

Workshop:

Current trends in landscape fragmentation and connectivity assessment

This one-day workshop will cover concepts and applications of recently developed methodologies, metrics and tools for the analysis of landscape fragmentation and connectivity (based on remote sensing and GIS). The workshop is organized along with the thematic session “New perspectives in landscape fragmentation and connectivity assessment”, and is part of the project “Integration of categorical- and gradient-based approaches in landscape fragmentation and connectivity modelling using GIS&T” (no. 2011/03/D/ST10/05568) founded by the Polish National Science Centre (<http://www.ncn.gov.pl/>).

Workshop program

Time	Topic	Lecturer
9:00 – 10:45	The state of the art in fragmentation and connectivity assessment on landscape and habitat level (discussion)	Katarzyna Ostapowicz Peter Vogt Elżbieta Ziólkowska
10:45 – 11:15	Coffee break	
11:15 – 13:00	Part 1: Morphological spatial pattern analysis (MSPA) (computer exercises)	Peter Vogt
13:00 – 14:00	Lunch break	
14:00 – 15:30	Part 2 & 3: Assessment of fragmentation and connectivity on landscape and habitat level (computer exercises)	Katarzyna Ostapowicz Elżbieta Ziólkowska

Computer exercises

Part 2: Assessment of fragmentation

Goals

- construction of continuous surface base on output from the morphological spatial pattern analysis (MSPA) – categorical models
- use of the MSPA in fragmentation assessment

Data

- categorical maps: forest/non forest map (spatial resolution: 30, obtained from the Landsat image – part of the scene 186/26)

Software

- ArcGIS 10.1
- Guidos 2.1

Workflow

In this part of the workshop we will analysis forest fragmentation using the MSPA and density analysis. You will still use the forest map from the eastern part of the Polish Carpathians.

1. In the first step, create a project *fragmentation_analysis.mxd* in the ArcGIS software

Morphological spatial pattern analysis (MSPA)

In the next step we will create binary maps for two MSPA classes of forest structure: core (*core.img*) and edge (*edge.img*).

2. Add to the project the MSPA map which you obtained in the first part of this workshop using GUIDOS software
3. Identify codes/ids for two MSPA classes: core and edge (please use help from the GUIDOS software)
4. Reclassify the layer *MSPA.img* (Reclassify Spatial Analyst Tools > *Reclassify*) and create two mentioned above binary layers: core (*core.img*) and edge (*edge.img*).

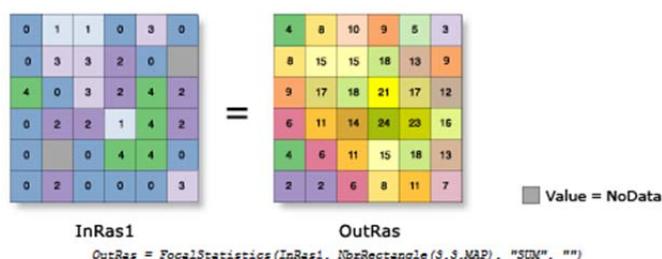
MSPA and continues model

In this step, we will create continues maps with a density of core (*den_core.img*) and a density of edge (*den_edge.img*) which allow us to locate spots with high and/or low proportion of given MSPA class. Based on this information we will assess a degree of fragmentation. We assume that

e.g. high degree of fragmentation is expressed by high density of edges (high values on the *den_edge.img* map) but low density of core (low values on *den_core.img* map).

5. Using map algebra and focal operations (Neighborhood Tools > **Focal Statistics**) create continuous maps with a density of core and a density of edge.

6. We will execute the process from point 5 twice for different parameters of moving window (3 and 7) to check if in this operation is any scale issue involved.



7. To create a maps of MSPA classes proportion with values from 0 to 100 (for easiest fragmentation degree assessment) we will use map algebra and local operation (Map Algebra > **Raster Calculator**) with equation: ["value from density map"*100/"area of moving window in pixels"].

MSPA and fragmentation assessment

Now, we will try to assess simultaneously different aspects of fragmentation which could be caused by e.g. degree of edge or core areas.

7. In final step, again using map algebra and local operation (Map Algebra > **Raster Calculator**) we will overlay two layers *den_core.img* and *den_edge.img* [(100 - *den_core_100.img*) + *den_edge_100.img*] and will create a layer *fragmentation.img* (values from 0 to 100). Based on output result we will identify the most fragmented areas (hot spots, areas with values close to 100).

Part 3: Assessment of habitat connectivity: example for the European bison in the Carpathian Mountains

Goals

- Comparison of different (binary, categorical and continuous) movement resistance surfaces for the European bison in the Carpathians
- Movement corridors vs movement paths – application of least-cost algorithms
- Construction and comparison of movement paths as least-cost paths delineated between habitat patches based on different movement resistance surfaces
- Using graph theory to assess the importance of habitat network elements

Data

- Categorical movement resistance surface created based on satellite land cover map, spatial resolution: 100m (source: classification of Landsat images, Kuemmerle et al. 2010)
- Habitat suitability map for the European bison (*Bison bonasus*) in the Carpathians, spatial resolution: 100m (source: Kuemmerle et al. 2010)
- Continuous movement resistance surface created based on habitat suitability map, spatial resolution: 100m
- Potential habitat patches delineated based on habitat suitability map (HSI > 0.6, area > 30km²)

Software

- ArcGIS 10.1
- Conefor Sensinode 2.6 (<http://www.conefor.org/>)

Workflow

1. From the folder **IGU_workshop\connectivity** open the ArcMap project **connectivity_analysis.mxd**

Different movement resistance surfaces for European Bison in the Carpathians

2. Under table of contents, you see one active data frame **bison connectivity**. Expand data under the first group layer **resistance surfaces**.
3. Compare three available resistance surfaces:
 - Binary: habitat / non-habitat (shapefile **habitat_patches.shp** contains potential bison habitat patches delineated based on habitat suitability model **HIS_bison_100m.tif** as groups of pixels with habitat suitability index > 0.6 and area > 30km²)

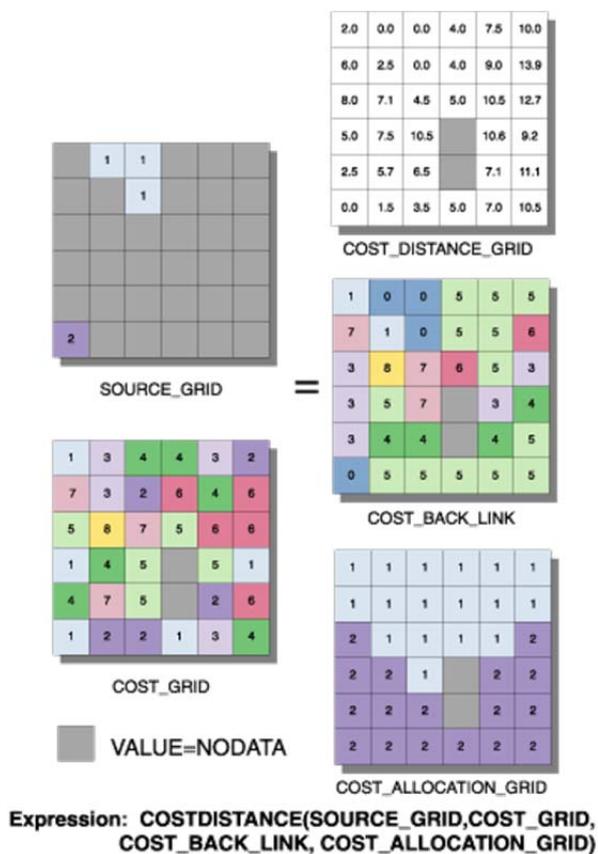
- Categorical **cost_LC.tif**: different levels of resistance to movement assigned to different land cover categories
- Continuous **cost_HSI.tif**: matrix defined as a continuous surface based on inverted habitat suitability model **HSI_bison_100m.tif** (from Kuemmerle et al. 2010¹)

Movement corridors vs movement paths – application of least-cost algorithms

- Under table of contents, expand data under the second group layer **path vs corridor**.

In this example we will create and compare movement path and movement corridor between two habitat patches.

Movement path

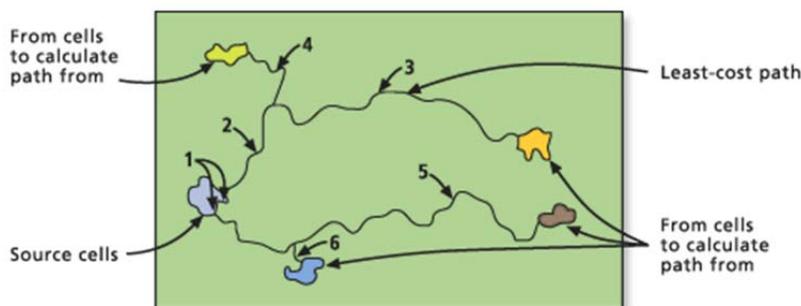


- We will use **Cost Path** tool available under the **Spatial Analyst Tools**. The **Cost Path** tool produces an output raster that records the least-cost path or paths from selected locations to the closest source cell defined within the accumulative cost surface, in terms of cost distance. Two of the weighted cost tools (**Cost Distance** and **Cost Back Link**) are required to run prior to running Cost Path to create the input cost distance and back link rasters. These are mandatory input rasters to Cost Path.

Cost Distance and Cost Back Link raster have to be created for the source habitat patch and together with destination patch they are inputs to Cost Path tool.

¹ Kuemmerle, T., Perzanowski, K., Chaskovskyy, O., Ostapowicz, K., Halada, L., Bashta, A. -T., Hostert, P., Waller, D.M. and Radeloff, V.C. (2010): European bison habitat in the Carpathian Mountains. *Biological Conservation*, 143, 908-916.

6. In order to create polyline feature with least-cost path between habitat patches we need to first reclassify the Cost Path raster (Spatial Analyst Tools > **Reclassify**) and then use one of the conversion tools (Conversion Tools > **Raster to Polyline**).



Movement corridor

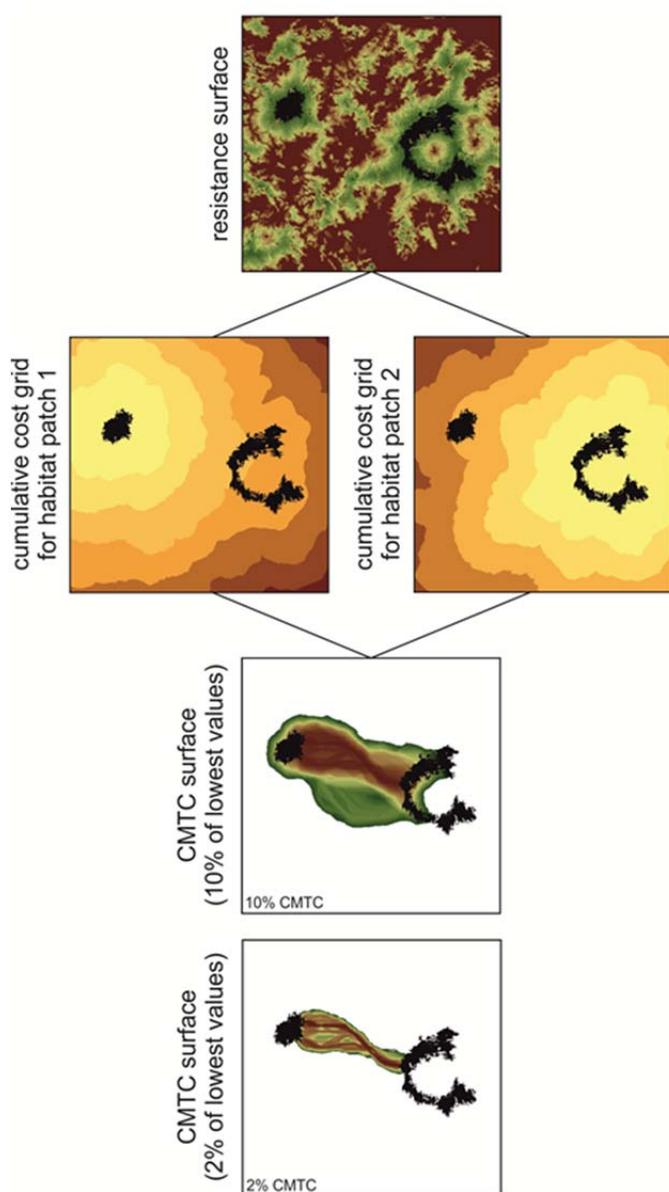
To visualize movement corridors, i.e., 'slices' of the landscape, each representing a zone of grid cells with costs below a certain threshold, we will use the **Conditional Minimum Transit Cost** (CMTC) method (Pinto and Keitt 2009²):

Consider a vertex (V) located between groups of source vertices (S) and target vertices (T). The CMTC for V is the cost-weighted distance to move from S to T, conditional on the route forming the shortest passage between S and T while passing through V. It is calculated as:

$$CMTC(V, S) = Cumulative\ cost(V, S) + Cumulative\ cost(V, T)$$

The final CMTC grid is obtained by masking out all cells with CMTC values larger than the minimum CMTC value plus e.g. 10%. The remaining values are then divided by the grid's maximum CMTC.

7. To create CMTC raster add Cost Distance rasters (Spatial Analyst Tools > **Map Algebra**) created for both habitat patches.



² Pinto, N., Keitt, T.H.: (2009) Beyond the least-cost path: evaluating corridor redundancy using a graph-theoretic approach. *Landscape Ecology*, 24, 253-266.

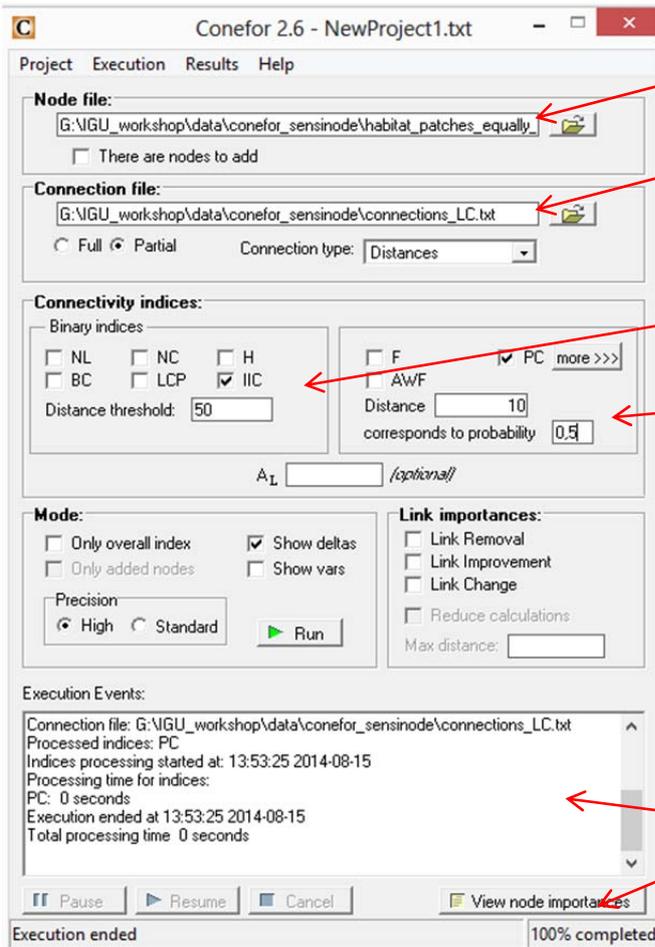
8. Visualize zones of grid cells with costs below a certain threshold using raster properties.

Comparison of least-cost paths delineated between habitat patches based on different movement resistance surfaces

9. Under table of contents, expand data under the third group layer **least-cost paths**.
10. Compare least-cost paths created based on three different resistance surfaces you explored earlier:
 - Binary resistance surface -> movement paths as straight lines between habitat patches: ***Euclidean_paths.shp***
 - Categorical resistance surface -> movement paths as least-cost paths between habitat patches: ***cost_paths_LC.shp***
 - Continuous resistance surface -> movement paths as least-cost paths between habitat patches: ***cost_paths_HSI.shp***

Conefor Sensinode and importance of habitat network elements

11. Open Conefor Sensinode 2.6 software (available on the desktop)
12. Test how importance of habitat patches in the habitat network will change if different weights of nodes and connections are used:
 - nodes: equally-weighted (***habitat_patches_equally_weighted.txt***) / area-weighted (***habitat_patches_area_weighted.txt***) / HSI-weighted (***habitat_patches_HSI_weighted.txt***)
 - connections: length of least cost paths delineated based on binary (***connections_Euclidean.txt***) / categorical (***connections_LC.txt***) / continuous movement resistance surface (***connections_HSI.txt***)
13. We will test the performance of two graph-based connectivity indices: ***integral index of connectivity*** and ***probability of connectivity*** with the following assumptions:
 - Movement distance of 10km corresponds to movement probability of 0.5
 - Distance threshold (maximum movement distance): 50km



node file

connection file

selection of binary connectivity indices

selection of probabilistic connectivity indices

results