



Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

Swiss Confederation

Bundesamt für Umwelt BAFU  
Office fédéral de l'environnement OFEV  
Ufficio federale dell'ambiente UFAM  
Federal Office for the environment FOEN

# Landscape Fragmentation

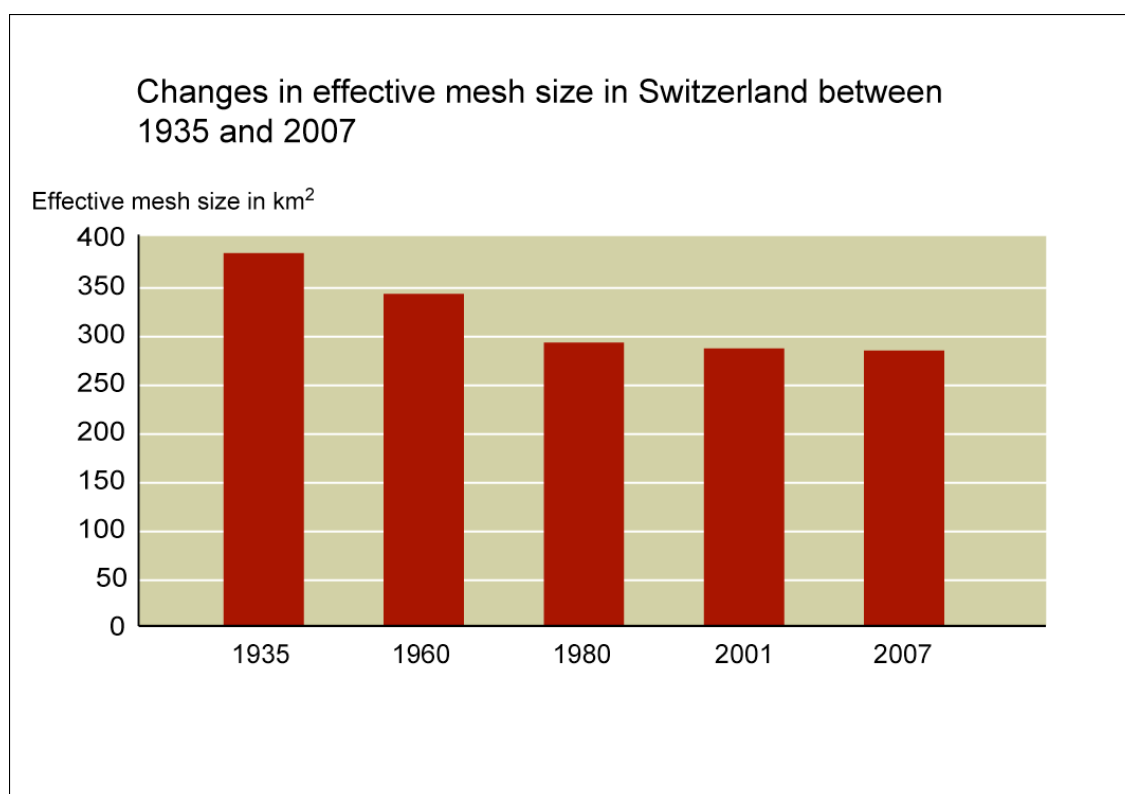
The Landscape Fragmentation indicator records the degree to which Switzerland's landscape below 2,100 meters above sea level is cut up by artificial barriers such as roads or settlements. As more and more such barriers split up the landscape, animals are increasingly prevented from moving about freely, which in turn keeps adding to the pressure exerted on biodiversity.

For the latest data, please go to [www.biodiversitymonitoring.ch](http://www.biodiversitymonitoring.ch)

## Development in Switzerland

Landscape fragmentation is measured by effective mesh size, i.e. the size of patches remaining free of barriers cutting up the landscape. The greater the number of barriers cutting up a landscape, the smaller the effective mesh size. In the past 70 years, the effective mesh size has been steadily decreasing, as Switzerland's landscape underwent major fragmentation processes during that period of time.

Effective mesh size in square kilometers					
	1935	1960	1980	2001	2007
<b>Switzerland</b>	383	341	291	285	283



**Interpretation example:** The effective mesh size in Switzerland has been narrowed down from 383 square kilometers in 1935 to 283 square kilometers in 2007. Please note that the last observation interval is considerably shorter than all that precede it.

### Comments

- Effective mesh sizes refer to Switzerland's landscape below 2,100 meters above sea level, excluding waterbodies.
- Data are available for 1935, 1960, 1980, 2001 and 2007, the years when completely revised National Maps of Switzerland were published. 2001 and 2007 datasets were created using original digital data (VECTOR25), while existing National Maps (1:100,000) as well as the Dufour Map were digitalized in order to obtain the necessary information for 1935, 1960 and 1980.
- Barriers shown on old maps were digitalized manually. However, this only marginally affected effective mesh size, which tends to be represented as too narrow in the years before 2001.

- In computing effective mesh size, national borders were considered to be actual barriers, while regional boundaries were not taken into account.
- Sections of roads and railroad tracks may be reclassified for political or methodological reasons, which impacts effective mesh size.
- Directional lanes of highways count as two individual roads.
- As a measuring unit, effective mesh size assigns equal weight to all barriers. In real life, however, it makes a big difference whether an animal is confronted with a small country road or a highway. While it is possible that for some species, all listed infrastructure elements might constitute insurmountable obstacles, for most species, it will be the nature of the barrier placed in their path (volume of traffic, wideness, animal-tight fences, etc.) that carries the most weight.
- Switzerland's villages, agricultural areas and forests are rendered accessible by a multitude of small roads. Taking them into account would reduce the country's effective mesh size by two thirds—or even nine tenths on the Central Plateau<sup>1</sup>. However, small country and forest roads were disregarded in computing effective mesh size for the purposes of the E15 indicator.
- The issue of landscape fragmentation has been on the agenda of Swiss authorities for a while. Back in 1998, a joint publication by the Federal Offices for the Environment and for Spatial Development titled *Landschaftskonzept Schweiz* ("Swiss Landscape Concept")<sup>2</sup> requires the sprawling of settlements to be contained and the fragmentation of landscapes by new and existing roads or railroad tracks to be minimized (material objectives 8c and 10d).

**Source**

FOEN, Landscape Watch Switzerland (LABES), 3003 Bern

**Status**

2009. Fragmentation data will be updated once all Swiss National Maps have been revised again. These map revisions take place every six years, with current surveys by the Federal Office of Topography scheduled for the period of 2009 to 2014.

<sup>1</sup> Environmental Watch Network Switzerland (NUS), evaluation protocol for parameter 9a (unpublished working paper, not available in English)

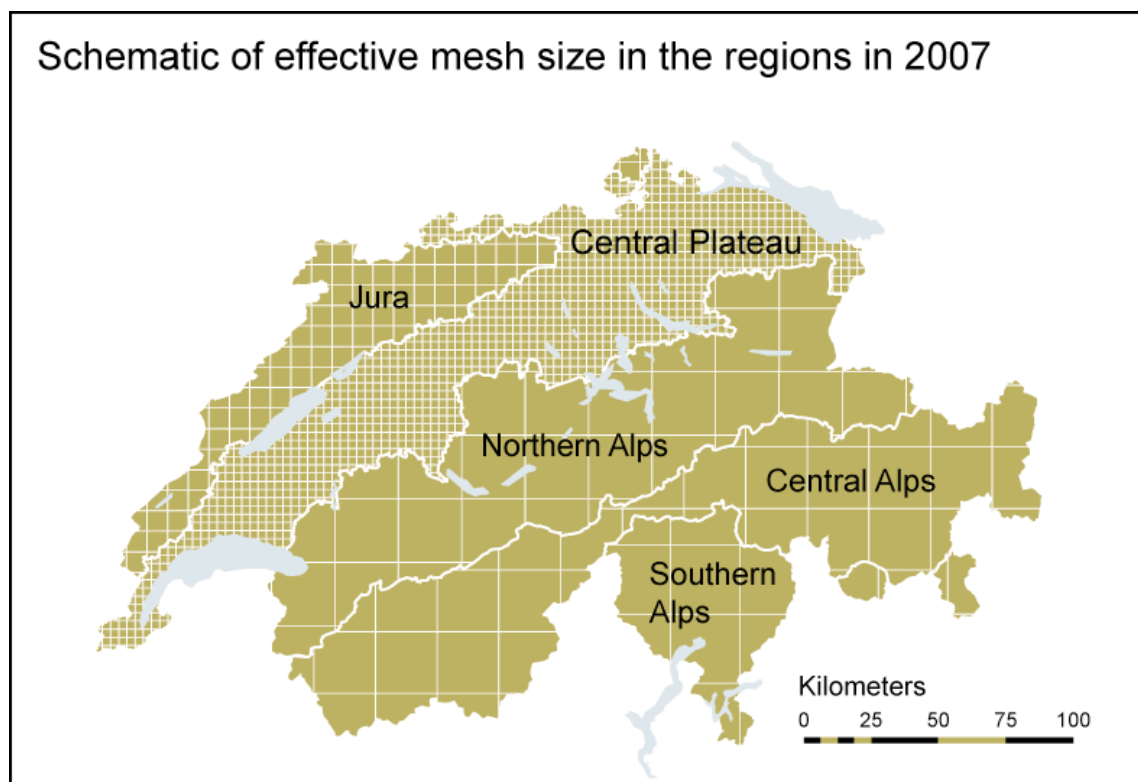
<sup>2</sup> Federal Office for the Environment, Federal Office for Spatial Development (ed.), 1998: *Landschaftskonzept Schweiz*. ARE-Reihe Konzepte und Sachpläne. Bern, Federal Office for the Environment, Federal Office for Spatial Development. 175 p. (abstract available in English)

## Development in the regions

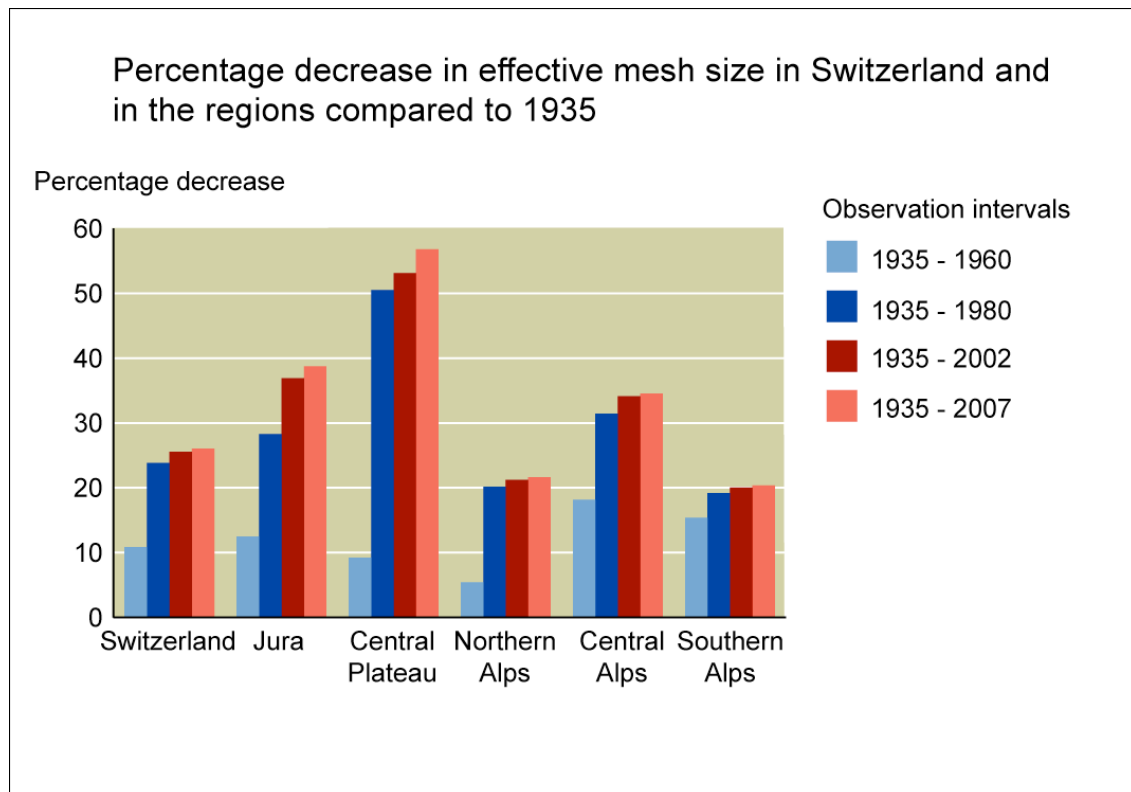
Landscape fragmentation differs in individual regions. At just over 8 square kilometers, effective mesh size on the Central Plateau is 56 to 71 times smaller than in the Alps.

	Effective mesh size in square kilometers				
	1935	1960	1980	2001	2007
<b>Jura</b>	85	75	61	54	52
<b>Central Plateau</b>	19	18	10	9	8
<b>Northern Alps</b>	637	602	508	502	499
<b>Central Alps</b>	719	589	493	474	471
<b>Southern Alps</b>	748	633	604	598	595
<b>Switzerland</b>	383	341	291	285	283

**Interpretation example:** On the Central Plateau, effective mesh size dropped from 18 square kilometers in 1960 to 8 square kilometers in 2007. Obviously, this region's landscape has been severely split up by artificial barriers in recent decades.



Schematic of the effective mesh size in Switzerland's biogeographical regions in 2007. Meshes are tightest on the Central Plateau (8 square kilometers) and loosest in the Southern Alps (595 square kilometers). Source: adapted from Jaeger et al., 2007.



Percentage decrease in effective mesh size in Switzerland and its regions since 1935.

### Comments

- Switzerland's landscape has been most severely fragmented between 1960 and 1980. Only in the Central and Southern Alps, landscape fragmentation was even more pronounced before 1960 than later on.
- As early as in 1935, landscape fragmentation in individual regions differed very markedly. On the Central Plateau and in the Jura, effective mesh size was a lot tighter (19 and 85 square kilometers respectively) than in the Alps (roughly 700 square kilometers) even in those days.
- Between 1935 and 1960, landscapes were most severely cut up in the Central Alps, the Southern Alps, and the Jura. During the same period of time, the situation in the Northern Alps hardly changed at all.
- From 1960 until 1980, landscape fragmentation progressed noticeably in all regions, with the development being most marked on the Central Plateau, where effective mesh size plummeted by 45%.
- Between 1980 and 2001, the 12% decrease of the effective mesh size in the Jura exceeded the Swiss average of 2% by sixfold. In all other regions, effective mesh size diminished by 1% to 5%.
- Unlike the Jura and the Central Plateau, the Alps were only subjected to a minor increase in landscape fragmentation from 1980 until 2007.
- At 8%, effective mesh size on the Central Plateau shrank more markedly again between 2001 and 2007, while landscape fragmentation did not continue to progress in the Alps.

### Source

FOEN, Landscape Watch Switzerland (LABES), 3003 Bern

### Status

2009. Fragmentation data will be updated once all Swiss National Maps have been revised again. These map revisions take place every six years, with current surveys by the Federal Office of Topography scheduled for the period of 2009 to 2014.

## Significance for biodiversity

In the past 70 years, Switzerland's landscape has increasingly been fragmented by a growing number of infrastructures. The more barriers are erected in a landscape, the more restrictions are placed upon the freedom of movement animals used to have.

New structures reduce the habitat size available to wild animal and plant species, since roads, railroad tracks, residential buildings and factories need room (see also BDM indicator E2: "Size of Areas of Defined Use"). In addition, a large number of vertebrates and countless insects end up as road kill each year.

What is more, infrastructures not only deprive plants and animals of habitat, but they also have an indirect impact on the landscape, generating noise, light and air pollution or changing microclimates. Some species avoid man-made structures, which reduces their potential habitats even more. As a result, areas in which animals feel undisturbed become ever more scarce due to landscape fragmentation.

As habitats are trimmed down and cut up, existing animal populations are decimated and isolated, increasing the risk that species might disappear on a local level. For most species, the effect of habitat diminution and fragmentation is not known, and in many cases, there is a substantial time delay to be observed between that process and a species' response to it.

Infrastructures prevent a great many animal species from spreading out, for example because they shy away from crossing human settlements. For species living on the ground, roads may be impassable, being either too dry, too wide, too busy, or fenced in. Landscape fragmentation particularly affects species requiring a lot of space, such as the European Lynx, which has been measured to cover average action ranges of 150 square kilometers in Switzerland. Seasonal migrators are often confronted with sizeable obstacles as well. Red Deer, for example, are used to traveling dozens of kilometers from their summer pastures in the mountains to milder winter quarters in the valleys below. Frogs and toads are known to cover several kilometers to reach their spawning sites.

## Further information

### In charge of this indicator

Mr. Lukas Kohli, kohli@hintermannweber.ch, +41 (0)31 310 13 02

FOEN expert contact: Mr. Gilbert Thélin, gilbert.thelin@bafu.admin.ch, +41 (0)31 322 80 97

### Additional sources of information

*Umweltbericht 2007*, Kapitel 12. Landschaft und Biodiversität, www.bfs.admin.ch (not available in English).

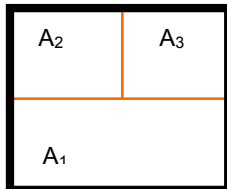
Jaeger, J.; Bertiller, R.; Schwick, C., 2007: *Landschaftszerschneidung Schweiz: Zerschneidungsanalyse 1885-2002 und Folgerungen für die Verkehrs- und Raumplanung*. Kurzfassung. Federal Statistical Office, Neuchâtel. 36 S. (not available in English).

## Definition

Changes in landscape fragmentation of the terrestrial expanse below 2,100 meters above sea level in Switzerland and its biogeographical regions.

## Surveying methods

Landscape fragmentation is measured by effective mesh size ( $m_{\text{eff}}$ ), which is computed using the following formula:



Area $A_{\text{total}}$ :	4 km <sup>2</sup>
$A_1$	2 km <sup>2</sup>
$A_2 = A_3$	1 km <sup>2</sup>
Effective mesh size:	1,5 km <sup>2</sup>

$$m_{\text{eff}} = \frac{1}{A_{\text{total}}} (A_1^2 + A_2^2 + A_3^2 + A_4^2 + A_5^2 + \dots + A_n^2)$$

Applied to the above example, the effective mesh size is:  $m_{\text{eff}} = \frac{1}{4} (2^2 + 1^2 + 1^2) = \frac{4 + 1 + 1}{4} = \frac{3}{2} = 1,5 \text{ km}^2$

Regarding 2007 and 2001, data are based on original digital 1:25,000 National Maps of Switzerland (VECTOR25), while 1:100,000 National Maps and Dufour Maps were digitalized regarding 1980 / 1960 and 1935, respectively. Barriers are considered to be formed by highways, 1<sup>st</sup> and 2<sup>nd</sup> class roads, railroad tracks, dams and pressure lines, settlement and industrial areas (including airports and railroad stations). Switzerland's national border counts as a barrier as well, except for the enclaves at Büsingen and Campione. Artificial fragmentation by regional boundaries is avoided by using the Cross-Boundary Connections (CBC) procedure (Moser *et al.*, 2007)<sup>1</sup>.

*This information is based on the German document 800 330 Produkt E15\_V1.doc dated November 23, 2009.*

<sup>1</sup> Moser, B.; Jaeger, J.A.G.; Tappeiner, U.; Tasser, E.; Eiselt, B., 2007: Modification of the effective mesh size for measuring landscape fragmentation to solve the boundary problem. – Landscape Ecology 22(3): 447-459.