Measurement of the Landscape Matrix

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The measurement of the matrix of the landscape has become a very important aspect of landscape ecology in the past few years, no longer is matrix seen only as the uninhabitable portions of the landscape. As our ability to monitor and map the landscape has become more refined with technology, such as GIS, our understanding of how different species interact with the landscape has likewise increased. These advances in technology have expanded our traditional view of the landscape beyond suitable and unsuitable to varying grades of suitability. Artificial reconstruction of landscapes to better suit human needs has forced animal and plant species to adapt by moving into areas of the landscape that traditional ecology has declared unsuitable for them. Thus, a more holistic and dynamic understanding of landscapes, which includes the matrix, has become of paramount importance in reformulating the needs for species protection.

In the traditional island ocean model of landscape ecology, the islands represented the habitable portions of the landscape where the species being studied could exist. The water portion of the landscape is where the species could not exist or would “drown”. It is this water portion that was defined as the matrix, it was seen as completely uninhabitable by the migratory species (Vandermeer, 2001). The matrix is also assumed to be homogeneous and ecologically unimportant. The recent literature has begun to acknowledge that the matrix matters and that further investigation of its potential effects is vitally important to conservation. The different types of matrix habitats in the landscape can affect rates of inter-patch movement. For example, a group of frogs that is migrating from one pond to another might prefer to move though a forest. If the forest is fragmented with agricultural fields, this changes the mortality rate of the
frogs. The agricultural fields pose greater obstacle to the frogs’ migration. If a road were put in between the frogs’ ponds, this would create an even higher obstacle to the frogs’ migration. The measurement of the matrix of the landscape focuses on accurately quantifying these resistance levels to correctly model the species to assess mortality (Ricketts, 2001).

There have been several different approaches to modeling the matrix. The most popular approach has been an expansion of connectivity theories and matrices. In spatial studies of populations, Euclidian distance is commonly used to measure the structural connectivity between habitat patches. However, in these models, the matrix and its effects on the species are completely ignored. A new cost-distance GIS model was created to incorporate the effects of the matrix. Using the Cost-Distance model, created by ESRI, a cost grid map is generated, where each cell has a resistance value depending on its land-use type. Land-use types that can function as movement corridors are given low resistance values, while elements that hinder movement get higher values. These values are preferably based on empirical data, or else on expert judgment (Chadon et al 2003,). There are several studies that have successfully used this technique to study the matrix. Chadon et al. specifically compared cost distance measuring with Euclidian distance on Speckled wood butterflies. It was found that cost distance measuring was a more accurate measure of connectivity. Grahman (2001) used the cost distance model to study movement patterns of Toucans. This study calculated the amount of energy Toucans were using flying between forest patches, and found that different types of non-forest matrices would affect the Toucans. The landscapes with small shrubby trees provided places for the Toucans to land while flying from one patch to another, unlike grassy areas, which do not. Because the Toucans could land they would spend less energy and those birds thrived despite the loss of habitat. Verbeylen et al. (2003) studied urban matrix effects on Red Squirrels. Using
statistical models, the resistance values of the matrix were calculated and a model was created that accurately predicted how urban matrices affected Red Squirrel mortality. A GIS Cost distance model is an effective way of modeling the matrix values of a species to understand how that species is using the landscape.

One of the major drawbacks to cost distance modeling is the complexity of calculating the resistance values of the cost distance model. In the studies sited above, several different methods were used, however all required intense study of the species. Some used statistical analysis of presence absence data, others used radio collars to track the species for long periods of time. A resource manager can even make educated guesses on the resistance value of the matrix and create these models. While such a map would not be valid in a strictly scientific aspect, this could be a useful starting point for a resource manager.

There have been other methods besides resistance mapping that have been explored to measure landscape matrices. One method is habitat contour mapping. This method seeks to use resource managers and scientist’s familiarity of contour maps to graphically represent a species’ use of the landscape. The model has a peak spot of high use with contour lines expanding outward from the center showing less and less use. The model can demonstrate abrupt drop-off of use by clustering the lines together, much the same way a contour map would denote a cliff. It can also show a slow drop-off of use with the lines spread out, much a like a gentle slope. This method also has the advantage of showing where different species would overlap. Resistance mapping has problems showing such an overlap as clearly as this method. This method does have the drawback that the contour lines generalize the data. This method is more for display than scientific accuracy (Ficher et al. 2004).

The best method for measuring the landscape matrix is to use traditional observations of the species and landscape. This method involves transecting the
different land cover types and observing the species movement though the different landscapes. Using catch and release measurements, the resistance values and the mortality rates of the matrix can be quantified. GIS tools, such as cost distance extension, can then be used to expand this information beyond the study site. GIS tools are helpful in predicting how gains and loss of the land cover will affect the target species. However, without the core research data the GIS models are not enough. In the case of the Toucans, (Grahman, 2001) radio collars were used to track the Toucans and create the base data for the GIS model. The model was then used to calculate the impact of development to the area. Several management plans were created using this model to insure the protection of enough core habitat and matrix habitat to insure survival of the Toucan.

Correctly assessing the effects of matrix types on different species has become an important part of preserving habitat for species. As man continues to develop more and more of the landscape, it is valuable to understand how different species will be using these areas. Species will not stay confided to the habitat areas that we choose to preserve. They will be found in field, parks, yards and streets. It is important that we develop quality models that look at the whole landscape so that land managers can assess development impact on the species.

Brotons, et al examined the relationship between of the Boreal forest birds and their fragmented landscape. This article details several different hypotheses, including the matrix quality hypothesis, that could explain the breeding patterns seen in the birds. Using statistical analysis, the authors focus on the effect of matrix quality on the relationship between density and patch area. Their findings support the matrix quality hypothesis.


Chardon et al compare Euclidean distance to cost distance analysis under controlled circumstances. They used presence absence data of the Speckled wood butterfly. It was concluded that cost distance analysis was a better matrix measure because it incorporated the resistance of intermediate landscapes. This was a very good paper at comparing the two methods. I highly recommend it.


Graham does an excellent job of detailing her experiment and the use of the ‘Cost Distance’ extension of Spatial Analyst. The article showed how a researcher could use animal movement to qualify the measurements need to create a cost distance model. This model was then used to examine the effects of different management plans of the Toucans.

This was a well document project with a large amount of data. This is an excellent paper, I highly recommend it.

Fischer, Joern, David B. Lindenmayer, and Ioan Fazey 2003 Apprecation Ecological Complexity: Habitat Contours as a Conceptual Landscape Model. Conservation Biology Volume 18 No. 5 1245-1253

Fischer et al discusses a new form of displaying matrix values of species on the landscape using contour lines. The authors took the position that often resource managers have trouble interpreting how species interact on the landscape and using contours lines would provide a simplified version that can be easily understood. This method of contouring species has the advantage that multiple species can be display and areas where they overlap can be identified.

Overall, I thought it was a very good article.


Joly, et al lay out the basic concepts for modeling the landscape matrix using the ‘cost distance’ extension of Spatial Analyst in ArcView 3.2. The review the basic
concepts of what a researcher might be interested in and how friction maps can help display this type of information. They show the type of data need to build a friction map and how to add in mortality risks to the model. The authors discuss how these friction maps can be applied to different situation.

This article does not provide the actually data that was used in the study, nor does it present any result. However, I think it does provide a quick overview of what could accomplished with the ‘cost distance’ extension of Spatial Analyst in ArcView 3.2


Jonsen et al focused on the influence of matrix habitat on the Aphthona flea beetle immigration. For this study, matrix habitat was defined as grass or shrub. It was found that metapopulation dynamics of the flea beetle maybe strongly effected by matrix habitat. This article was of interest because it showed how measurement of the landscape matrix can be applied to management solutions and that matrix measurement can be as simple as cover type.


This article was interesting from a measurement standpoint because matrix measurement was conducted in a more traditional format. Ricketts created transect lines across the matrix to determine the different types of landscapes. He then performed a catch and release study on the butterflies to determine the effect of matrix on the species. Overall, I thought it was a very good article and would be useful for someone attempting to design an experiment for an individual species.


This article was excellent at reviewing the original theories of landscape matrix. Vandermeer and Carvajal start with the island model, and then walk the reader though how the definition of matrix has changed, showing that the quality of the matrix does effect the species in the area. It discusses the advantages and disadvantages of low quality and high quality matrix and the relevant formulas. While the article is a little difficult to follow with the formulas, I feel it is an excellent paper for someone who wants to know the basics of landscape matrixes.


The goal of this paper was to test the “cost distance” approach to matrix resistance quantification. To quantify isolation based on matrix resistance the ‘cost distance’ extension of Spatial Analyst in ArcView 3.2 was used. The Verbeylan et al tested a wide range of variables, such as patch size, quality and isolation. They created different models using different landscape resistance to determine which formulas explained the isolation effects the best. They tested different numbers of classes of landscape type as well.
Overall, this was the best paper for understanding the measurement of matrix. I highly recommend reading this paper.