Fragmentation indicator FRA (project regions)

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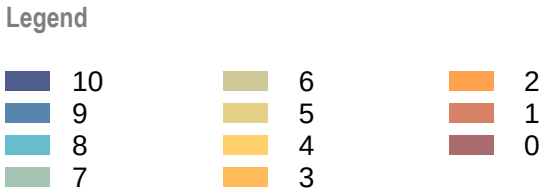
Summary Representation of the influence of landscape fragmentation on ecological connectivity. Fragmentation is expressed as the effective mesh density. It is one of the indicators belonging to the continuum suitability indices CSI (consisting of LAN, POP, FRA, INF, TOP and ENV).



1 Introduction

Based on island biogeography (Simberloff and Abele, 1976), areas rich in biodiversity need to be of a minimum size in order to maintain their species richness. Small disconnected areas that do not allow for movement lose their biodiversity within a short time. Fragmentation is a landscape-level phenomenon – it results from habitat loss and subsequent division of large and continuous areas into small isolated remnants, and alters community structure and ecosystem functioning (Didham, 2010). The aim of the fragmentation index is to represent the influence of landscape fragmentation on ecological connectivity. It is expressed as the effective mesh density, a measure based on effective mesh size (Jaeger, 2000).

2 Data

We used regional infrastructure data. Height-dependent analyses were conducted with the ASTER Global Digital Elevation Model (NASA et al., 2011) with a spatial resolution of 30m. The complete list is provided in Table 1.

Table 1: Regional infrastructure data.

Fragmentation geometry	Country	Region(s)	Dataset(s)	Categories
Highways and important main roads (Tunnels with a length of >1km removed)	Austria	Kärnten, Salzburg, Niederösterreich, Oberösterreich, Steiermark, Tirol	regional datasets	A: Autobahn, S: Schnellstraße, B: Landesstraße B (ehem. Bundesstrassen)
	France	Haute-Savoie	BDTOPO	Autoroute, Quasi-autoroute, Bretelle, Route à 2 chaussées, Nationale
	Germany	Bayern	ATKIS	Europastrasse, Bundesstrasse, Staatsstrasse (ohne Anliegerstrassen)
	Italy	Aosta	PTP	autostrade, strade viabilita principale (partly)
		Friuli Venezia Giulia	Strade (IRDAT)	Autostrada, Raccordi autostradali, Strada Statale
		Lombardia	Strade principali	all
		Südtirol		Autobahn, Staatsstrasse
		Trento	PTP	strade principali

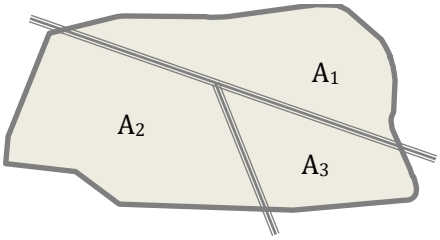
Fragmentation geometry	Country	Region(s)	Dataset(s)	Categories
	Slovenia		regional dataset	highway (avtocesta), fast road (2hitra cesta), main road class I (glavna cesta I. reda)
	Switzerland	Valais, Graubünden	TLM	Hochleistungsstrasse, Durchgangsstrasse
All main roads and railways (Tunnels with a length of >1km removed)	Austria	Kärnten, Salzburg, Niederösterreich, Oberösterreich, Steiermark, Tirol	regional datasets	A: Autobahn, S: Schnellstraße, B: Landesstraße B (ehem. Bundesstrassen), L: Landesstraße L, H: Hauptstraße, P: Hochrangige Privatstraße, EH: Eisenbahn hochrangig, EN: Eisenbahn Nebenbahn, ES: Eisenbahn Sonstige
	France	Haute-Savoie	BDTOPO	Importance 1-3, TRONCON_VOIE_FERREE
	Germany	Bayern	ATKIS	Europastrasse, Bundesstrasse, Staatsstrasse, Kreisstrasse
	Italy	Aosta	PTP	autostrade, strade viabilita principale
		Friuli Venezia Giulia	Strade (IRDAT)	Autostrada, Raccordi autostradali, Strada Statale, strada provinciale, strada regionale
		Lombardia	Strade principali	strade principali
			Strade secondarie	Strade secondarie
			Ferroviaria	Ferroviaria
		Südtirol		Autobahn, Eisenbahn, Landesstrasse, Staatsstrasse, Gemeindestrasse in Landesinstandhaltung
		Trento	PTP	
	Slovenia			highway (avtocesta), fast road (2hitra cesta), main road class I (glavna cesta I. reda), main road class II (glavna cesta II. reda)
	Switzerland	Valais, Graubünden	TLM	Hochleistungsstrasse, Durchgangsstrasse, Verbindungsstrasse, Eisenbahn
Settlements and facilities (airports etc.)	Austria	Kärnten, Salzburg, Niederösterreich, Oberösterreich, Steiermark, Tirol	Siedlung Statistik Austria	all
	France	Haute-Savoie	BDTOPO	
	Germany	Bayern	ATKIS	Ortslage
	Italy	Aosta	PTP	
		Friuli Venezia Giulia	OSM	
		Lombardia	OSM	
		Südtirol	Land use plan	
		Trento	PTP	
	Slovenia		OSM	
	Switzerland	Valais, Graubünden	TLM	Siedlungsname, Verkehrsbaute, Verkehrsareal
High altitude areas (>2900 m a.s.l.)	all countries		SRTM	

3 Methods

Fragmentation was calculated twice: 1) using the whole dataset, and 2) using only high- and motorways. With this approach, high- and motorways are assigned greater importance. For the analysis tunnels with a length of 1km were deleted. Shorter tunnels were treated as fragmentation geometries. The effective mesh size (meff; Jaeger, 2000) was calculated for both datasets as:

$$m_{eff} = \frac{1}{A_{tot}} \sum_{i=1}^{n} A_i^2$$

A schematic example of the calculation of the effective mesh size is sketched in Figure 1.



$$m_{eff} = \frac{1}{A_{tot}} (A_1^2 + A_2^2 + A_3^2)$$

Figure 1:Schematic example of effective mesh size (m_{eff})

In order to omit border effects, the cross-boundary connections approach of the effective mesh size presented by Moser et al. (2007) was applied. It is sketched in Figure 2.

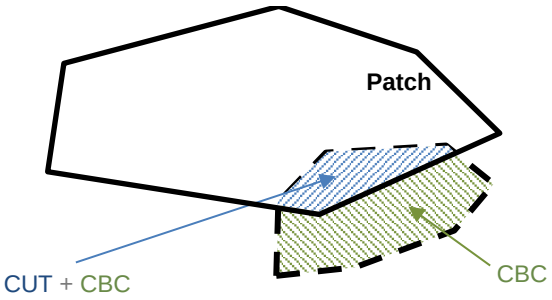


Figure 2:Sketch of the CBC method and the commonly applied cutting-out procedure CUT.

Instead of evaluating the effective mesh size for administrative boundaries as done by Bertiller et al. (2007) and many others, it was calculated for a regular grid. For every point, the effective mesh size was calculated for the surrounding 10km^2. For the evaluation of fragmentation, the effective mesh density s_{eff}CBC per 1000km^2 was used – it is directly derived from the effective mesh size:

$$s_{eff}CBC = 1000\ km^2 / m_{eff}CBC$$

The effective mesh density was reclassified according to the classification schemes in Table 2. Afterwards, a weighted mean of the two analyses was calculated:

$$FRA = 0.75 * value_{(Seff,all)} + 0.25 * value_{(seff,motor-/highway)}$$

Table 2: Classification schemes

s_{eff}(all)		s_{eff}(motor-/highway)	
Number of meshes per 1000 km² (s_{eff})	**Indicator Value (0-10)**	**Number of meshes per 1000 km² (s_{eff})**	**Indicator Value (0-10)**
<0.5	10	<0.0001	10
0.5-1	9		9
1-2	8		8
2-5	7		7
5-10	6	0.0001-0.0005	6
10-20	5	0.0005-0.001	5
20-30	4	0.001-0.005	4
30-50	3	0.005-0.01	3
50-75	2	0.01-0.05	2
75-100	1	>0.05	1
>100	0		0

4 References

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