the forest species will contribute to the initial recovery process, which is very important for management.