Netherlands

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Introduction

Nitrogen deposition in the Netherlands, which often exceeds the critical loads, is a large threat to protected habitats and species. Environmental policies follow a two way approach to reduce problems due to critical load exceedances. On the one hand there is the international policy to reduce emissions at the international level as stated in the LRTAP Convention. On the other hand there is a Dutch Programmatic Approach to Nitrogen (PAN; Ministerie van Economische Zaken & Ministerie van Infrastructuur en Milieu, 2015) to reduce emissions on national, sub-regional and local levels, give or reject permits for plans and projects which may influence emissions, and to take restoration measures in sensitive Natura 2000 areas. Both policies use critical loads for nitrogen which are based on calculations with SMART2 combined with empirical critical loads (Van Dobben et al, 2006; Van Dobben et al., 2014).
In response to the 2014-2015 Call for Data, the Dutch NFC delivered an updated map of critical loads for use under the LRTAP convention, calculated by VSD^+, on a grid of 250 x 250 m^2. Input parameters depend on soil type (soil physical parameters, organic matter, CEC, base saturation and weathering) and vegetation type (nutrient uptake, litter production). Precipitation, upward seepage and base cation deposition were location specific. The calculated critical loads were compared with the critical loads used in the Dutch PAN.
Besides, the Dutch NFC has tested a method to calculate critical loads for dry heath with critical limits derived with the PROPS model, based on the Habitat Suitability Index (HSI) described in the call-for-data.

Critical load map NL

The updated map of critical loads for the Netherlands is calculated with VSD^+, instead of previously used SMART2 model. The critical conditions are based on protection of plant associations of nature target types against eutrophication and too much acidification. Nitrogen availability and pH were used to describe these critical conditions (Van Hinsberg and Kros, 2001). The calculated critical load is the maximum N deposition where the most strict (binding) critical condition is met (either maximum N availability or minimum pH).

Model input
Litter fall and N seepage are considered to be the most important input parameters which influence the critical load in situations where N availability is the binding condition. N in seepage water is taken from a map (Pastoors, 1993; Bolsius et al., 1994). Litter fall is calculated with SUMO (Wamelink et al., 2009) and used for calibration. Compared to default input, extra litter fall in forests is assumed due to litterfall from ground vegetation and litter fall in selected (managed) grasslands is reduced because the default values only applies to wet, productive, grasslands and not to e.g. dune grasslands and other poor systems.

In cases where pH is the binding condition, critical loads are more affected by input and output fluxes. Most important input fluxes are deposition, weathering, upward seepage and mineralisation. The main output fluxes are downward seepage and net uptake. A yearly water balance is needed to calculate the seepage fluxes. Deposition (of base cations and Cl) and rainfall are regionally variable and described in maps. Other parameters are considered to vary per soil type (CEC, base saturation, exchange constants, weathering rates), vegetation type (mineralisation rates, nutrient contents) or a combination of both (transpiration).Compared to the former critical load map delivered to the CCE, weathering rates have been improved for löss. Upward seepage was assigned per nature target type.

Results
A database with critical loads on 250 m x 250 m gridcells was delivered to the CCE. In Table NL.1, a comparison is made between the average critical load for nitrogen in the CCE database, the empirical ranges and the critical loads used in the Dutch policy (PAN). The critical loads in the database correspond quite well with the PAN critical loads for the given the habitat types and they are all within the empirical ranges. For some habitat types however (data not shown), the results are less consistent with the PAN, which indicates the limitations of the current database for local analyses. The reasons for the difference between the critical loads in the CCE database and the PAN critical loads lies in the calculation method itself, model input and critical conditions. Whereas the critical loads of the CCE database are all calculated with VSD+ alone, the PAN critical loads are a combination of empirical critical loads and calculations. Moreover, the calculated critical loads for PAN were computed with an optimization routine in SMART2 to find the N deposition where the maximum N availability was not exceeded and the pH was not too low, whereas the calculation with VSD+ is really a steady state calculation from condition to critical load. So the calculation method itself is different which causes different results. In addition, the model input for the CCE calculations is partly considered local variable (rainfall and base cation deposition), whereas the PAN critical loads were calculated for average conditions. Additional effort is needed to further tune model input and both databases. It is also important to harmonize the maps of plant associations, i.e. the maps of habitat types protected in the PAN and the maps of nature targets used for calculation of the CCE database.

Table NL.1 Critical loads in database CCE compared with empirical ranges and critical loads used in Dutch policy (PAN)

Type	Habitat type	Critical load (kg N ha^{-1} yr^{-1})		
		Database CCE	Empirical range	PAN
Bogs	H7110	6	5-10	7
Dune grasslands	H2130	9	8-15	10
Dry heathland	H4030	15	10-20	15
Salt marches	H1330	29	20-30	22
Dry nutrient-poor forest	habitat for protected animals	16	10-20	15

Modelling CLs using HSI
The protected habitat types in the Habitat Directive are in the Netherlands formally described in terms of abiotic ranges, lists of typical species and lists of desired plant associations. The abiotic ranges for habitat types are however only broadly defined, with terms like 'nutrient poor' and 'medium acid'. For calculations of critical loads a stricter and clearer definition is needed. By combining PROPS with lists of typical species and lists of species belonging to desired plant associations, such stricter and quantitative conditions can be defined.

Method
For the habitat type dry heath (H4030) we have calculated critical loads with critical conditions derived from the Habitat Suitability Index (HSI), calculated with PROPS. Critical loads were computed for three different selections of species: one with all wanted species in H4030 (all typical species and species belonging to plant associations with good quality), one with the typical species listed in the habitat description, including mosses and lichens, and one with typical species according to Schaminée et al. (2011).
All sets of species show optima at low NO_3 contents and at a pH roughly between 3.5 and 5.5 (Figure NL.1). The species set of Schaminée has the highest probability (isoline with highest value of 0.5 instead of 0.3 for the other two sets). Based on these figures, several combinations of critical pH and NO_3 contents on the isoline HSI=0.3 have been selected to calculate critical loads. To calculate critical loads, NO_3 content (mg kg^{-1}) had to be converted to N-concentration (eq m^{-3}) using:
$N\text{-}conc = NO_3 * \rho / \theta / 62$
Where *N-conc* is the critical N-concentration in soil solution (eq m^{-3}), *NO3* is NO_3-content (mg kg^{-1}) read from the isolines graph, ρ is bulk density, θ is soil moisture content. Bulk density and soil moisture content were set at resp. 1.416 g cm^{-3} and 0.148), being default values for this soil type. With this conversion an uncertainty is introduced, because the critical limit is linearly correlated with bulk density and soil moisture content, and both these soil parameters are somewhat uncertain.

Results
Figure NL.1 shows the critical loads for nitrogen for the selected combinations of NO_3 and pH on the isoline of HSI=0.3. The critical loads,

i.e. the N deposition where the most strict (binding) critical condition is met (either NO_3 content or pH), are depicted in the various boxes in this figure. Different species selections result in different patterns of isolines and thus different critical limits.
For the selected combinations of critical pH and NO_3, the critical loads vary between 6 and 9 kg N ha^{-1}, except for one point on the isoline with a pH of 5.6: such a high pH can only be reached with very low depositions. The various calculated critical loads with this method at HSI=0.3 are close to the lowest value of the empirical range but lower than the critical load in PAN and the average critical load in the database (see Table NL.1). The question is, however, which list of species should be considered and which HSI should be used for the calculation of critical loads. Mosses and lichens should, may be, be excluded or treated separately, since they are affected by pH and NO_3-contents from shallower soil depths than the soil depth where plant roots grow. Also a HSI of 0.3 might be too low to fully obtain optimal conditions for *all* desired species.

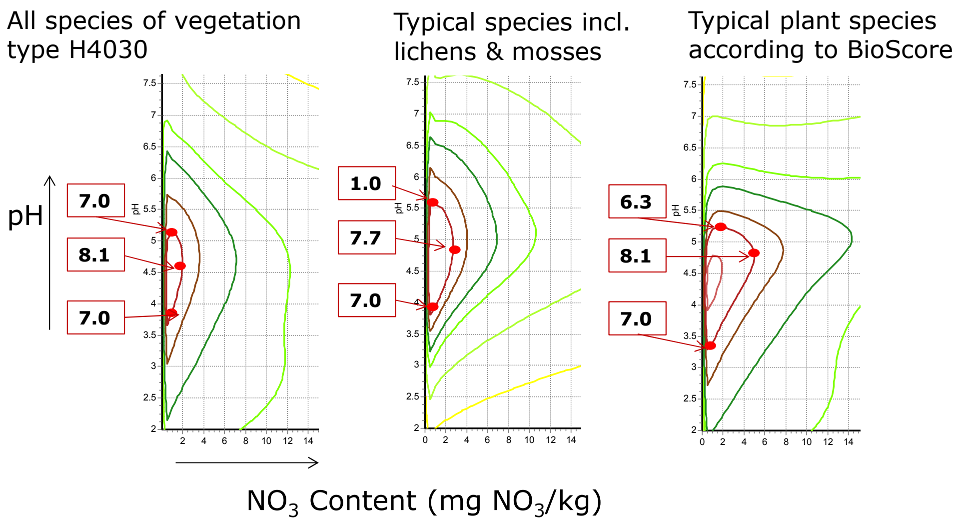

Figure NL.1 HSI isolines for three selections of species for vegetation type H4030 with calculated critical loads (kg N ha-1 yr-1) belonging to the dots on the isoline HSI = 0.3.

Conclusions

- A more detailed CL-map for EU-wide scenario analyses is now available for the Netherlands. However, this current map is not appropriate to draw site specific conclusions, since the critical loads do not always correspond with local site conditions.
- More work is needed to improve the correspondence of the CL map with local information. The improvement will be focussed on consistency of input maps (habitat maps) and calibration of system in- and outputs like litter fall and uptake.
- Since the current critical limits for habitat types are defined broad and not quantitative, the HSI bases modelling might be a fruitful way to go. It is recommended to define a common list of species per habitat type to make the results between different areas or countries comparable. An automatized procedure is needed to apply this technique on a larger scale.

- For the investigated habitat type, the HSI based critical loads were close to the empirical range. Uncertainties in HSI based method are caused by the conversion from NO_3 content to critical N concentration, the critical value for the HSI used, and the selection of species.

References

Bolsius ECA, Eulderink JHM, Groen CLG, Harms WB, Bregt AK, Van der Linden M, Looise BJ, Maas GJ, Querner EP, Tamis WLM, De Waal RW, Wolfert HP, Van 't Zelfde M, 1994. Eén digitaal bestand voor de landschapsecologie van Nederland. Den Haag, VROM, LKN rapport 4.

Ministerie van Economische Zaken & Ministerie van Infrastructuur en Milieu, 2015. Programma Aanpak Stikstof 2015-2021, Ontwerp. Den Haag.

Pastoors MJH, 1993. Landelijk grondwater model; conceptuele modelbeschrijving -- Onderzoek effecten grondwaterwinning 10, Bilthoven, RIVM rapport 714305004

Schaminée JHJ, Janssen JAM, Hennekens SM, Ozinga WA, 2011. Large vegetation databases and information systems: New instruments for ecological research, nature conservation, and policy making, Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology: Official Journal of the Societa Botanica Italiana, 145: sup1, 85-90

Van Dobben HF, Van Hinsberg A, Schouwenberg EPAG, Jansen M, Mol-Dijkstra JP, Wiegers HJJ, Kros J, De Vries W, 2006. Simulation of critical loads for nitrogen for terrestrial plant communities in the Netherlands. Ecosystems 9: 32–45

Van Dobben H, Bobbink R, Bal D, Van Hinsberg A, 2014. Overview of critical loads for nitrogen deposition of Natura 2000 habitat types occurring in The Netherlands. Report 2488, Alterra, Wageningen UR, Wageningen

Van Hinsberg A, Kros H, 2001. Dynamic modelling and the calculation of critical loads for biodiversity. In: Posch M et al. (eds), CCE Status Report 2001, Bilthoven, Netherlands

Wamelink GWW, Van Dobben HF, Berendse F, 2009. Vegetation succession as affected by decreasing nitrogen deposition, soil characteristics and site management: A modelling approach. Forest Ecology and Management 258: 1762–1773.