8.1 INTRODUCTION

This chapter is particularly important because it is an attempt to quantify, using different approaches, the main attributes of a landscape. Routines and practical examples are provided to guide the reader through a number of ways to quantify many but not all the attributes of landscapes.

Landscape approaches are so diverse that it is not possible to review them all comprehensively and to indicate standard methodologies. Many come from geostatistics, geobotanics, animal population analysis, behavioural ecology etc. Image processing, geographic information systems, spatial statistics and fractal geometry represent the most common ways to explain landscape complexity, but there are many others.

Generally maps, aerial photographs and satellite images are commonly used before and after any field inventory. This material suffers from many biases due to time, resolution and quality, and often it is difficult to normalize the information that can be drawn.

Depending on the scale of resolution we need, we move from a coarse-grained resolution of 30 m or more provided by Landsat images, to the 10 m resolution of Spot images of satellites. Using aerial photographs the resolution may range from 2–3 m to a few centimetres, depending on the altitude at which the images were obtained.

Recently the use of video cameras suspended from a low-altitude balloon has opened new perspectives in remote sensing techniques. For instance, a video camera has been utilized to study the evolution of vegetation on mountain prairies. Some examples are presented in this chapter but most of the data are still under study.

Collecting field data requires us to know exactly where we are, and so the use of detailed maps (1:5000 to 1:25 000) is required. Recently we have been able to localize features of interest using the Global Positioning System (GPS). This system, developed for missile and aeroplane automatic navigation systems, is based on radio information on the field position calculated by a cluster of satellites. A practical use of GPS has been in the study of bird communities (Farina 1997). The birds’ positions were entered by an operator into a data logger and transferred to a computer for processing. This information was then inserted into a GIS for mapping and spatiostatistical elaboration.

For the most popular measures we have prepared simple and unsophisticated programs in Basic language, reported in the Appendix.

8.2 NUMERICAL AND SPATIAL DATA PROCESSING

The spatial elaboration of data is central to landscape ecology, and for this reason a large amount of space is dedicated to this argument. Many techniques have been borrowed, mainly from spatial
statistics or geostatistics, image analysis and fractal geometry. Euclidean and non-Euclidean geometry are often combined to analyse the complexity of spatial processes and patterns across temporal and spatial scales.

Two types of information are processed in this analysis: the patch attributes and the landscape attributes. In the first case the analysis focuses on every patch in terms of size, shape and spatial arrangement. In the second case more complicated analyses are necessary to explore the complexity of the land mosaic. For the second approach in particular, a great variability can be expected on changing the scale of resolution.

8.2.1 Measures of patch characteristics (see Basic routine in Box 8.1)

**Patch size** $S$ is the measure of the area of each patch composing a mosaic (Fig. 8.1).

**Patch Perimeter** $L$ is the measure of the perimeter of each patch composing a mosaic.

**Patch shape** Many indices exist to measure patch shape, especially in a geographical context. We have selected some used in direct landscape analysis. These indices must be adopted and used with caution because often their precise ecological meaning is not so easily found. The approach to the study of patch shape is important for the consequences that patch regularity/irregularity has on organisms. We assume a circle to be a regular patch; the more irregular a patch the more edges and less interior area are available. An irregular patch probably has more heterogeneous processes than a regular one. Habitat suitability, predation risk and microclimatic stress are some of the direct consequences of an irregular patch. This, of course, is important for some species but not for all. Six indices for calculating patch shape are described:

1. **Perimeter–area ratio** $(L/S)$
   The perimeter of each patch is divided by its area: $L/S$ where $L =$ perimeter and $S =$ area. This index varies according to the size of the patch even when the shape is constant. See Buechiner (1989) for an application to the field study of mammal dispersal.

2. **Corrected perimeter–area** (CPA)
   This index is corrected for solving the size problems of index 1 and varies between 0.0, a perfect circle, and infinity for an infinitely long and narrow shape:
   $$\text{CPA} = \frac{0.282 xL}{\sqrt{S}}$$

3. **Related circumscribing circle** (RCC)
   This index compares the patch size with the size of a circle that can circumscribe the patch:
   $$\text{RCC} = 2 \times \frac{\text{area} \times \pi^{1/2}}{\text{longest axis}}$$
   This index varies between 0.0 and 1.0 as the shape of the patch approaches a circle.

4. **$S1$** (Hulshoff 1995)
   $$S1 = \frac{1}{Ni} \sum (Li/Si)$$
   where $Ni$ is the number of patches of category $i$ in a map, $Li$ is the perimeter and $Si$ the area of each patch in category $i$. A high value of this index indicates the presence of many patches with small interiors.

5. **$S2$** (Hulshoff 1995) is the measure of isodiametric attributes of patches:
   $$S2 = \frac{1}{Ni} \sum (Li/4\sqrt{Si})$$
   where $Ni$ is the number of patches of category $i$, $Li$ is the perimeter and $Si$ is the size of each patch in the category. The further $S2$ is far from 1, the more the patches deviate from an isodiametric shape.

6. **Fractal dimension** $D$ (see more on fractals in Section 8.3). The complexity of path shape can be measured by regressing the log of patch perimeter $L$ with the log of patch size $S$:
   $$D = 2s$$
   where $s$ is the slope of the regression.

8.2.2 Measure of the spatial arrangement of patches

**Richness** is the number of different patch attributes that are present in the study area.