GEOG 413/613

LECTURE 7

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Landscape Metrics

- As natural processes unfold, spatial patterns are formed within landscapes
  - There are reciprocal interactions between patterns and process
- Pattern and Process
  - Processes in natural systems
    - Spatial pattern (form) can influence process
  - Spatial patterns
    - Formed from processes
    - Patterns tell us about process

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Pattern and Process

- Spatial patterns important…processes
  - to understand
  - to manage
- Quantification helps us to appreciate the complexity of nature
  - measure ecological functioning (e.g. biodiversity, connectivity)
  - measure land use processes (land consumption, fragmentation, urban sprawl)
- Quantification
  - Measures of composition (without reference to spatial attributes)
  - Measures of configuration (have reference to location - spatial information)

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Landscape Metrics

- Landscape metrics are indices developed to quantify categorical map patterns
  - algorithms that quantify specific spatial characteristics of patches, classes of patches, or entire landscape mosaics.
  - metrics has been developed to quantify categorical map patterns
  - more than one hundred metrics have been developed, many are not useful
    - Recent studies have focused on using meaningful, simpler indices

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Landscape Metrics

- **P: Patch-level metrics** are defined for individual patches, and characterize the spatial character and context of patches. In most applications, patch metrics serve primarily as the computational basis for several of the landscape metrics, for example by averaging patch attributes across all patches in the class or landscape; the computed values for each individual patch may have little interpretive value.
- **C: Class-level metrics** are integrated over all the patches of a given type (class). These may be integrated by simple averaging, or through some sort of weighted-averaging scheme to bias the estimate to reflect the greater contribution of large patches to the overall index. There are additional aggregate properties at the class level that result from the unique configuration of patches across the landscape.
- **L: Landscape-level metrics** are integrated over all patch types or classes over the full extent of the data (i.e., the entire landscape). Like class metrics, these may be integrated by a simple or weighted averaging, or may reflect aggregate properties of the patch mosaic. In many applications, the primary interest is in the pattern (i.e., composition and configuration) of the entire landscape mosaic.

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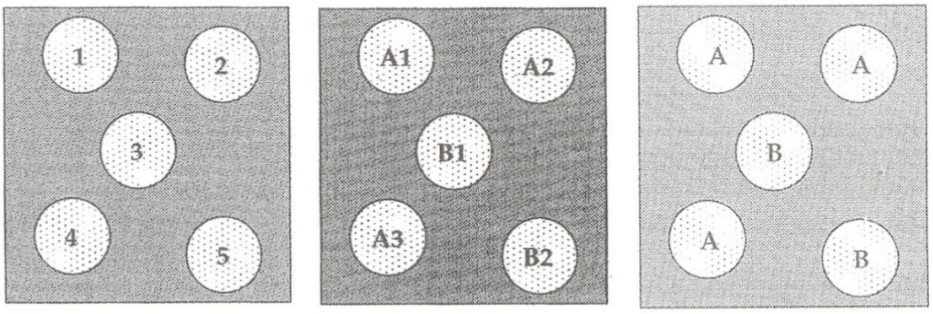
Landscape Metrics



Patch level Class level Landscape level

Farina, A. 2000. Landscape ecology in action. Kluwer Academic Publishers, Netherlands

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Ecological processes

- Ecological processes
  - interactions between abiot and biotic systems, including movements of energy, nutrients and species
  - produce natural resources and fibre, transfer carbon and nutrients, drivers of soil formation, and enable organisms to reproduce
  - impacted by both natural forces and anthropogenic activities happening over a variety of temporal and spatial scales
  - Scale is important to process and pattern
    - In an ecological sense scale is the resolution at which an organism perceives its environment

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Landscape Function

- Landscape function considered as the capacity or potential of landscapes to provide services. It involves understanding
  - the spatial relationships among landscape elements
  - the flows of energy, materials and species between the landscape elements (e.g.patches, corridors)
  - the dynamics of the landscape elements over time.
- Consider:
  - Flows from forested blocks (patches) into clear-cut can have important effects on vegetation dynamics in clear cuts
  - Disturbed boundaries can have very different dynamics from the interior of a patch
  - Boundaries can also change location through time, with resulting effects on landscape structure
  - corridors linking similar landscape elements tend to improve or enhance flows.

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Metrics of landscape composition

- These metrics measure the variety and abundance of what is present in the landscape
- Does not consider the spatial character, placement, or location of patches within the mosaic
- Applicable only at landscape scale

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Metrics of landscape composition

- **Proportional Abundance** of each Class: One of the simplest and perhaps most useful pieces of information that can be derived is the proportion of each class relative to the entire map
- **Richness:** Richness is simply the number of different patch types

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Metrics of landscape composition

- **Evenness:** Evenness is the relative abundance of different patch types, typically emphasizing either relative dominance or its complement, equitability.

- **Diversity**: A composite measure of richness and evenness and can be computed in a variety of forms (e.g., Shannon and Weaver 1949, Simpson 1949), depending on the relative emphasis placed on these two components.
  - How diverse the distribution of class types

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Metrics of landscape configuration

- **Patch size distribution and density**: The simplest measure of configuration is patch size, which represents a fundamental attribute of the spatial character of a patch. Most landscape metrics either directly incorporate patch size information or are affected by patch size. Patch size distribution can be summarized at the class and landscape levels in a variety of ways (e.g., mean, median, max, variance, etc.), or, alternatively, represented as patch density, which is simply the number of patches per unit area.

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Metrics of landscape configuration

- **Patch shape complexity**: Shape complexity relates to the geometry of patches--whether they tend to be simple and compact, or irregular and convoluted.
  - generally index overall shape complexity rather than attempt to assign a value to each unique shape.
  - based on the relative amount of perimeter per unit area, usually indexed in terms of a perimeter-to-area ratio, or as a fractal dimension, and often standardized to a simple Euclidean shape (e.g., circle or square)

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Metrics of landscape configuration

- **Core Area**: Core area represents the interior area of patches after a user-specified edge buffer is eliminated.
- The core area is unaffected by the "edge effect"
- Core area integrates patch size, shape, and edge effect distance into a single measure.
  - All other things equal, smaller patches with greater shape complexity have less core area.

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Metrics of landscape configuration

- **Isolation/Proximity**: the tendency for patches to be relatively isolated in space (i.e., distant) from other patches of the same or similar (ecologically friendly) class.
- **Contrast**: relative difference among patch types.
  - A mature forest next to younger forest might have a lower-contrast edge than mature forest adjacent to open field
- **Dispersion**: Dispersion refers to the tendency for patches to be regularly or contagiously distributed (i.e., clumped) with respect to each other.
  - A common approach is based on nearest-neighbor distances between patches of the same type

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Metrics of landscape configuration

- **Contagion and Interspersion**: the tendency of patch types to be spatially aggregated
  - Contagion: occurrence in large, aggregated or "contagious" distributions.
  - Interspersion: the intermixing of patches of different types
- **Subdivision**: the degree to which a patch type is broken up (i.e., subdivided) into separate patches (i.e., fragments)
  - not the size, shape, relative location, or spatial arrangement of those patches.
- distinguishes between overall landscape patterns that are clumped or dissected

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Metrics of landscape configuration

- **Connectivity**: the functional connections among patches.
  - "functional connection" is application dependent
  - patches that are connected for bird dispersal might not be connected for, fire spread, or hydrologic flow.
- Connections might be based on
  - strict adjacency (touching),
  - threshold distance,
  - some decreasing function of distance that reflects the probability of connection at a given distance

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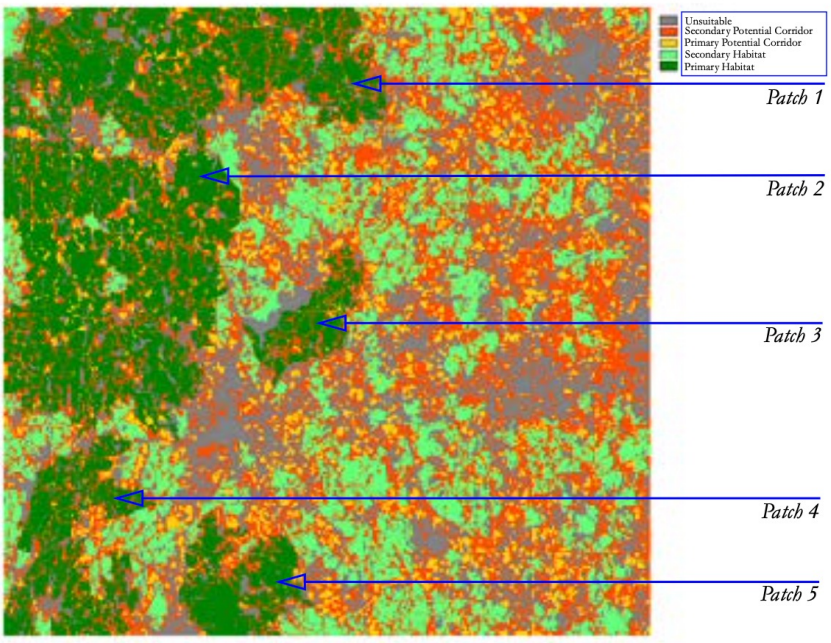

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