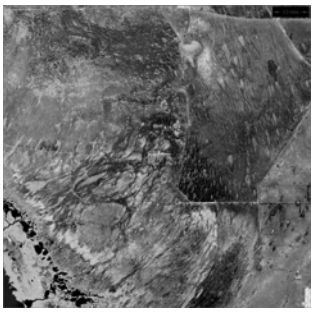
Quantifying Pattern



Florida Everglades
Image taken 2/5/2000

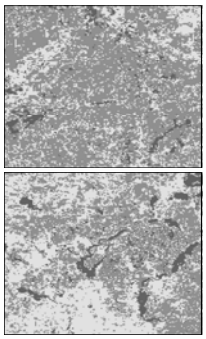
Spanning the southern tip of the Florida Peninsula and most of Florida Bay, Everglades National Park is the only subtropical preserve in North America. It contains both temperate and tropical plant communities, including sawgrass prairie, mangrove and cypress swamps, pinelands, and hardwood hammocks, as well as marine and estuarine environments. The park is known for its rich bird life, particularly large wading birds, such as the roseate spoonbill, wood stork, great blue heron, and a variety of egrets. It is also the only place in the world where alligators and crocodiles exist side by side.

The Everglades can be found on Landsat 7 WRS Path 15 Row 42, center: 26.00, -80.43.

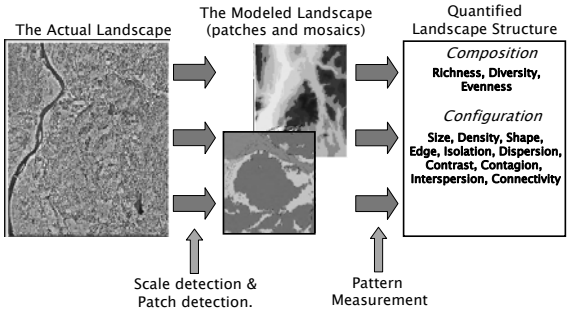
US Geological Survey/NASA http://astroboy.gsfc.nasa.gov/earthasart/index.html

Why Quantify Landscape Pattern and Scale?

- In order to relate landscape pattern to process, we need to quantify the pattern.
- Often have hypotheses relating pattern to ecological processes.
- Describe change over time.
- Compare different landscapes.



Quantifying Landscape Pattern



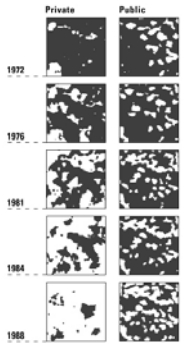
Basic components of metrics

- Fraction or proportion (p) of landscape occupied
- Number of land cover classes present
- Probabilities of adjacency among classes
- Contagion or 'clumpiness' within a class

Basic components of metrics—patch based

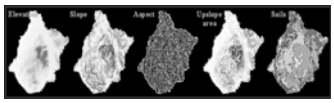
- Patch area or size
- Patch perimeter
- Connectivity/fragmentation within a cover type class (e.g., mean interpatch distance)
- Patch shape and edge characteristics

Why compute indices of landscape pattern?



For comparative purposes: To summarize differences between study areas or landscapes.

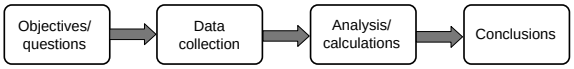
To infer drivers of pattern: As an explanatory analysis as a precursor to more strategic hypothesis testing.



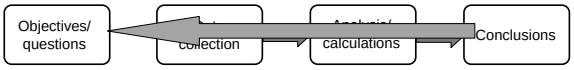
Critical caveats about landscape metrics

1. A clear, *a priori* statement of objectives is critical to avoiding misleading comparisons between metrics;

YES:



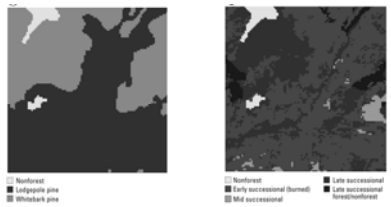
NO:



Critical caveats about landscape metrics

1. A clear, *a priori* statement of objectives is critical to avoiding misleading comparisons between metrics.

2. The classification scheme must be relevant and consistent for proper interpretation of landscape metrics.



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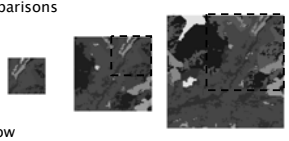
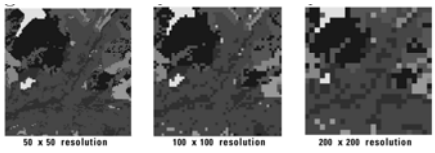


3. Both grain and extent will affect how landscape metrics are calculated and interpreted, and must be consistent across landscapes to be compared.



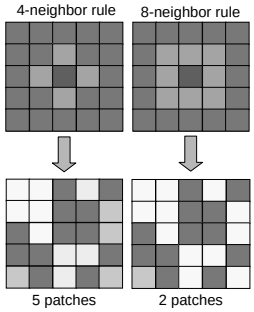
Critical caveats about landscape metrics

1. A clear, *a priori* statement of objectives is critical to avoiding misleading comparisons between metrics.

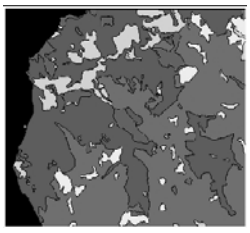
2. The classification scheme must be relevant and consistent for proper interpretation of landscape metrics.

3. Both grain and extent will affect how landscape metrics are interpreted, and must consistent across landscapes to be compared.

4. Neighbor rules are critical in defining landscape metrics.



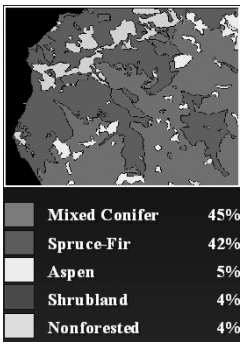
Components of landscape structure



Landscape composition:
The variety and relative abundance of landscape elements (diversity indices).

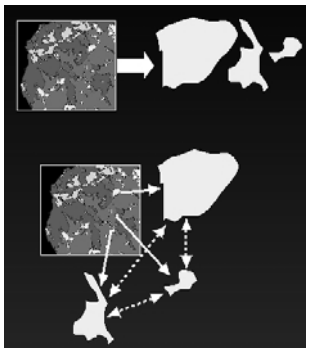
Landscape configuration:
The spatial characteristics and distribution of landscape elements.

Landscape Composition



- Number of patch types
  - Patch richness
- Proportion of each patch type
  - % of landscape
- Evenness
  - Shannon's Evenness Index
  - Simpson's Evenness Index
- Diversity
  - Shannon's Diversity Index
  - Simpson's Evenness Index

Landscape Configuration

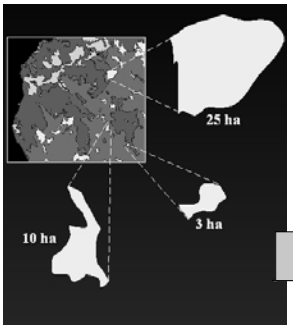


Patch level metrics
Patch data at the level of the individual patch type.

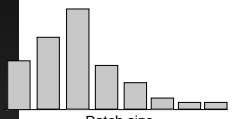
Between patch metrics
The importance of the surrounding neighborhood is acknowledged. *Spatially explicit*.

Landscape level metrics
The relative location of all patches on the landscape are included in calculations. The importance of spatial arrangement is acknowledged. *Spatially explicit*.

Metrics of Landscape Configuration

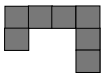


Patch size distribution and density
- Mean patch size
- Largest patch area
- Variation in patch size
- Patch density



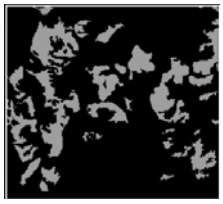
Metrics of Landscape Configuration

Low edge/area
Low complexity



Higher edge/area
Higher complexity

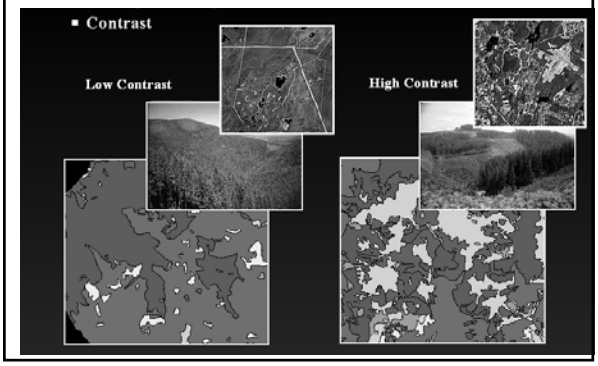
Shape complexity
- Edge-to-area ratio
- Shape index



Complex geometry

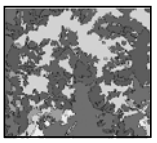
Simple geometry

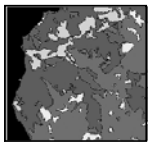
Metrics of Landscape Configuration



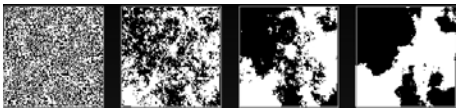
Metrics of Landscape Configuration

Contagion
- Contagion index





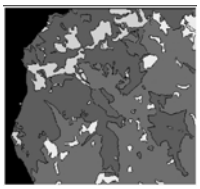
Low contagion → High contagion



Metrics of Landscape Configuration

- Refers to functional connections between patches.
- The "functional connection" depends on the object of interest
- May be based on:
  - Strict adjacency or a threshold distance
  - A decreasing function of distance
  - A distance function weighted for resistance – the least-cost path between patches

Connectivity Metrics
- Connectance
- Patch cohesion index
- Percolating cluster
- Correlation length
- Traversability index

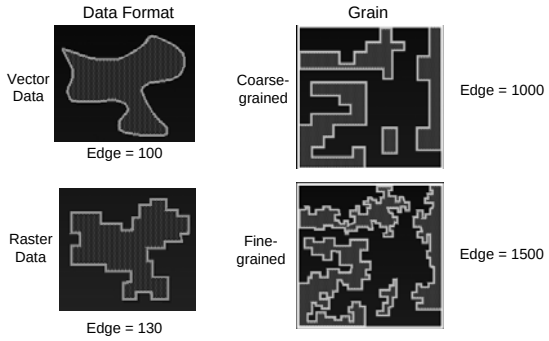


Landscape metrics--

Important limitations

Landscape metrics: Important limitations

Data format/Grain size

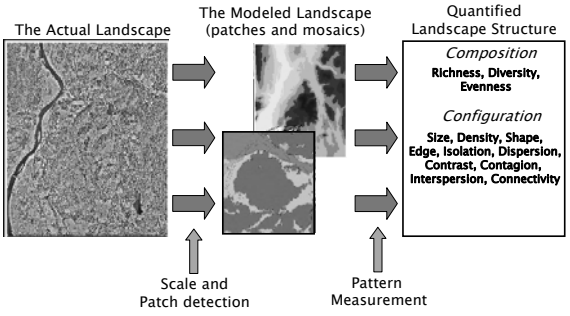


Landscape metrics: Important limitations

Boundary Effects

Landscape metrics: Important limitations

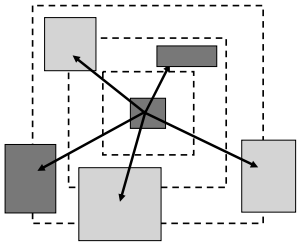
Information is always lost:



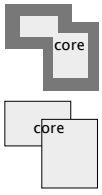
Landscape metrics: Important limitations

Measured vs. functional heterogeneity

Example: Two distinct ecological neighborhoods within one landscape



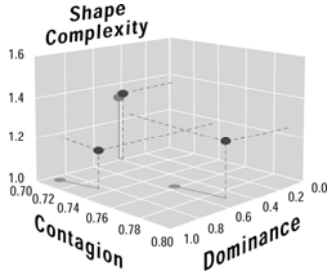
Example: Relevant buffer size and core area. Which core area is relevant? Is either?



Landscape with edge effects that limit core size

Landscape without any edge effect

One index is not sufficient--but how many?



Three-dimensional pattern space in which three subregions of the southeastern United States are characterized by three landscape metrics.

From Turner, Gardner, and O'Neill 2002

Landscape metrics: Important limitations

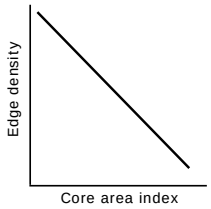
Redundancy/correlation of landscape metrics

Redundant/correlated by definition:

$$\text{Mean Patch Size} = \frac{\text{Total area}}{\text{Number of patches}}$$

$$\text{Patch Density} = \frac{\text{Number of patches}}{\text{Total area}}$$

Statistically redundant/correlated:



Landscape metrics: Conclusions

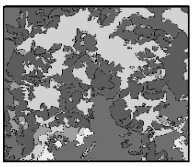
Primary measures of landscape pattern:

- Patch type
- Area
- Edge/shape
- Neighbor or surrounding types

All metrics are derived from these!

Main point:

The most important aspect of pattern depends on the application – which depends on the original hypothesis!



Looking at a large sample of classified landscapes, Riitters et al. (1995) found that only five metrics were needed to explain most of the variability in their samples:

- Number of patch types
- Mean edge/area ratio
- Contagion
- Average patch shape
- Fractal measurements