

LAB EXERCISE #2 – Defining the Landscape

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Overview: In this exercise, you will experience the challenges associated with defining a study landscape in an ecologically meaningful manner given real-world practical considerations (e.g., data limitations) and management objectives. Specifically, you will evaluate alternative landscape definitions and discuss the challenges and implications of choosing among alternative definitions.

Objectives

- To get familiar with the steps in defining a study landscape.
- To gain an appreciation for the many challenges in defining a landscape for purposes of analysis.

Background Information

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 valley. The overall purpose of this study is to determine the effects of forest loss and fragmentation caused by urban and residential development on breeding bird community structure and the abundances of several bird species associated with forested habitat. We are particularly interested in determining whether thresholds exist in avian response to habitat loss and fragmentation and to determine if the existence and nature of any threshold response to habitat loss is effected by habitat configuration (i.e., fragmentation).

The study area encompasses the 141,040-ha Connecticut River Valley ecoregion (hereafter referred to as the “Valley”) in western Massachusetts. This area falls within Franklin, Hampshire and Hampden counties and includes all or part of 33 towns, including Springfield, Holyoke, North Hampton and Amherst, including the area experiencing the greatest urban/residential sprawl in the Connecticut River watershed in Massachusetts. The Valley includes the lower reaches of several major tributaries to the Connecticut River, including the Westfield and Deerfield Rivers on the west and the Mill and Chicopee Rivers on the east. The Valley is comprised of a mixture of developed and undeveloped land use/land cover types, including forested uplands (36%), non-forested uplands (<1%), wetlands and aquatic (11%), urban (9%), residential (23%) and agriculture/open grassland (21%). The latter land cover type is comprised of agriculture - principally cropland (16%), open fields (2%) and cultural grasslands - principally hayfields and pasture (3%). In addition, the Valley is densely roaded with 6,542 km of roads and includes portions of I-91 and the Mass Pike.

Detailed Instructions

Step 1. Get familiar with the landscape: GIS data overview

The first step is to get familiar with the study landscape and the associated GIS data. Although a wealth of GIS data is available for this landscape, for this exercise we will focus on only a few key layers.

Open up in ArcMap the project file "...\\exercises\\landscape\\valley.mxd"

Take some time to review the gis layers listed below for the purpose of familiarizing yourself with the landscape. In addition, using the color orthophotos provided (west5-west8), take note of any errors in the spatial data layers, especially errors in classification and alignment.

Boundary This is a vector polygon coverage outlining the boundary of the Connecticut River Valley Ecoregion, from MassGIS.

Roads This is a vector line coverage derived from from MassGIS's 1:25k roads and trains (see MassGIS for details). Includes a variety of attributes such as road class.

Streams This is a 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.

Landuse This is a vector polygon coverage derived from 1999 aerial photographic interpretation by the Resources Mapping Lab at UMass (see MassGIS for details).

West5 MrSid image Color orthophoto, spring 2001; northern most section.

West6 MrSid image Color orthophoto, spring 2001; north-central section.

West7 MrSid image Color orthophoto, spring 2001; south-central section.

West8 MrSid image Color orthophoto, spring 2001; southern most section.

Connusgs TIFF image, USGS topo map of Connecticut River Valley (4:1 TIFF image, fast but ugly) from MassGIS

Questions to consider:

1.1 What are the major errors in the GIS data and how significant are they?

Step 2. Establish objectives for the landscape analysis

The next step is to define the objectives of the analysis. Ultimately, all landscape analyses must be guided by well-formulated objectives. Objectives among other things provide the basis for defining the landscape in a meaningful manner, since there are myriad ways to define a

landscape for purposes of analysis.

For this exercise our objective is rather vague since we don't have a single ecological process or focal organism under consideration (yet). For now, we are simply interested in representing and characterizing the major land cover patterns in the study area as a precursor to subsequent hypothesis-driven analyses. Here, our objective is purely heuristic: to gain an appreciation of the challenges in defining a landscape in an ecologically relevant manner and the quantitative implications of doing so. However, looking ahead, we are also interested in quantifying the area and configuration of forest for examining forest loss and fragmentation.

Step 3. Define the landscape extent and delineate its boundary

The next step is to define the landscape extent and delineate its boundary. For this exercise the landscape extent (and boundary delineation) has been already defined and corresponds to our study landscape in the Connecticut River Valley Ecoregion. However, we should carefully consider the implications of this delineation.

Questions to consider:

- 3.1 *How large is the landscape extent relative to the grain of patchiness?*
- 3.2 *How is the landscape delineated; i.e., what constitutes the boundary of the landscape?*
- 3.3 *What agents of pattern formation, both natural and anthropogenic, operate at this scale?*
- 3.4 *What organisms and ecological processes (e.g., disturbances) operate at this scale and therefore may affect and be affected by patterns at this scale?*
- 3.5 *Is this landscape boundary meaningful for the organisms and ecological processes under consideration; i.e., how "closed" is this ecological system for the organisms or processes under consideration?*
- 3.6 *Is this landscape boundary arbitrarily constrained by data availability and, if so, what are the ramifications given the answers to the previous questions?*

Step 4. Establish a digital model of the landscape structure

The next step is to establish a digital model of the landscape structure. This step has many important considerations; here we will consider just a few of them.

First, as discussed in lecture there are at least two fundamentally different and contrasting conceptual models of landscape structure: 1) the *landscape mosaic (or patch mosaic) model* and 2) the *landscape gradient model*. For practical reasons, we will limit our consideration to the landscape mosaic model, since most of the landscape analysis tools at our disposal are geared towards this framework. However, it is important throughout this and other exercises to carefully consider the ramifications of choosing this categorical framework.

Second, given the framework of the landscape mosaic model, we must next decide on the thematic and spatial scale of the map. Clearly, these decisions are constrained by available GIS data (step 1), the objectives of the analysis (step 2), and the extent of the landscape (step 3). Given these constraints, consider the following methods:

- Reclassifying the land cover classes into fewer aggregate classes.
- Reclassifying roads and/or streams into a single class by aggregating across size classes.
- Rasterizing the vector coverages (landuse, roads and streams) to a meaningful and appropriate grid resolution.
- Eliminating patches below a specified minimum mapping unit.
- Eliminating patches below a specified minimum mapping unit for specific cover classes only.
- Smoothing the derived raster map using a filter (e.g., focal majority).
- Merging land cover, roads and/or streams into a single land cover scheme, but considering the order of the merge (what takes priority?)
- Merging land cover, roads and/or streams as above, but restricting the roads and/or streams to the large size class only.
- Combining the above spatial methods but considering the logical ordering of resampling, min mapping, and/or merging.

The choices among these and other methods can result in an almost unlimited number of variations in landscape definitions that can have important implications for the landscape analysis (as we shall see). For heuristic purposes, we shall consider only a small subset of these alternatives. Briefly, we used the ArcInfo macro language (AML) to create several alternative land cover maps (i.e., landscape definitions) from the GIS data layers described . If you are interested, the AML script used to create these landscapes is included (...landscape\scripts\landcover.aml). Specifically, we created an incomplete factorial combination of 7 different landscape definitions based on the following three factors:

1. Thematic resolution - three levels: 1) 10 broad cover classes, 2) 38 cover classes, including major rivers and roads, and 3) 66 cover classes, including all roads and streams.
2. Spatial resolution - three levels: 1) 30 m, 2) 60 m, and 3) 90 m, all based on resampling an initial 30 m resolution grid derived from the vector data to 60 and 90 m. Note, spatial resolution was varied only for the 38 cover class grid (#1 above) with a minimum mapping unit of 1 cell (#3 below).
3. Minimum mapping unit - three levels: 1) 1 cell, 2) 4 cells, and 3) 8 cells. Note, minimum mapping unit was varied only for the 38 cover class grid (#1 above) at the 30 m resolution (#2 above).

Take some time to compare the various landcover maps in the ArcMap project. The grid naming convention is as follows. Given the file name: cov38r30m1

cov? thematic resolution:
 cov10 = 10 land cover classes
 cov38 = 38 land cover classes
 cov66 = 66 land cover classes
 *note, in all cases the order of precedence was roads > streams > other land cover (i.e., streams mapped on top of land cover and roads on top of streams).

r? spatial resolution:
r30 = 30 m cell size
r60 = 60 m cell size
r90 = 90 m cell size
*note, in all cases the resampling was applied to the final map, after the roads and streams were added to the base land use map.

m? minimum mapping unit:
m1 = 1 cell minimum patch size
m4 = 4 cell minimum patch size
m8 = 8 cell minimum patch size
*note, in all cases the minimum mapping algorithm was applied to the final map, after the roads and streams were added to the base land use map.

Questions to consider:

- 4.1 *What are the tradeoffs associated with changing the thematic content? Are there other environmental attributes (data layers) than those used here that could be meaningfully employed to define the thematic content of the landscape?*
- 4.2 *What are the tradeoffs associated with changing the thematic resolution? What criteria might be used to chose the “right” thematic resolution?*
- 4.3 *What are the tradeoffs associated with changing the spatial resolution? Are there any land cover classes or spatial contexts affected more than others?*
- 4.4 *What are the tradeoffs associated with changing the minimum mapping unit? What criteria might be used to chose the “right” minimum mapping unit? How does varying the minimum mapping unit differ from varying the spatial resolution for example through resampling?*
- 4.5 *What are the ramifications of varying the logical ordering of the various operations considered? For example, does it matter whether the minimum mapping unit algorithm is applied before or after merging the cover, roads and streams?*

Step 5: Quantify landscape pattern under alternative landscape definitions

As an example of the quantitative implications of defining the landscape, the final step in this exercise is to quantify landscape patterns for the alternative landscape definitions under consideration. This step has many important considerations that we will consider in a subsequent lab. Moreover, it involves using the landscape pattern analysis program, FRAGSTATS, that we will also explore in detail in a subsequent lab. For now, we need simply to look at the results of this landscape pattern analysis in the context of this exercise.

Open up in Excel the spreadsheet “...\\landscape\\results\\fragland.xls”

This spreadsheet contains the results of a FRAGSTATS analysis of the various landscape definitions. Specifically, each row in the table represents one of the different landscape definitions (see above) and each column represents a different landscape metric; i.e., a different measure of the composition or configuration of the landscape mosaic. For complete descriptions

of these metrics consult the FRAGSTATS help files. For now, it is not important to fully understand the intricacies of each metric. Instead, focus on the few metrics that have an obvious intuitive interpretation. For example, focus on the following:

NP = Number of patches

TE = Total length (m) of edge

AREA_MN = Mean patch size (ha)

AREA_MD = Median patch size (ha)

TCA = Total core area (ha)[based on 100 m edge depth]

PR = Patch richness (number of different patch types or land cover classes)

SIDI = Simpson's Diversity Index

Examine the effect of landscape definition on each of these metrics. For this examination, it may be useful to use the chart tool in Excel. For example, create a column barplot with y-axis representing one of the landscape metrics and the x-axis representing the different landscapes (rows). Alternatively, use the existing chart and after clicking on the chart, simply move the box highlighting the displayed column to another column (i.e., metric).

Open up in Excel the spreadsheet "...\\landscape\\fragstats\\fragclass.xls"

This spreadsheet contains the class level results of the FRAGSTATS analysis. Specifically, each row in the table represents a unique class (land cover type) for one of the different landscape definitions (see above) and each column represents a different class metric; i.e., a different measure of the composition or configuration of the corresponding class. For complete descriptions of these metrics consult the FRAGSTATS help files. For now, it is not important to fully understand the intricacies of each metric. Instead, focus on just one metric:

PLAND = Percentage of the landscape comprised of the corresponding class

Examine the effect of landscape definition on the composition of the landscape.

Questions to consider:

- 5.1 *What is the effect of landscape definition on the magnitude of each metric? Are there any patterns evident?*
- 5.2 *Are all metrics effected equivalently?*
- 5.3 *Are all land cover classes effected similarly? If not, are there any discernable patterns in the differences (e.g., abundant versus rare cover types)?*
- 5.4 *Given the results, what are the overall implications for landscape pattern analysis?*