

21 April 2008
JLW-SSP

Net Landscape Ecological Potential of Europe
and change 1990-2000

*Jean-Louis Weber, Rania Spyropoulou, EEA
Tomas Soukup, Ferran Páramo, ETCLUSI*

Introduction

Ecosystem integrity¹ has been defined as the ability of managed ecosystems to support and maintain balanced, integrated, adaptive biological communities having a species composition, diversity and functional organization comparable to that of a natural habitat in the region. Integrity is a key determinant of the potential of healthy ecosystems to deliver over time those multiple services necessary for society development and human wellbeing. To move towards sustainable development implies that societies in Europe and elsewhere in the world must seek to manage ecosystems towards achieving/ maintaining a good ecological potential, given their changed conditions.

At the macro scale for terrestrial ecosystems, an ecological potential can be described in terms of landscape characteristics, species diversity and biomass.

This paper introduces the Net Landscape Ecological Potential (NLEP) as a way to measure and assess ecosystem integrity at a macro scale in Europe on the basis of land cover changes. The signal of land cover changes is enhanced by the probability of presence of areas representing high species/ habitats diversity and by the weighting of presence of areas with high density of transportation networks. The first proxy index of landscape ecological potential is based on vegetation types and physiognomy which are correlated to both natural characteristics and land use intensity. In addition to land cover by vegetation, the areas which have been designated for nature conservation on the basis of their habitats and species of particular importance supply a second proxy indicator for ecological value. Last, habitat fragmentation can be a limiting factor for species abundance and diversity as it reduces the area which can be used by species populations and blocks the functioning of ecological networks. A third proxy index reflecting fragmentation is calculated from transport networks density.

A given configuration of these 3 indexes results in a digital image which can be translated into a conventional indicator, the net landscape ecological potential (NLEP).

NLEP, the Net Landscape Ecological Potential is a macro indicator derived from Land and Ecosystem Accounts (LEAC)² and spatial analysis tools developed at the EEA. Spatially distributed by 1km² grids,

¹ Ecosystem integrity, goods and services is one of the four thematic areas, adopted in 2005 by the Convention of Biological Diversity, aiming to monitor progress towards the 2010 target for significantly reducing biodiversity loss

² Land accounts for Europe 1990-2000, *Towards integrated land and ecosystem accounting*,
EEA Report No 11/2006 http://reports.eea.europa.eu/eea_report_2006_11/en

NLEP enables connecting ecological potentials and human pressure via land use and detect impacts in a systematic way.

NLEP for Europe is the combination of 3 different geographical datasets (layers, indexes):

1. The so-called green background landscape index (GBLI)³ which expresses the vegetation potential of the territory according to land use intensity; at the most aggregated level, land cover types are aggregated in 2 classes, the “green” – the less intensive use – and the non-green – the most intensive use, conventionally: artificial land and cropland. The data are computed from Corine land cover and updated accordingly.
2. The social value given to nature assessed via the importance of its designation by science and policy; this is computed from the combination of European (Natura 2000), internationally, and nationally (CDDA) designated sites maps. It captures what cannot be seen from the satellite images, namely, the species richness/habitats of landscape which has motivated designation for nature conservation.
3. The fragmentation of landscape by roads and railways, which is not captured in the previous 2 layers. The indicator retained is the “effective mesh size” (MEFF), for its natural logarithm (ln) value. The lower the effective mesh size, the higher the fragmentation.

The 3 layers are computed using the standard European 1 km² grid; they are finally combined for producing NLEP.

The Making of LNEP:

- GBLI = Aggregation of CLC classes 2B, 3, 4 & 5, smoothed at 5 km. Range [0-100]
- NATURILIS_COMB or COMB = Union of N2K and CDDA, smoothed at 5 km. Range [0-100]
- Gross_LEP or GLEP= GBLI + COMB. Range [0-200]
- GLEPscaled = (GLEP * 255) / max(GLEP). Range [0-255]
- ln(MEFF). Range [0-255]

and

$$\text{NLEP} = \sqrt{\text{GLEPscaled} * \ln(\text{MEFF})}. \text{ Range [0-255]}$$

1. Construction of NLEP

(1) ***Green Background Landscape Index (GBLI): Landscape characteristics favourable to nature***

Agro-systems with pastures and/or mosaics of parcels, forests and other semi-natural or natural dry land, wetlands and water bodies are land cover types a priori favourable to nature. They may be or not designated and protected for their natural value. This ***Green Background Landscape*** is a natural asset in its own as well as an important component (with rivers) of the connectivity between areas of high ecological interest.

GBLI is mapped from a selection of CLC classes (*see annex 1*) smoothed in order to compute their value in their neighbourhood (CORILIS). The methodology is presented in Land accounts for Europe 1990-2000⁴. GBLI is a modifiable index and map:

- The standard map is based on CLC classes 2B, 3, 4 and 5 but the selection of elementary classes can be modified (the CORILIS layers are additive);
- Current applications are presented with 1 km² grid cells and 5 km span but smoothing can be processed with a different radius (radius used at the European scale are of 5, 10 and 20 km).

³ Land accounts for Europe 1990-2000, op. cit. – see in particular page 71

⁴ Op. cit.

- CORILIS layers based on Corine land cover raster maps at 100 m (1 ha grid cells) will be processed in 2008, with 1, 3 and 5 km radius for local applications.
- The green background index is expressed as a value between 0 and 100; a map of the GBLI can present continuous (stretch) values (between 0 and 100 or 0 and 255) or refer to any appropriate thresholds.

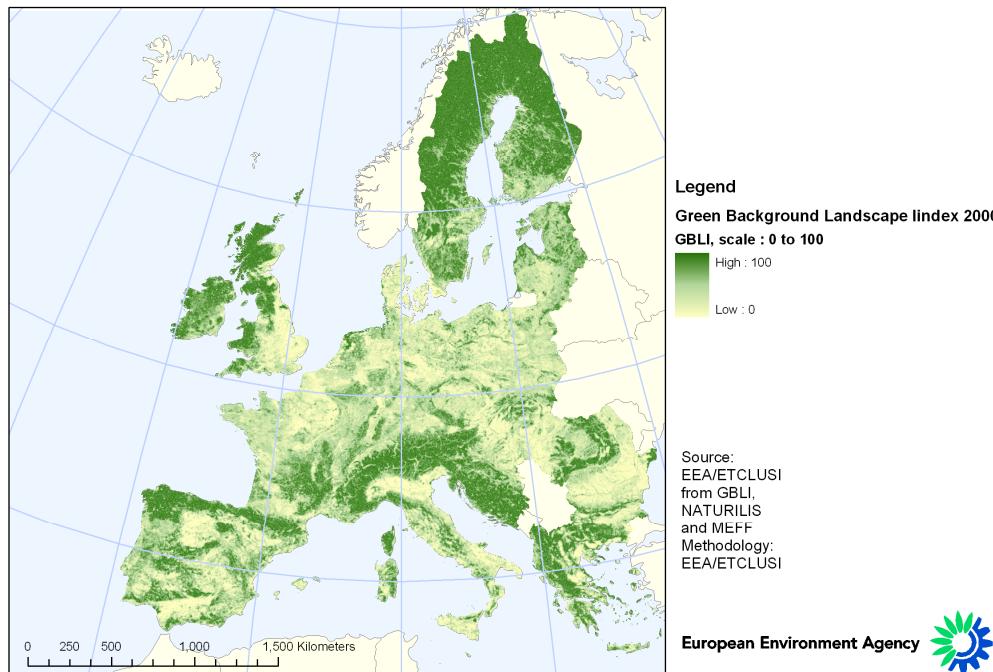


Figure 1: the Green Background Landscape Index, a measurement of less intensive land use and potential landscape connectivity is displayed in grades of green

(2) Combined NATURILIS map: Areas of high ecological value

Designated areas for nature protection do not exist in isolation to their surroundings. They are created for providing protection to natural features within their boundaries, as well as for providing refuge to nature in core areas which will in turn influence their neighbourhood and in many cases they are created to serve as corridors or nodes of ecological networks. Symmetrically, the long term sustainability of many high value habitats depends on their exchanges with their environment and/or similar habitats.

Therefore, the areas of high **ecological value** to consider are not only important in themselves but their buffer zones as well (see definition of the ecological networks, CoE 2007⁵). The buffers should reflect an influence which is proportional to the size and inversely proportional to the distance from the border of the designated area. This is the “potential in the neighbourhood” of designated areas. By analogy to CORILIS, the database of smoothed values of designated areas of high ecological value is called NATURILIS (or COMB_NATURILIS when several layers are combined).

Without judging whether nature conservation has achieved all its objectives, the areas of high ecological value are defined, in a first instance, from the designated areas: CDDA national designations, Natura2000 sites, EMERALD sites, and other international designations. This restrictive approach, based on the value attributed by society, bears the advantage of a broad scientific consensus on the designated sites and consequently on available databases.

⁵ Council of Europe (CoE), The Pan-European Ecological Network: taking stock - Nature and Environment N°146 (2007)

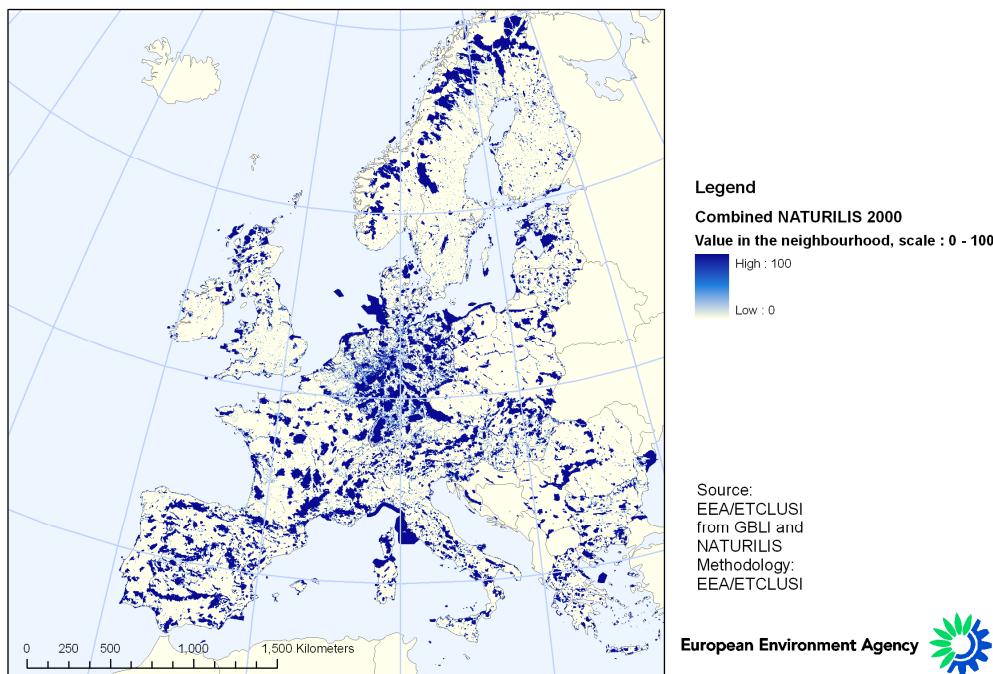


Figure 2: Combined NATURILIS: natural potential or high ecological value in a neighbourhood of 5 km of designated sites

(3) Gross Landscape Ecological Potential

When adding GBLI and COMB_NATURILIS maps, we get for each grid cells a measurement which reflects an ecological potential from both points of view. It can be summarised as such:

		Not Designated	
		Designated	Not Designated
Green	Designated	Dark Green	Light Green
	Not Green	Yellow	Orange

Green designated areas are in principle the most valuable. “Green landscape not designated” is a space favourable to ecological connectivity and a category close to that of “wider countryside”, the landscapes which host the common species. “Not green” landscape when “designated” relates to niches for rare or endangered species or habitats within intensive agriculture land. Last, not green and not designated land has the lowest nature value. Between these 4 extreme values, a range of situations will be described in relation to the values of GBLI. At this stage, the Naturilis index is not weighted according to types of designation.

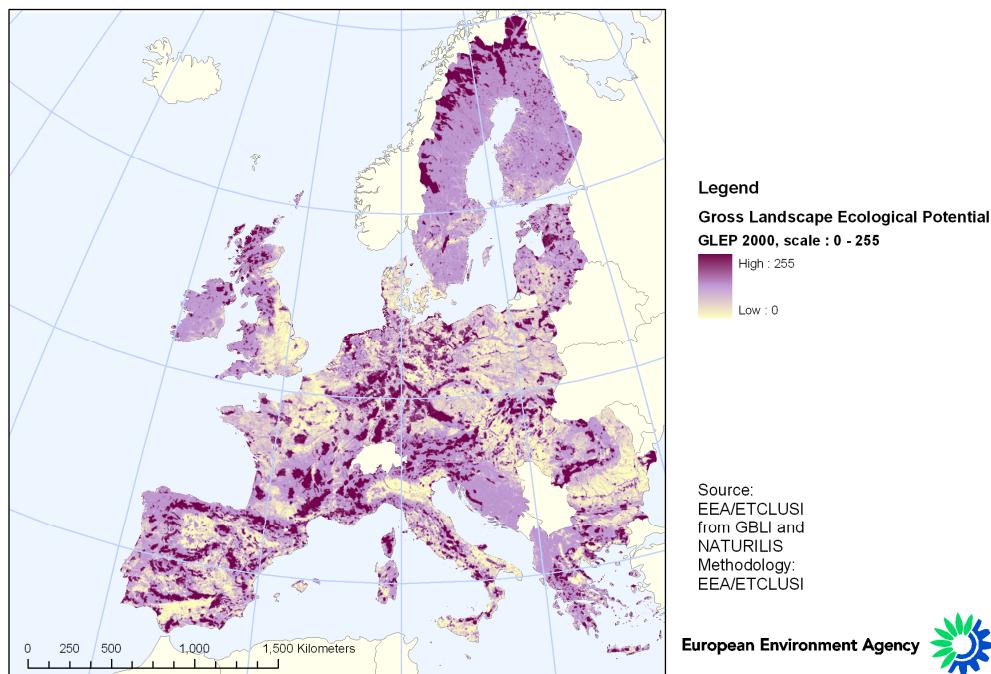


Figure 3: Gross Landscape Ecological Potential as an addition of GBLI and NATURILIS

(4) Fragmentation: the Effective Mesh Size

The Gross Landscape Ecological Potential is based on surface measurements which don't capture handicaps to wildlife resulting from barrier effect of land fragmentation by roads, railways and constructions. Fragmentation is a limiting factor of how this ecological potential can be utilized in relation to minimum size of territories as well as connectivity issues. The assessment of fragmentation is based on the Effective Mesh Size (MEFF)⁶ 'cross-boundary connections' (MEFF-CBC) methodology computed for 1km² grid. It uses TeleAtlas roads and railways and UMZ⁷ data as fragmenting factors.

MEFF value can be interpreted as the expected size of the area that is accessible when starting a movement at a randomly chosen point inside the reporting unit (in our case 1km grid) without encountering a physical barrier. So the higher MEFF value the less fragmented area around.

MEFF CBC calculation has been implemented by EEA/ETCLUSI/GISAT on the standard European 1km² grid with a (huge) seamless European-wide database. As a result, MEFF calculated on European scale has very nonlinear distribution (values: 0 - 46000, mean=1301, median=145), so nonlinear scaling has been applied on the natural logarithmic values, with the basic idea that it is not so relevant to distinguish whether patches are very big or very-very big.

⁶ Moser B., Jaeger J. et alii, 2005, *Modification of the effective mesh size for measuring landscape fragmentation to solve the boundary problem*, Landscape Ecology DOI 10.1007/s10980-006-9023-0123

⁷ UMZ states for Urban Morphological Zones, an agglomeration of Corine land cover neighbouring urban and other artificial land cover units for mapping towns.

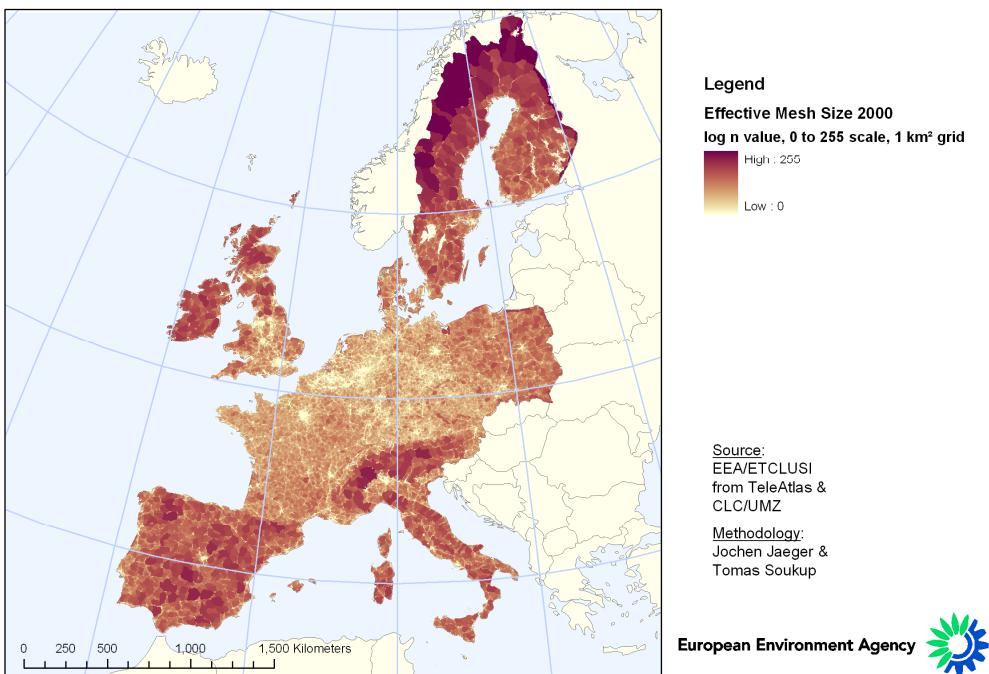


Figure 4: Effective Mesh Size or MEFF, computed from TeleAtlas and Corine Land Cover

(5) **the Net Landscape Ecological Potential** is calculated as the quadratic mean (mean root square) of GLEP and MEFF.

$$\text{NLEP} = \sqrt{\text{GLEP} * \ln\text{MEFF}}. \text{ Range [0-255]}$$

The NLEP is a STATE indicator, which measures **landscape ecological integrity**. The decrease of the indicator reflects a **degradation** of the land potential, the increase an improvement.

The maps below present NLEP and its change between 1990 and 2000 by grid cells and NUTS 2/3.

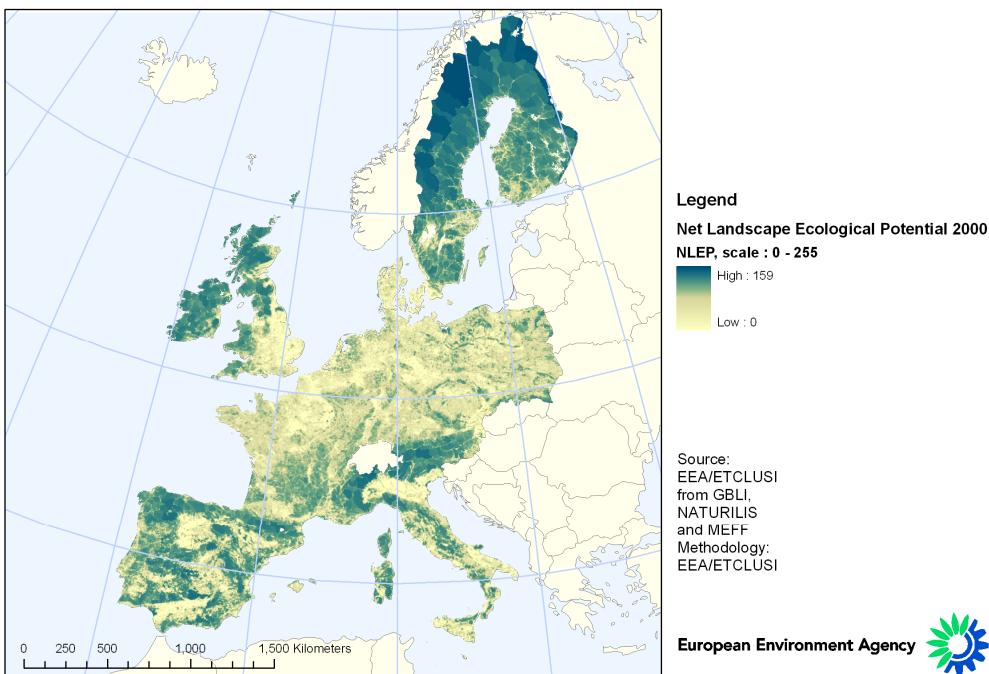


Figure 5: Net Landscape Ecological Potential 2000, by 1 km² grid

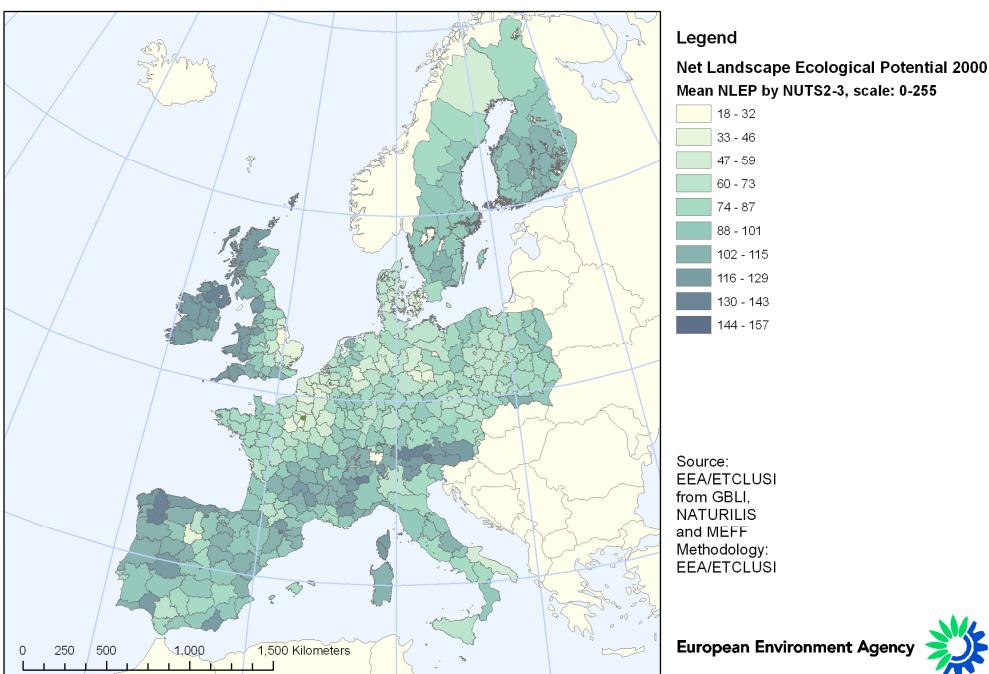


Figure 6: Mean Net Landscape Ecological Potential 2000, by NUTS2/3

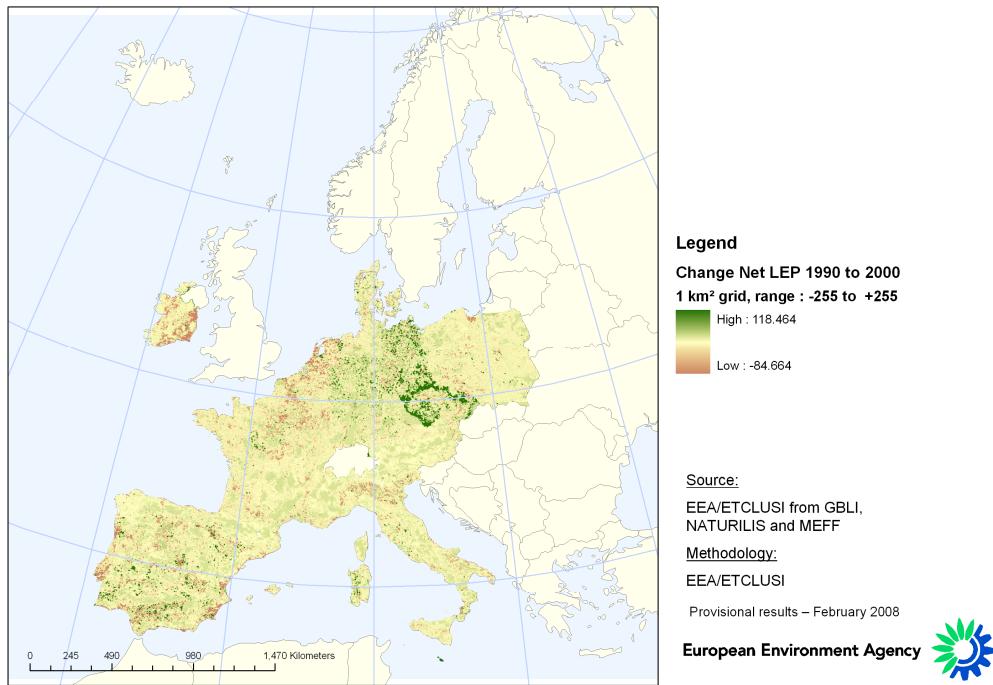


Figure 7: Change in Net Landscape Ecological Potential 1990-2000, by 1 km² grid

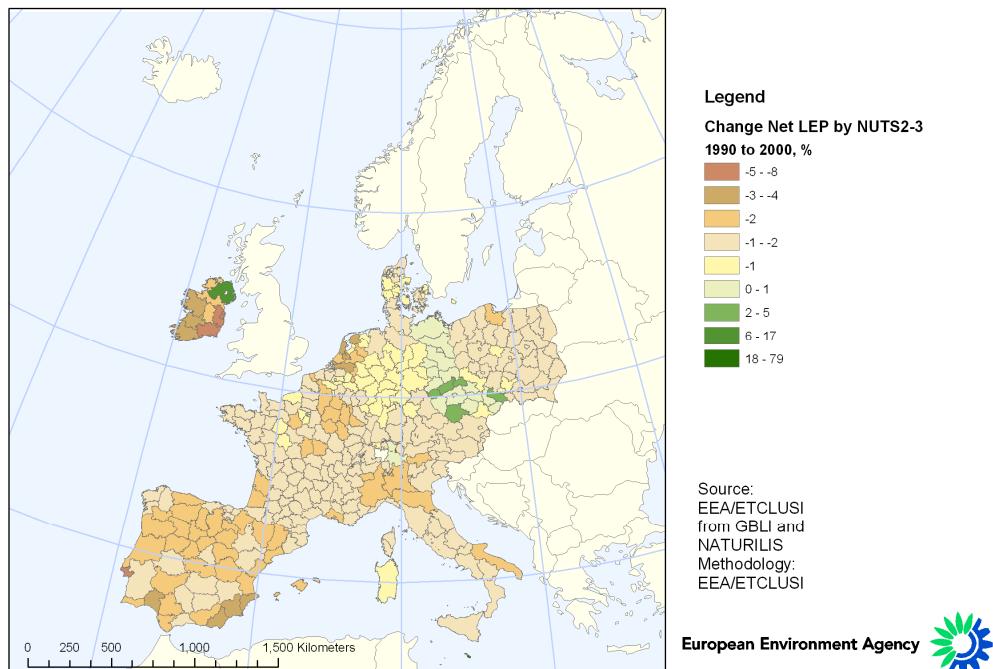


Figure 8: Mean change in Net Landscape Ecological Potential 1990-2000, by NUTS2/3

2. Discussion of results and quality assessment

a. What does NLEP tell and doesn't tell?

An overview of the distribution over Europe of ecological potentials is presented on figures 5 & 6.. Values are displayed by cells of the standard European 1 km² grid or by regions.

Looking at figures 7 & 8, we see on most of Europe either LNEP stability or slow decline. Where improvement appears (East Germany, Czech Republic – and probably, we'll see the same for the other New Member countries when the computation will be expanded), it is an effect of farmland abandonment during the period. Some reverse process can be foreseen when CLC2006 will be integrated and road data updated.

The way in which these potentials are obtained is not explicit at this stage but some information can be derived from the observation of the component maps and/or (better), by a decomposition analysis of the Green Background Landscape in order to focus separately on e.g. forests or mosaic agriculture or wetlands... All individual layers are available at the EEA for specific analysis. Anyway, the aggregated indicator keeps a proficiency of warning on the overall state of the ecosystem and its change. It is a macro indicator with specific uses at the various scales. At the global/continental/national scales, NLEP helps in framing the potentials and provides a quick monitoring of the state. Coming to the local scale, its usefulness is only to facilitate comparisons between different sites, in terms of state and trends. It is in no way a substitute for the detailed information required for understanding the complex interactions and finally acting.

The existence of an overweighting of cities as compared to intensive agriculture has to be stressed. Indeed, cities are a first time considered as “not green” in GBLI and are clipped out (as UMZ) in effective mesh size calculation. At the same time intensive agriculture is processed only once, in GBLI. This difference in weighting urban areas and intensive agriculture satisfies the common sense, even though the implicit weighting factor could be discussed.

Because 1/ natural designation is a socio-political process and in no way an indication of change and 2/ because no historical dataset on roads and railways could be used, changes are driven by GBLI (CLC) only. The combination of layers makes as well fuzzy the dates of change which should be understood as “around 2000-2006” for one and “1986-1995” for the other.

Due to the combination of maps, some countries are missing, because one of those maps is missing. The data gap is accented for change in LNEP. The data gaps on transport networks is progressively bridged with the extension of the coverage by commercial products such as TeleAtlas; INSPIRE should contribute in improving the situation in the future. Remain two difficulties:

- the first one is with the selection of the roads and railways for fragmentation calculation: this is currently done from the typology contained in the database, basically the size of the ways. A useful information would be the traffic on these ways, which determine the environmental impacts;
- the second one is the absence of time series, which limits the understanding of the way the development of transport networks has impacted on the ecological potential over time; such a database could be easily produced starting from the most up-to-date data and backdating the database by deleting year after year the corresponding works.

A 4th dimension of NLEP – not yet developed – is based on ecotones. Its role would be to enhance the sensitivity of NLEP with micro and linear landscape features. This indicator can be implanted with high resolution satellite images; its format could include the fractal dimension of ecotones as well land cover classes combinations.

As indicated at the beginning of this note, NLEP should be usefully supplemented by a few other indicators which capture other important aspects of the vigour and resilience of the ecosystems. Two of them have an outstanding importance: Net Primary Production (NPP) and Specialism of Species Communities (SSC) and Total Exergy of River Basins.

The first one reflecting capacity of absorbing solar energy is the Net Primary Production. NPP varies according to climate and to human appropriation, direct (harvesting, felling) or indirect (landscape restructuring).

The second macro indicator is the specialization degree (or “specialism”) of species communities in a given area. Within a given community, specialist species show the best aptitude for exploiting a given habitat – but they need time to settle. Therefore, their presence is more likely to take place in old – normally biodiversity-rich – ecosystems. Oppositely, generalist species are less productive in a given habitat but they can adapt quickly to change and will be found in larger number in transitional, recent or stressed habitats. Therefore, the ratio specialist/generalist is a good indication, from a species perspective of the state of ecosystems. Empirical observation shows that different species communities (e.g birds, butterflies, fishes...) react in the same way to the same conditions, which makes the computation of the indicator easier from heterogeneous data bases.

In the case of rivers, equivalent aggregated indicators can be defined for LNEP (based on pollution, protection and fragmentation) and “specialism” of species (identical as the indicator for land species). However, NPP is not the appropriate indicator of the energy potential of the water system – in fact a negative one considering water quality. In the case of water, the appropriate indicator is the “eco-integrator” based on the addition of the thermodynamic properties of river basins, in particular their hydraulic power (quantity of usable energy or exergy – decreasing with the down flowing or water abstraction or evaporation...) and their osmotic power (loss of exergy resulting from increase of water salinity).

These 4 general macro indicators can be downscaled and decomposed for producing more accurate information for a local or a sector use.

b. Summary of advantages and disadvantages and SEBI 2010 criteria

• **Main advantages:**

Methodology: By presenting land cover changes in this context it is possible to reach a certain conclusion of what these changes mean for ecosystem integrity at the different parts of Europe, at the macro scale, i.e. looking across the region. This assessment allows to overcome at once the problem of uneven spatial distribution of ecosystems (green landscapes), and of their nature conservation value (protected areas) and of pressures to them (fragmentation due to transport). The indicator is flexible to positive and negative changes as indicated in the 1990-2000 assessment. .

Acceptance and comprehension : NLP is good for comparing ecological potentials of different regions: a higher value reflects an overall better situation; it is reproducible and measures trends: similar ingredients leading to similar results an increase of the indicator means an overall improvement of the situation, a decrease a degradation;

- NLP has high intelligibility: the user can easily identify the weight of the different components of the indicator; and
- NLP has modifiability for producing variants adapted to specific contexts or scales, when more accurate results are necessary.

Data availability : Land Cover changes are a data set that is expected to continue being updated , same as the protected areas data set.

Spatial coverage: All EEA countries can be covered in coming years.

Policy relevance: the indicator presents a measurement that can express ecosystem integrity and allows a good reading across Europe. It is a Status indicator and can be useful for assessing progress towards the biodiversity 2010 and can be included in the SEBI set.

• **Main disadvantages:**

Methodology: The indicator is not built around ecological data that would exactly demonstrate which are the desired adaptive biological communities, their species composition, diversity and functional

organization comparable to that of a natural habitat in the region under discussion. In this respect the indicator cannot show in which ways the ecosystem integrity can be restored, nor does it have a pure ecological meaning. Even though the indicator can be calculated in any disaggregated manner, its meaningfulness has not been tested yet for assessing ecosystem integrity at the micro -scale.

Data availability: Fragmentation calculations with the effective mesh size can be updated with new transport network data, but no provision for this exists at the moment. Historical data are lacking.

- ***Application of the SEBI 2010 criteria to NLEP:***

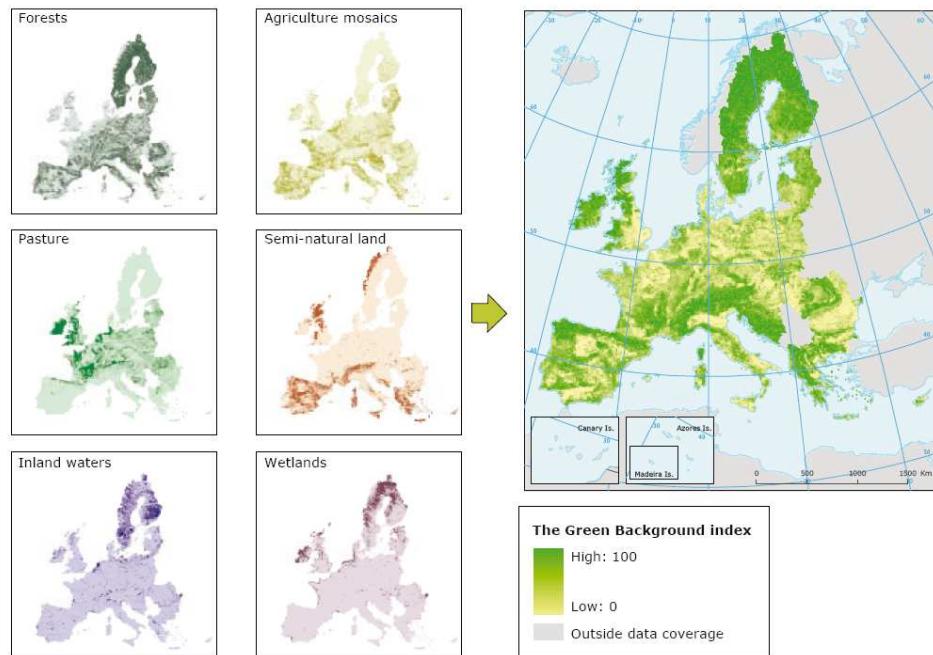
Criteria	Evaluation	Points
Policy relevance	Yes – it is highly relevant for the 2010 target, as ecosystems and habitats comprise biodiversity components, and provides a good proxy for measuring the effects of human activities on the integrity of terrestrial ecosystems. It is relevant to environmental policies (decisions to stop the loss of the main ecosystems/habitats).	3
Biodiversity relevance	Yes – it provides a measurement of change that affects several biodiversity components, even though it does not use direct measurements of species and habitat types (land cover is wider than habitats).	3
Progress towards 2010	It depends on the availability of an update between 2006 and 2010, but the slightest change in some categories will be highly significant.	2
Methodology well founded	Methodology needs testing on the interpretation of results and small improvements on the relation between land cover categories and ecosystems/habitats for using Globcover at the pan European level.	2
Acceptance and understandability	Indicator is well defined and easy to understand the main point. Its acceptance from policy makers has to be improved.	3
Routinely collected data	Data are regularly collected until now, but depends on strong will of European commission and member states, and has to be enforced outside E.U.	3
Cause - effect relationship	Easy to establish but not for all kind of ecosystems, sometimes complicated to quantify precisely.	2
Spatial coverage	12 countries are covered out of the 35 EEA countries part of Corine. Access to a better coverage of road/railways geographical data is a limited factor. Regarding the land cover-based layers, more countries (Pan-European and Mediterranean areas) could be considered if “GlobCover” is integrated. Similarly, the progress in the CDDA database	2
Temporal trend	Trend will cover a 20 years period in 2010. Backdating with the same methodology is in principle feasible as far as 1975.	2
Country comparison	Regional comparison or between subset of countries is possible, but the aggregated LNEP covers important differences between countries or regions. Topical LNEP targeted to e.g. forest, grassland, agriculture... should be considered. .	2
Sensitivity towards change	Indicator is sensitive to change, but does not distinguish between human and natural causes of changes. It needs to be supplemented with macro scale spatial indicators of pressure by urban or intensive agriculture land use.	2
Total score:		26

Annex: CORILIS and GBLI

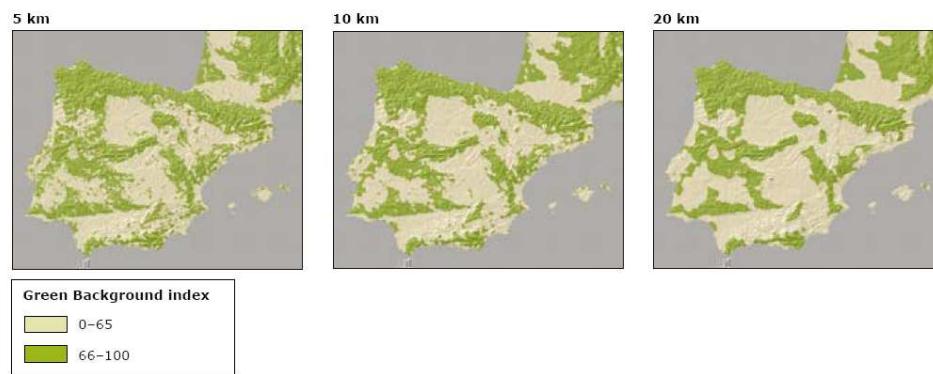
Part III Methodologies | Recording patterns of change: construction of the LEAC database

Figure 8.3 Green Background index derived from the combination of CORILIS layers

(a) Creation of the LEAC Green Background from CORILIS layers for pasture, agriculture mosaics, forests, other semi-natural land, wetlands and inland waters



(b) The Green Background for three different smoothing radii (example with 65 % threshold)



Note: The Green Background map is a modifiable map, both in terms of smoothing radii and minimum intensity. The use of the CORILIS components shows the make-up of a given region or location with the Green Background index. This gives a possibility to modify the selection of the thematic CORILIS layers.