Critical load exceedance for nitrogen

European Environment Agency

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Exceedance of critical loads for nitrogen deposition indicating risks for biodiversity loss in (semi)-natural ecosystems.

Assessment versions

Published (reviewed and quality assured)

- 21 May 2010, 12:00 AM - Critical load exceedance for nitrogen

Rationale

Justification for indicator selection

MAIN ADVANTAGES OF THE INDICATOR

- Geographical and temporal coverage: deposition data is available at different spatial resolution. Results from the EMEP Unified Model are available for the European EMEP area that includes EU-27. Critical loads are regularly updated to reflect new knowledge and used by the CCE to compute exceedances.
- Use: indicator is used in various European directives and policies (UNECE LRTAP, Clean Air for Europe (CAFE)).
- Robustness: methodology of calculating both deposition and critical loads has changed over the last decades. The higher resolution and land cover specific modelling of the EMEP Unified Model have increased the estimated exceedances. Both critical loads and land cover specific EMEP deposition data are geo-referenced with a harmonized land cover data set, allowing for spatially consistent critical load exceedance maps.
- Costs of production: the Convention on LRTAP applies a financing mechanism involving all the Parties to support core activities. Expenses for data collection are covered on a long-term basis by ongoing programmes.

Scientific references

- No rationale references available

Indicator definition

Exceedance of critical loads for nitrogen deposition indicating risks for biodiversity loss in (semi)-natural ecosystems.

Units

%
eq ha-1 a-1

Policy context and targets

Context description

The availability of nutrients is one of the most important abiotic factors that determine plant species composition in ecosystems. Nitrogen is the limiting nutrient for plant growth in many natural and semi-natural ecosystems. Most of the plant species from oligotrophic and mesotrophic habitats are adapted to nutrient-poor conditions, and can only survive or compete successfully on soils with low nitrogen availability. High nitrogen deposition causes changes in vegetation composition and vegetation structure. These changes in turn affect the fauna composition (UNECE, 2003).

High variations in sensitivity to atmospheric nitrogen deposition have been observed between and within different natural and semi-natural ecosystems. Critical loads are used to describe this sensitivity. A critical load is defined as 'a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge' (Nilsson and Grennfelt, 1988). Exceedances of critical loads by current or future nitrogen loads indicate risks for adverse effects on biodiversity.

Because of short- and long-range atmospheric transport, nitrogen (N) deposition has increased in many natural and semi-natural ecosystems across the world. The emissions of ammonia (NH3) and nitrogen oxides (NOX) strongly increased in Europe in the second half of the 20th century. Ammonia is volatilised from intensive agricultural systems, whereas nitrogen oxides originate mainly from burning of fossil fuel by traffic and industry (UNEP, 2005).

Significant geographical variability occurs in emissions and deposition of nitrogen compounds across Europe. Historically emission control strategies have focussed on reducing the emission of oxides of nitrogen. However across Europe it is now clear that nitrogen deposition is dominated by agricultural releases, predominantly ammonia. Therefore, while past effort has focussed predominately on reducing the oxides of nitrogen, future effort must also take into account reduced forms of nitrogen.

Relation of the indicator to the focal area

Excess nitrogen is one of the major threats to biodiversity. Excessive levels of reactive forms of nitrogen in the biosphere and atmosphere constitute a major threat to biodiversity in terrestrial, aquatic and coastal ecosystems. On land it causes loss of sensitive species and hence biodiversity by favouring a few nitrogen tolerant species over less tolerant ones. In coastal waters it leads to algal blooms and deoxygenated dead zones in which only a few bacteria may survive.

Targets

No targets have been specified

Related policy documents

No related policy documents have been specified

Key policy question

What are the trends in nitrogen emissions and where in Europe does atmospheric nitrogen deposition threaten biodiversity?

Methodology

Methodology for indicator calculation

Deposition loads are modelled as part of EMEP; on a European scale, the EMEP Unified Model is used (see http://www.emep.int/index_model.html). Monitoring of nitrogen deposition is used to calibrate the models.

European critical loads are assessed using scientifically reviewed methods and data.
There are various endpoints (protection aims) for setting critical loads. The ICP MandM and CCE have developed methods to derive critical loads for protecting (semi)-natural ecosystems (www.mnp.nl/cce):

1. Critical loads based on empirical data;
2. Critical loads based on dynamic ecosystem models;
3. Critical loads based on steady state modelling.

Methods 1 and 2 are particularly relevant for setting critical loads for protecting biodiversity.

Below are described the methodologies helping to produce the different maps/graphs relevant for this indicator.

(1) European maps of percentage natural area with critical load exceedances

- Combine recent European deposition map (EMEP) with recent European critical load map (CCE).
- Sum in each 50 x 50 km EMEP-grid the total natural area where the deposition (in mol/ha/yr) exceeds the critical loads (in mol/ha/yr) and divide this by the total natural area. Use the ecosystem specific deposition rates.
- Plot the percentage area with exceeded critical loads within each EMEP-grid.

(2) European maps of the percentage natural area protected under the EU Habitat directive With critical load exceedances

- See steps described above

(3) European maps of the height of the exceedance in natural areas or protected areas

- Combine recent European deposition map (EMEP) with recent European critical load map (CCE).
- Sum in each 50 x 50 km EMEP-grid the deposition which exceeds the critical load. Use the ecosystem specific deposition rates.
- Plot the calculated sum of excess of deposition within each EMEP-grid.

(4) Graphs of changes in percentage natural area with critical load exceedances or height of the exceedances

- Combine a number of recent European deposition maps with the recent European critical load map (CCE).
- Sum per year, in all European EMEP-grids the total natural area where the deposition (in mol/ha/yr) exceeds the critical loads (in mol/ha/yr) and divide this by the total natural area in Europe. Use the ecosystem specific deposition rates. Similar calculations can be made for individual countries.
- Plot the calculated percentage per year in a graph.
- Similar calculations can be made for the excess of deposition.

Methodology for gap filling

No methodology for gap filling has been specified. Probably this info has been added together with indicator calculation.

Methodology references

- Establishing baseline indices for the environmental quality of the Feest, A. (2006). Restoration Ecology, 14:112-122.
- Critical loads for sulphur and nitrogen. Nilsson, J. and Grennfelt, P. (1988) Report

from a workshop held at Skokloster, Sweden, 19-24 March 1988.

- Empirical Critical Loads for Nitrogen. UN/ECE, 2003. Expert workshop 2002.
- Indicators for assessing progress towards the 2010 target: Nitrogen UNEP, 2005. UNEP/CBD/SBSTTA/10/INF/16.

Data specifications

EEA data references

- No datasets have been specified here.

External data references

- Exceedance of critical loads for the most sensitive ecosystems (dataset URL is not available)

Data sources in latest figures

Uncertainties

Methodology uncertainty

No uncertainty has been specified

Data sets uncertainty

No uncertainty has been specified

Rationale uncertainty

MAIN DISADVANTAGES OF THE INDICATOR

- Not all critical loads are defined to protect biodiversity. Empirical critical loads (Method 1 above) are often set to protect for changes in species composition and/or vegetation changes. Method 2 (used in some countries) is often based on criteria that should protect biota (plants, fish, trees etc) and yields critical loads comparable to empirical critical loads. Method 3 is more indirectly linked to risks for biota; it is presently based on chemical soil and/or water conditions. However, National Focal Centres often use several methods for calibration and/or validation purposes.
- Critical load exceedances indicate risks but not immediate effects of air pollution. Nevertheless time delay is often short in respect to effects of nitrogen deposition on biota.

- The indicator is focusing only on threats to (semi-natural) terrestrial ecosystems. However, excessive levels of nitrogen (and phosphorus) in water bodies, including rivers, coastal zones and other wetlands also cause major damage to biodiversity including fisheries. However, in most aquatic ecosystems in Europe the main source of nitrogen is not atmospheric deposition but run-off of nitrates and other nitrogenous compounds from agricultural lands.

Further work

Short term work

Work specified here requires to be completed within 1 year from now.

Long term work

Work specified here will require more than 1 year (from now) to be completed.

Work description

SUGGESTIONS FOR IMPROVEMENT Short term improvements Strengthen the link between critical load exceedance and loss of biodiversity and quantify CLE impacts in protected areas in Europe. Validate the indicator against biodiversity quality of sensitive groups such as butterflies, bryophytes and macrofungi. Methods for this are to be found in Feest (2006) and van Swaay and Feest (in prep.). Use current network of the LRTAP to deliver desired information to improve link to biodiversity goals set in CBD, EU and Natura 2000 sites. Improve dynamic ecosystem modelling of critical loads for biodiversity effects. Improvement of the current methods could begin in bringing together EU-relevant databases on relationships between biodiversity and a-biotic conditions, which can be used in the current (dynamic) critical load models. Investigate whether data could become available from the ICPs water, forests and vegetation and/or from national monitoring data needed for the EU Habitat directive. Some countries (e.g. Denmark, Germany and the Netherlands) have already started to use such data and combine them with dynamic models. Focus on critical load setting for habitats protected under the EU Habitat directive and bring the national monitoring information together to improve models (see above). More research is necessary to improve the empirical critical loads for northern areas where species and habitats may respond in a different way compared to Central and Southern Europe due to different climate etc. Relate height of exceedance of critical loads to height of risk for biodiversity loss. Long term improvements Extend the indicator with effects on aquatic and agricultural ecosystems. Extend the indicator to the full nitrogen cycle.

Resource needs

No resource needs have been specified

Status

Not started

Deadline

2099/01/01 00:00:00 GMT+1

Work description

COSTS RELATED TO DEVELOPING, PRODUCING AND UPDATING THE INDICATOR (as available) The Convention on LRTAP applies a financing mechanism involving all the Parties to support core activities in the field of atmospheric dispersion, effects on human health and ecosystems and of integrated assessment. Expenses for data collection are covered on a long-term basis by ongoing programmes. On the basis of these known costs further expansion or development as outlined in the 'Suggestions for improvement' section can be estimated.

Resource needs

No resource needs have been specified

Status

Not started

Deadline

2099/01/01 00:00:00 GMT+1

General metadata

Responsibility and ownership

EEA Contact Info

Katarzyna Biala

Ownership

- Coordination Centre for Effects (UNECE)
- European Environment Agency (EEA)

Identification

Indicator code
SEBI 009
Specification
Link: critical-load-exceedance-for-nitrogen
Version id: 1
First draft created:
26 Feb 2007, 09:57 AM
Publish date:
21 May 2010, 12:00 AM
Last modified:
26 Oct 2017, 10:59 AM
Primary theme:  Biodiversity — Ecosystems

Frequency of updates

Updates are scheduled every 5 years

Classification

DPSIR: Pressure
Typology: Performance indicator (Type B - Does it matter?)

Related content

Data references used

Exceedance of critical loads for the most sensitive ecosystems (dataset URL is not available)

[https://www.eea.europa.eu/data-and-maps/data/external/exceedance-of-critical-loads-of]

Latest figures and vizualizations

Total emissions of acidifying substances (sulphur, nitrogen) and of nitrogen in the EEA-32 from 1990 to 2006 [https://www.eea.europa.eu/data-and-maps/figures/total-emissions-of-acidifying-substances-sulphur-nitrogen-and-of-nitrogen-in-the-eea-32-from-1990-to-2006]

Exceedance of the critical loads for eutrophication in Europe (as average accumulated exceedances), 2004 [https://www.eea.europa.eu/data-and-maps/figures/exceedance-of-the-critical-loads-for-eutrophication-in-europe-as-average-accumulated-exceedances-2004]

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