LAB EXERCISE #4 – Quantifying Landscape Patterns

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Overview: In this exercise, you will learn to use the program FRAGSTATS and interpret the output in the context of the case study landscape. FRAGSTATS is a program for quantifying landscape patterns for categorical maps. You will gain a practical understanding of how to select and compute landscape metrics and even create one of your own. Specifically, students will use landscape metrics to compare and contrast the structure of several sub-landscapes representing a gradient in forest extent and fragmentation.

Objectives

- To learn how to use FRAGSTATS to quantify landscape patterns.
- To learn how to select and interpret landscape metrics for specific applications.
- To learn how to develop a landscape metric and apply it.
- To gain a practical understanding of the challenges in quantifying landscape pattern.

Detailed Instructions

Step 1. Establish the objective of the analysis

The first step is to establish the objective of the analysis. As described in lab #3, we are currently in the planning stages of a study on the effects of forest loss and fragmentation on breeding birds in the Connecticut River watershed. The overall purpose of this study is to determine the effects of forest loss and fragmentation caused by urban/residential and agricultural development on breeding bird community structure and the abundances of several bird species associated with interior forested habitat. We are particularly interested in determining whether thresholds exist in avian response to habitat loss and fragmentation and determining if the existence and nature of any threshold response to habitat loss is effected by habitat configuration (i.e., fragmentation).

In this exercise, we are going to focus on the following specific questions (but note that the methods and principles applied and learned in this exercise are broadly applicable to a wide range of related questions):

> *Given the current distribution of forest cover in the case study landscape, can we establish gradients in forest extent and fragmentation using a parsimonious suite of landscape metrics (using extant metrics or one of your own creation) for the purpose of exploring the relationship between breeding birds and forest loss and fragmentation.*

Step 2. Establish the study design and define the digital landscapes

Given the objective above, the next step is to establish an appropriate study design. It is important to note that there are many possible study designs for meeting this objective, each with its own strengths and weaknesses. For the purpose of this exercise, here is what we did.

We delineated a somewhat arbitrary study area encompassing 214,900 ha surrounding the cities of Amherst, North Hampton, Holyoke, and Springfield. This study area includes the towns with a preponderance of agricultural land and experiencing the greatest urban/residential sprawl in the Connecticut River watershed in Massachusetts. To facilitate study site selection and to aid in our understanding of landscape structure gradients within the study area, we compiled a GIS database consisting of the following data layers:

(1) 1985 Land use/cover map (created by our Resources Mapping Lab using aerial photo interpretation). For our purposes, we have aggregated land use/cover classes into 6 broad classes (forest, open, residential, urban, wetland, water) and converted the original vector coverage, mapped at a minimum resolution of $\geq$0.5 acre (varied among cover classes), to a raster grid with a 50 m cell size (0.25 ha).

(2) 1-km square grid superimposed over the study area.

Eeach 1-km square "window" was used to clip the land use/cover map, resulting in 2149 individual 1-km square, arbitrary landscapes. Each landscape was analyzed using FRAGSTATS to quantify the composition and configuration of the landscape based on the land use/cover classes. The class-level metrics associated with each land use/cover type were subjected to a Principal Components Analysis in an attempt to identify the major gradients in landscape structure at the scale of 1-km square landscapes. The results suggested that forest cover was structured along two main gradients, one corresponding to the proportion of a landscape in forest cover (i.e., landscape composition) and the other corresponding to the fragmentation of forest cover (i.e., landscape configuration). For this exercise, I selected a sample of 14 1-km square landscapes to represent the full range of these gradients.

Open up in ArcMap the project file "…\exercises\pattern\pattern.mxd"

Take some time to review each layer for the purpose of familiarizing yourself with the sample landscapes (see Appendix A for a description of each spatial layer). Note, the ArcMap project contains a few additional layers not considered in the study design. In particular, the GAP land cover grid is included to provide additional detail on the composition and structure of the landscape. In addition, the roads and streams layers are included because they represent potential fragmenting features of the landscape.

Questions to ponder (but not answer):

2.1 What are the tradeoffs associated with the chosen sampling design? How would you design the study to address the stated objective?

2.2 What are the tradeoffs and/or limitations imposed by the chosen landscape definition? Is the thematic content and resolution of the landscape appropriate for the stated objective? How would you modify the thematic content and resolution and what would be the ramifications of doing so? Is the spatial extent and resolution appropriate for the stated objective? How would you modify the spatial scale of the analysis to better meet the stated objective and why?

Step 3. Select landscape metrics

The next step is to chose a parsimonious suite of no more than **6-10** metrics to evaluate the structure of the sample landscapes. The choice of metrics is limited to those computed in the FRAGSTATS software (step 4). To view the list of available metrics and a complete description of each, open up the FRAGSTATS help files, as follows:

Program files ➥ Fragstats 3.3 ➥ Fragstats Help
In the left-hand window, click on (or expand) the item named "metrics"
Navigate to the desired metric

In your selection of metrics, consider the following:

1. Given the objective, the focus is on the forest class; thus, focus on the selection of *class-level* metrics not *landscape-level* metrics.
2. Include both *composition* and *configuration* metrics. Note, PLAND at the class level is generally considered an essential composition metric in all analyses.
3. Include both *structural* and *functional* metrics if possible.
4. Include *nonredundant* metrics; i.e., those that measure different aspects of landscape pattern and/or have a different ecological interpretation.
5. Keep in mind the focus of the analysis – fragmentation.

If you select any functional metrics, complete their parameterization. Specifically, if you select any metrics dealing with core area, edge contrast or similarity, review the following included weights files and modify them as needed:

...\exercises\pattern\fragstats\edgedepth.csv = edge depth weights for core area metrics
...\exercises\pattern\fragstats\contrast.csv = edge contrast weights for contrast metrics
...\exercises\pattern\fragstats\similarity.csv = similarity weights for similarity metrics

Note, information on how to construct and interpret these weights files is given in the FRAGSTATS help files (see below).

Step 4. Conduct FRAGSTATS analysis

The next step is to compute the landscape metrics using FRAGSTATS – a spatial pattern analysis program for categorical maps. It is beyond the scope of this document to describe the use of the FRAGSTATS software, but a complete user manual is included as a reference guide (see ...\exercises\pattern\fragstats.pdf). The instructor will guide you through the use of FRAGSTATS for this exercise.

Step 5. Examine the results

The last step is to examine the results of the landscape pattern analysis.

Open EXCEL and import the FRAGSTATS output files.

Note, the FRAGSTATS output files are comma-delimited ascii files, so use the import wizard in EXCEL with the data type = “delimited” and delimiters = “comma” options to import the files directly into a spreadsheet.

Next, examine the tabular results and/or create graphical displays to aid in your examination.

Assignment

As a team, complete the exercise above and discuss the findings. One team will be selected to present an oral report and the remaining teams will submit a single written lab report containing answers to the following questions.

1. Provide a brief justification of the choice of metrics using information provided in lecture and readings to support your case. In your justification be sure to address the following questions:
   - Does it represent landscape composition or configuration, or both?
   - What aspect of configuration, if any, does it represent?
   - Is it spatially explicit, and, if so, at the patch or landscape level?
   - How is it effected by the designation of a matrix element, if present?
   - Does the metric represent landscape structure in a manner ecologically meaningful to the phenomenon under consideration?

2. Based on the selected metrics, arrange the 14 sample landscapes according to the gradients in forest loss and fragmentation. Specifically, in tabular or graphical form, portray the relationship among landscapes with respect to forest loss and fragmentation. Provide a brief discussion of the empirical basis for the ordering, with particular attention to the choice and interpretation of metrics chosen as indices of forest fragmentation.

3. Develop a way to quantify landscape connectivity from at least one perspective in the sample landscapes. Carefully define the perspective being represented and describe the method or algorithm used to compute the index. Apply the metric to some or all of the sample landscapes (depending on how difficult the calculations) to demonstrate the utility and/or behavior of the metric.

4. Discuss issues of scale in the proposed study. First, given the existing data set, describe the lower and upper limits of resolution in our ability to relate habitat loss and fragmentation to bird species occurrence and abundance. Second, outline a sampling and analysis method to determine the scale, scales, or range of scales over which forest loss and fragmentation are having the most significant impact on bird communities.

The report should be well organized and presented in a clear and concise manner. There is no minimum or maximum page limit, although you should be able to complete the assignment in less than 4-5 single-spaced pages, not including tables and/or figures. Full references should be

included for all literature cited. Written reports must be submitted electronically; a hard copy is optional. Reports should effectively demonstrate that an interdisciplinary approach was used. In other words, I want a single integrated presentation that effectively demonstrates that the entire group discussed the results and reached some kind of consensus over the interpretation of those results. The report should not consist of several separate efforts combined at the end for purposes of the presentation. Moreover, the concepts discussed in lecture should be integrated into the discussion of the results to the extent possible.

Appendix A. Brief description of the GIS data layers included in the pattern.mxd project.

GIS Layer	Description
gap18	GRID at 30 m spatial resolution classified into 15 classes: 0 other 113 urban 117 tidal flat or open water 118 rich grassland or suburban forest 119 pasture, sparse grassland or agriculture 120 open, shrub or barren land 121 mixed deciduous/coniferous wetland 122 emergent or shrub wetland 123 mixed coniferous forest 124 mixed deciduous and coniferous forest 125 mixed deciduous forest 126 birch dominant deciduous forest 127 oak dominant deciduous forest 128 red maple dominant deciduous forest 129 northern hardwoods dominant forest
lugrid	GRID at 50 m spatial resolution classified into 6 classes; aggregated from original 1985 land use/cover map (created by our Resources Mapping Lab using aerial photo interpretation): 100 open 300 residential 400 water 500 forest 600 non-forested wetland 700 urban
hydro	VECTOR line coverage derived from MassGIS's 1:25k stream centerline data (see MassGIS for details). Includes a variety of attributes such as stream order.
roads	VECTOR line coverage derived from MassGIS's 1:25k roads and trains (see MassGIS for details). Includes a variety of attributes such as road class.

towns	VECTOR polygon coverage from MassGIS depicting boundaries of all townships in Massachusetts. Includes a variety of attributes associated with each town, such as census population size.
out1km2	VECTOR polygon coverage depicting a 1-km square grid superimposed over the study area.
fragrep1	VECTOR polygon coverage depicting the 14 1-km square sample landscapes selected for this study.
grid???	GRID at 50 m spatial resolution depicting each of the 1-km square sample landscapes (fragrep1) selected for this study. Note, these grids are this input landscapes for this study.