Overview of critical loads for nitrogen deposition for Natura 2000 habitat types occurring in The Netherlands

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2013

This is a pre-print of Alterra Report 2488

Summary

In this report an overview of unique critical load values for nitrogen deposition is presented for the Natura 2000 habitat types that occur in The Netherlands, and additionally for the nitrogen sensitive other habitats of species that are protected in Natura 2000 sites. The term 'critical load for nitrogen deposition' means in this report: the limit above which there is a risk that the quality of the habitat type is significantly damaged as the result of acidification or eutrophication from atmospheric nitrogen deposition. The term 'unique' means that the critical loads are not in the usual form of ranges but as a single values per habitat type.

The method for setting a unique critical load value per habitat is, in a nutshell:
- for each habitat type occurring in The Netherlands it was determined whether an international empirical critical load is available as adopted by the UNECE in 2010; if so, this range has been further specified with results of simulation models and (if necessary) expert opinion to set a unique value.
- if no empirical critical load was available, the critical load value has been based upon the mean value of the results from a national simulation model.
- if there was also no result available from a simulation model, the critical load value has been based upon expert opinion.

This report is a translated, updated and extended version of Van Dobben and Van Hinsberg (2008). The method used is identical to the one of the 2008 report.

Out of the 75 habitat (sub)types found in The Netherlands, 60 appear to be sensitive to nitrogen deposition (CL < 34 kg N/ha/y) and 15 are probably not sensitive. Furthermore another 14 nitrogen sensitive habitats of species of the Habitats and Birds Directive are included and given a critical load value.

1. Introduction

Effects of nitrogen deposition play an important role in the protection of Natura 2000 areas and their habitat types and species, both in an ecological and in a legal context. Therefore the best available scientific knowledge should be used for the assessment of such effects. This report is based on a compilation of the scientific knowledge on critical loads that is presently available. In scientific publications critical loads are usually described in the form of ranges. The widths of such ranges describe the variation in critical load due to differences in sensitivity within an ecosystem, but they are also confidence intervals that result from methodological uncertainty. In this report unique critical load values per habitat type are proposed for The Netherlands, i.e. not in the form of ranges but as a single values per habitat type, taking account of all available knowledge including the range widths. In The Netherlands a more precise assessment of critical loads is possible than Europe-wide because of the narrow and accurate definitions of the habitat types and habitats for species on the one hand (cf. http://www.synbiosys.alterra.nl/natura2000/gebiedendatabase.aspx?subj=habtypen&groep=0), and the availability of detailed ecological models on the other hand (cf. Van Dobben et al. 2006).

The term 'critical load for nitrogen deposition' means in this report: the limit above which there is a risk that the quality of the habitat type is significantly damaged as the result of acidification or eutrophication from atmospheric nitrogen deposition. The accepted international definition is "*a quantitative estimate of 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 & Grennfelt 1988). The critical load can be compared to the current or future deposition in order to estimate such effects. If the atmospheric deposition at a location exceeds the critical load for the existing (or desired) habitat type at the site, there is a clear risk of significant negative effects. In other words, the conservation objectives are not being achieved. Here we focus on the negative effects in terms of changes in biodiversity. The greater the critical load exceedence and the longer its duration, the higher the risk of undesirable changes in biodiversity.

This report is a translation of a Dutch report (Van Dobben et al. 2012), which in turn is an update of an earlier Dutch report (Van Dobben & Van Hinsberg 2008). In the present report the European framework by Achermann & Bobbink (2003) has been replaced by the update by Bobbink & Hettelingh (2011). The model results used in this report are however identical to those used by Van Dobben & Van Hinsberg (2008). All calculations have been repeated and some errors have been corrected, including rounding errors. All reported critical load values are now rounded to 1 kg/ha/y, and these values are recalculated to Mol/ha/y and rounded to 1 Mol. For some habitat types new variants are distinguished.

In this report all habitat types defined in the Habitats Directive Annex I (Council of the European Communities 1992) are considered as far as they occur in The Netherlands, expanded by a number of subtypes defined for The Netherlands (see http://www.synbiosys.alterra.nl/natura2000/gebiedendatabase.aspx?subj=habtypen&groep=0). For some habitat (sub)types variants are included, based on phytosociological, abiotic or geographic differences. This has been done in cases where the variation within a type is too large to define a unique critical load value for that type. Some nitrogen sensitive species that are protected under the Habitats Directive (Annexes II and IV) have habitats that do not occur in Annex I of this Directive. For these species fourteen additional 'habitats for species' are defined and given a critical load value.

2. Method

2.1 Available sources

The following sources are available to determine critical loads, listed in order of importance:

- *Empirical critical deposition loads for Europe*. These have most recently been assessed in a workshop in 2010 of the UNECE (Convention on long-range transboundary air pollution of the United Nations Economic Commission for Europe) (Bobbink & Hettelingh 2011). This source contains critical loads measured in the field or in laboratory experiments in combination with the perceived damaging effects. The critical loads are formulated in the form of ranges, as a consequence of (a) the rather course ecosystem typology (i.e. EUNIS classes, see 2.2), (b) geographical variation in abiotic conditions within Europe, and (c) methodological uncertainty. In some cases the ecological conditions are indicated where the lower or the upper limits of the ranges should be used.
- *Model output*. Results of the SMART2^{-1} model are available for the majority of vegetation types in The Netherlands (Van Dobben et al. 2004, 2006). In addition, for some ecosystems specific models have been developed (AquAcid for heath pools, Calluna for dry heaths). The model results allow a closer specification of critical load values within the empirical ranges. SMART2^{-1} always produces unique critical load values, whereas other models may produce ranges depending on e.g. hydrology or management.
- *Expert opinion.* In cases where neither empirical values, nor model output was available, expert opinion has been used. For this the present authors are primarily responsible, but for softwater pools the following experts were also consulted: Dr. G. Arts (Alterra) and Dr. R. Wortelboer (Planbureau voor de Leefomgeving).

2.2 Protocol to determine critical load values for habitat types

To determine unique critical load values per habitat (sub)type a strict protocol was used that is described below; details are given in Annexes 1 and 2.

1. The habitat type is compared to the ecosystem types of the European Nature Information System (EUNIS) (Davies et al., 2004; http://eunis.eea.europa.eu). This is a classification of European habitats at eight hierarchical levels. The empirical values in Bobbink & Hettelingh (2011) are given per EUNIS type, usually at the third level (coded as a capital letter plus two numeric digits). In Appendix 1 in Bobbink en Hettelingh (2011) these EUNIS types are translated to types of the Habitats Directive, where a distinction is made between 'corresponding' and 'comparable or related'; the authors consider this as a provisional translation. In most cases this translation has been followed in the present report, however sometimes a different translation was used; the differences are explained in Annex 1. As (a) empirical critical load ranges are not available for all habitat types that occur in The Netherlands, and (b) the EUNIS type definitions at the third level are usually quite broad, the following situations may apply:
    a. the habitat type is equivalent to, is part of, or sufficiently resembles a EUNIS type for which a critical load range is available; or
    b. the habitat type does not, or not sufficiently, resemble a EUNIS type for which a critical load range is available.
2. The result of step 1 is a range and needs to be further specified to a unique value (1a), or the unique value still has to be determined (1b). In both cases model results are used if these are available. The steps are applied in this order because the empirical values are broadly accepted, and the model results are considered as a further specification for The Netherlands of these internationally accepted values. This agrees with the use of critical load values proposed in UNECE's mapping manual (Spranger et al. 2004). In this step the

model output is critically screened for its use in critical load assessment in view of the shortcomings and uncertainties that exist for certain habitat types. There are two possible outcomes:

   a. the model results are considered sufficiently reliable to serve as a critical load. This is the case if the uncertainty range of the model output for the type concerned is not too large, *and* the output is ecologically plausible. In that case model results and empirical values are combined to a unique critical load value as explained in the following section.
   b. there are no useable model results. In that case a third step is required. Model results are not used in the following cases:
      - the uncertainty analysis by Van Dobben et al. (2004, 2006) indicates that the confidence interval of the model output is extremely large; or
      - the model output is ecologically not plausible (i.e. extremely large or extremely small).

3. In two situations an expert opinion is required:
   - The habitat type is equivalent to, forms part of, or sufficiently resembles a EUNIS type for which an empirical range is available (=1a), but no satisfactory model results are available. Within the range a unique value must be established on the basis of ecological considerations; these considerations are found in Annex 1. If no further data are available the range midpoint is used.
   - There are no empirical ranges (=1b) for the habitat type and neither are there satisfactory model results. In that case the critical load value has to be estimated solely on the basis of expert opinion. This expert opinion is usually based on knowledge of ecological processes, or on a comparison with related types.

   In both cases there are three possible outcomes:

   a. the expert opinion is considered sufficiently certain to assess a unique critical load;
   b. the expert opinion is uncertain but a possible critical load can be assessed;
   c. there is no expert opinion and therefore no critical load can be assessed.

Category 3c did not occur and 3b applied to only two habitat types. Therefore it can be concluded that for the vast majority of the habitat types well-founded unique critical load values can be assessed (=2a and 3a). Figure 1 gives a schematic representation of the above protocol.

2.3 Integration of empirical and simulated critical load values

Habitat types nearly always comprise several plant communities (known as associations and sub-associations). The SMART2-^{1} model does not give results at the habitat type level, but at the more detailed level of plant communities, for some communities differentiated per soil type. To determine a critical load per habitat type the model results of several plant communities and soil types have to be combined. In this step only the results of relevant plant communities are included, i.e. vegetation types representing a poor quality of the habitat type, and those that only occur in mosaic with the core types of the habitat, are not used. A special case are vegetation types that are only relevant if a number of typical species of the core of the habitat are present; such types have been excluded from the calculation if sufficient other model results are available. The complete translation table from habitat type to vegetation type is given in Annex 2, including an explanation why certain vegetation types have or have not been included.

The critical load for a habitat type is calculated by a composite averaging procedure:

1. if the critical load value for a (sub)association is different per soil type, the values of the soil types are averaged to a single value for that (sub)association;

2. if there are critical load values for several subassociations of one association, their values are averaged to a single value for that association;
3. if a habitat types comprises several (sub)associations, their critical load values are averaged to a single value for that habitat type.

Calculation details of this procedure can be found in Annex 2.

To comply with the broadly accepted empirical critical load values of Bobbink & Hettelingh (2011) the critical loads determined in the above steps are only used if they are within the range of the empirical values. This is not always the case and therefore the following extra rule is used:

4. if the (average) model result is above the empirical range, the upper threshold of the empirical range becomes the critical load; if the (average) model result is below the empirical range, the lower threshold of the empirical range becomes the critical load.

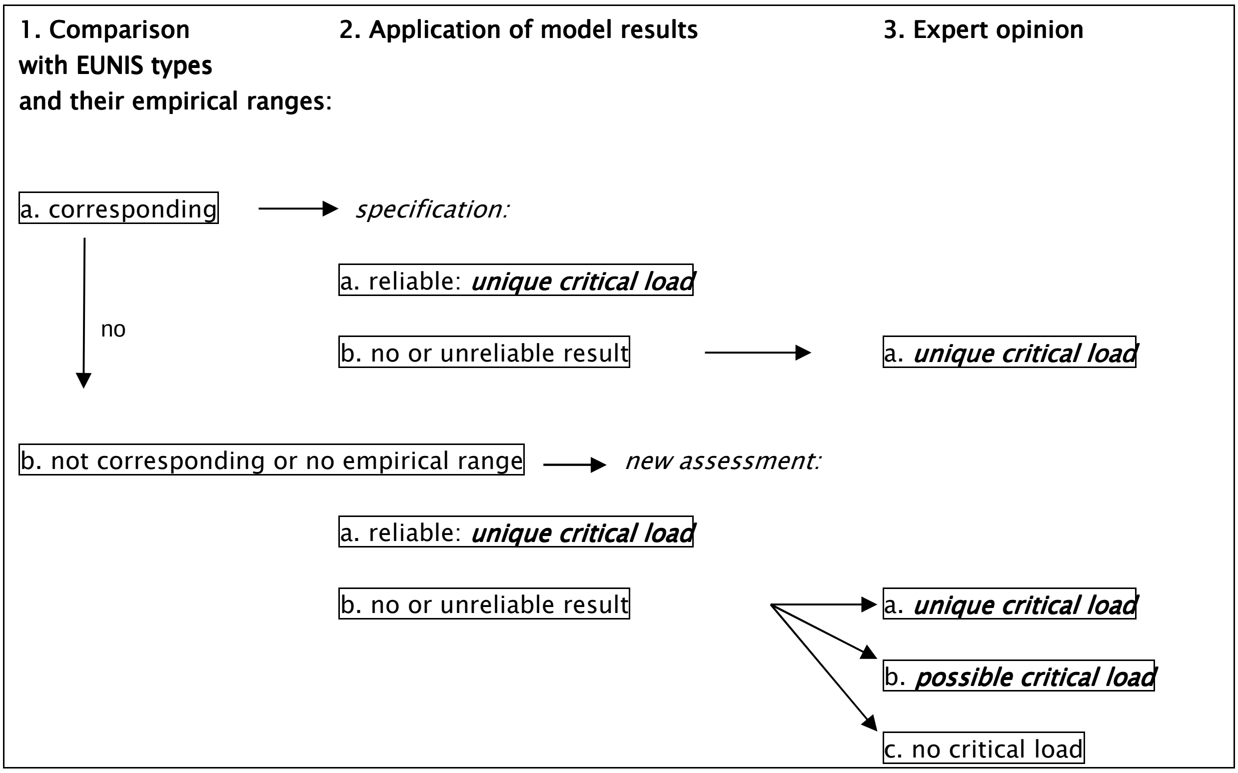

Figure 1. Flow diagram of the protocol to derive unique critical load values. The columns are the steps described in this paragraph, their possible outcomes are in boxes and the final critical load values are in ***bold and italic****.*

2.4 Habitat for species

Natura 2000 areas have not only been designated because of the presence of certain habitat types, but in many cases also because of the presence of certain species. These may be migratory or breeding birds of the Birds Directive, but also plants and animals of the Habitats Directive. The habitats of these species, as far as they are nitrogen sensitive and do not overlap with habitat types, are summarised in fourteen 'other habitats' ('overige leefgebieden') by Smits et al. (in prep). The definition of these habitats is derived from the 'nature target types' ('natuurdoeltypen') in Bal et al. (2001), and is given in Annex II. For a species-oriented application of the critical load approach it should be determined which habitats (i.e., habitat types, or other habitats) are used by a species; the complete habitat of a species may consist of several units (partial habitats) that each have their own critical load. In places where a species uses a habitat type, the critical load of that habitat type can be considered as the critical load of that species' habitat. In this report the critical load values for the fourteen other habitats have been determined in exactly the same way as for the habitat types of the Directive.

3 Results

The unique critical load values per habitat type resulting from the above procedure are given in Annex 1, together with a short explanation. The critical load values are expressed in kg N per ha per year (rounded to 1 kg) and recalculated to Mol N per ha per year (rounded to 1 Mol) using the following expressions[1]:
1 kg N = 71,43 Mol N
1 Mol N = 0,014 kg N
Values based on expert opinion are sometimes in the form of ' > 34 kg' and ' > 2400 Mol'. In these cases a critical load cannot be determined with any degree of certainty, however it is most probably above the indicated thresholds.
Calculation details are given in Annex 2.

In averaging and rounding the following procedures were used:

- all values are rounded to 1 kg N ha^{-1} y^{-1} in the usual way i.e. decimals greater than or equal to .5 are rounded to the next higher integer;
- the critical load values are first rounded to 1 kg N ha^{-1} y^{-1} and subsequently recalculated to Mol ha^{-1} y^{-1} using the expression above, and rounded to 1 Mol in the same way;
- in cases where there are no usable model results and Bobbink & Hettelingh (2011) do not give recommendations for the use of a subrange within the empirical range, the critical load becomes the range midpoint, rounded down to 1 kg N ha^{-1} y^{-1} (i.e. only decimals greater than .5 are rounded to the next higher integer);
- if Bobbink & Hettelingh (2011) recommend to use a certain subrange within the empirical critical load range (e.g. 'use lower end'/ 'use upper end'), a subrange is used defined between the range midpoint determined as above, and the lower or higher range endpoint; if there are no usable model results the critical load becomes the midpoint of this subrange;
- the subranges given by Bobbink & Hettelingh (2011) depend on abiotic (edaphic, climatological, hydrological) conditions. The choice of subranges is explained in Annex 1.

For some habitat (sub)types variants are included, based on abiotic differences that are reflected in phytosociological or geographical classifications. This has been done in cases where the variation within a type is too large to define a unique critical load value for that type. In practice this means that in some case not only the local habitat type has to be taken into account for the determination of the critical load, but also e.g. the 'Physico-Geographical Region' in the sense of Bal & Looise (1997, 2001). If the latter is unknown, the lowest critical load value should be used according to the precautionary principle.

A special case is formed by habitat type 7120 (Degraded raised bogs still capable of natural regeneration). This type has highly diverse abiotic and syntaxonomic conditions, and besides typical raised bog vegetation it also comprises vegetation types that occur in habitat types 4010A (Northern Atlantic wet heaths with *Erica tetralix*), 91D0 (bog woodland) and 7110A (Active raised bogs). In practice one may choose to maintain such vegetation types as they are, and in that case the critical load of 7120 would be too low if they resemble 4010 (wet heath) or 91D0 (bog woodland). Therefore three variants of this habitat type are distinguished: 'target like 4010A', 'target like 91D0', and 'target like 7110A'. In principle the latter should be chosen, however if one of the other targets is considered satisfactory for a prolonged period, one of the others may be chosen. The syntaxonomic identification of the plant communities belonging to the variants are given in Annex 2.

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[1] Mol column not included in Annex 1 of this preprint, will be added in the final version

4 Discussion

4.1 Evaluation of our method in the light of the precautionary principle

The above procedure estimates critical load values that have the highest likelihood; this is a direct consequence of the averaging procedure. However, the Habitats Directive intends to *'rule out significant negative effects'*. Many scientists appear to follow a strict interpretation of the precautionary principle, where the lower end of an uncertainty range is automatically used (cf. Appendix 4 in Van Dobben & Van Hinsberg 2008). Here we use range midpoint or even upper ends if there is sufficient scientific support to do so. By using the most likely critical load, significant negative effects cannot be entirely ruled out in practice, because there will always be situations that have a higher than average sensitivity to nitrogen deposition (although lower than average situations are equally likely). This is a disadvantage that is inherent to the application of generic standards at site level. It would require a very large effort to determine for each site if its local critical load is significantly different from the generic value. Therefore we choose to determine a unique value **within** a range using a well-defined method. The reviewers of Van Dobben & Van Hinsberg (2008) (Appendix 4) considered this methodology *'as a great step forward in applying science based effects thresholds in local and national environmental policy'*, although they recommend to discuss whether in case of uncertainty the lower range endpoint should be chosen to exclude negative effects. However, because of the main conclusion of the review cited above we decided to adhere to the above method.

4.2 Practical usage of critical load values

Van Dobben & Van Hinsberg (2008) make recommendations on the application of critical load values in practice. These recommendations partly relate to the estimation of the spatial variation of deposition within a Natura 2000 area, taking account of the effect of vegetation roughness on the deposition. This is most important if deposition is estimated on a course geographical resolution. However, the model AERIUS (www.aerius.nl) that is presently being developed, estimates deposition on a fine resolution, using high-resolution habitat type maps; this was one of the recommendations from international expert groups on the application of critical loads (see Bobbink & Hettelingh 2011). Therefore Appendix 3 in Van Dobben & Van Hinsberg (2008), that gives critical load values per Natura 2000 area, is now obsolete.

The reliability of critical load exceedences estimated in practical situation depends on uncertainties in both the critical load itself, and the deposition models and their input data. In these fields the best knowledge that is presently available is brought together in AERIUS. As more data and more sophisticated models become available, uncertainty ranges in both critical load and actual deposition will become smaller. Also the empirical values will be further developed. Presently, most attention is required in the following fields:

- the inclusion of more species groups than only green plants;
- the development of dynamic ecosystem models to further refine expert opinion and to estimate uncertainty ranges;
- the estimation of critical load values for individual nitrogen compounds i.e. nitrate and ammonia; results of some authors suggest different sensitivities to these compounds;
- experimental work in habitat types that have a high uncertainty in their critical load values because of a lack of data.

It is recommended to use the present critical loads for the obligatory reporting of the conservation status per habitat type to the European Union (Hicks et al. 2011).

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Annex 1: critical load values for nitrogen per habitat type

Explanation of column headers:

habitat type	code for habitat type according to Council of the European Communities (1992) (numerical), or habitat for species according to Smits et al. (in prep.) (numerical preceded by 'Hs')
subtype and/or variant	code for subtype (upper case) or variant (lower case) as used in The Netherlands
description of Habitat type	description of habitat type (as in Council of the European Communities 1992) or habitat for species (as in Smits et al. in prep.)
description of subtype or variant	description of subtype or variant. Subtypes are fully described in http://www.synbiosys.alterra.nl/natura2000/documenten/profielen/habitattypen/definitietabel%20habitattypen%20(versie%2024%20maart%202009).xls ; variants are described only in this table
EUNIS type	code for EUNIS type according to Davies at al. (2004)
description of EUNIS type	description of EUNIS type according to Davies at al. (2004)
empirical range	empirical critical load range according to B&H
reliability	reliability of empirical critical load range according to B&H, coded as: ## 'reliable', # 'quite reliable', (#) 'expert judgement'.
simulated value	simulated critical load value; the derivation of this value is specified in Annex 2
critical Load	final critical load value in kg N / ha / yr, rounded to 1 kg
explanation	methodological considerations used in the derivation of critical load value

Footnotes are indicated as (a), (b) etc. and explained after the table

B&H = Bobbink & Hettelingh (2011)

habitat type	subtype and/or variant	description of Habitat type	description of subtype or variant	EUNIS type	description of EUNIS type	empirical range	relia-bility	simu-lated value	critical Load	explanation
1110	A	Sandbanks which are slightly covered by sea water all the time	tidal area						> 34	expert opinion, based on sufficient buffering capacity and naturally (moderately) eutrophic
1110	B	Sandbanks which are slightly covered by sea water all the time	North sea coastal zone						> 34	expert opinion, based on sufficient buffering capacity and naturally (moderately) eutrophic
1110	C	Sandbanks which are slightly covered by sea water all the time	Dogger bank						> 34	expert opinion, based on sufficient buffering capacity and naturally (moderately) eutrophic
1130		Estuaries							> 34	expert opinion, based on sufficient buffering capacity and naturally (moderately) eutrophic (a)
1140	A	Mudflats and sandflats not covered by seawater at low tide	tidal area						> 34	expert opinion, based on sufficient buffering capacity and naturally (moderately) eutrophic
1140	B	Mudflats and sandflats not covered by seawater at low tide	North sea coastal zone						> 34	expert opinion, based on sufficient buffering capacity and naturally (moderately) eutrophic
1160		Large shallow inlets and bays							> 34	expert opinion, based on sufficient buffering capacity and naturally (moderately) eutrophic
1170		Reefs							> 34	expert opinion, based on sufficient buffering capacity and naturally (moderately) eutrophic
1310	A	*Salicornia* and other annuals colonizing mud and sand	*Salicornia* spp. dominated	A2.54	low-mid salt marshes	20-30	(#)	22.9	23	average model result, fits within empirical range

habitat type	subtype and/or variant	description of Habitat type	description of subtype or variant	EUNIS type	description of EUNIS type	empirical range	relia-bility	simu-lated value	critical Load	explanation
				A2.55	pioneer salt marshes	20-30	(#)			
1310	B	*Salicornia* and other annuals colonizing mud and sand	*Sagina maritima* present	A2.54	low-mid salt marshes	20-30	(#)	20.8	21	model result, fits within empirical range
1310	B	*Salicornia* and other annuals colonizing mud and sand	*Sagina maritima* present	A2.55	pioneer salt marshes	20-30	(#)			
1320		*Spartina* swards (Spartinion maritimae)		A2.54	low-mid salt marshes	20-30	(#)	23.3	23	model result, fits within empirical range
1320		*Spartina* swards (Spartinion maritimae)		A2.55	pioneer salt marshes	20-30	(#)			
1330	A	Atlantic salt meadows (Glauco-Puccinellietalia maritimae)	not protected by dykes	A2.54	low-mid salt marshes	20-30	(#)	22.3	22	average model result, fits within empirical range
1330	A	Atlantic salt meadows (Glauco-Puccinellietalia maritimae)	not protected by dykes	A2.55	pioneer salt marshes	20-30	(#)			
1330	B	Atlantic salt meadows (Glauco-Puccinellietalia maritimae)	protected by dykes	A2.54	low-mid salt marshes	20-30	(#)	22.3	22	average model result, fits within empirical range
1330	B	Atlantic salt meadows (Glauco-Puccinellietalia maritimae)	protected by dykes	A2.55	pioneer salt marshes	20-30	(#)			

habitat type	subtype and/or variant	description of Habitat type	description of subtype or variant	EUNIS type	description of EUNIS type	empirical range	relia-bility	simu-lated value	critical Load	explanation
2110		Embryonic shifting dunes		B1.3	Shifting coastal dunes	10-20	(#)	23.6	20	upper limit of empirical range, taking account of average model result
2120		Shifting dunes along the shoreline with *Ammophila arenaria* ("white dunes")		B1.3	Shifting coastal dunes	10-20	(#)	21.2	20	upper limit of empirical range, taking account of model result
2130	A	Fixed coastal dunes with herbaceous vegetation ("grey dunes")	calcareous	B1.4	Coastal stable dune grasslands	8-15	#	17.4	15	upper limit of range of empirical subrange, taking account of model result. Subrange is 10-15 given the calcareous character (see B&H footnote on p. 187)
2130	B	Fixed coastal dunes with herbaceous vegetation ("grey dunes")	non-calcareous	B1.4	Coastal stable dune grasslands	8-15	#	13.1	10	upper limit of range of empirical subrange, taking account of model result. Subrange is 8-10 given the non-calcareous character (see B&H footnote on p. 187)
2130	C	Fixed coastal dunes with herbaceous vegetation ("grey dunes")	grass-heath type	B1.4	Coastal stable dune grasslands	8-15	#	10.8	10	upper limit of range of empirical subrange, taking account of model result. Subrange is 8-10 given the non-calcareous character (see B&H footnote on p. 187)
2140	A	Decalcified fixed dunes with *Empetrum nigrum*	moist	B1.5	Coastal dune heaths	10-20	(#)		15	midpoint of the empirical range; the utility of the model result is limited by uncertainties in the parameterisation for heathland ecosystems (Van Hinsberg & Kros, 1999)

habitat type	subtype and/or variant	description of Habitat type	description of subtype or variant	EUNIS type	description of EUNIS type	empirical range	relia-bility	simu-lated value	critical Load	explanation
2140	B	Decalcified fixed dunes with *Empetrum nigrum*	dry	B1.5	Coastal dune heaths	10-20	(#)		15	midpoint of the empirical range; the utility of the model result is limited by uncertainties in the parameterisation for heathland ecosystems (Van Hinsberg & Kros, 1999)
2150		Atlantic decalcified fixed dunes (Calluno-Ulicetea)		B1.5	Coastal dune heaths	10-20	(#)		15	midpoint of the empirical range; the utility of the model result is limited by uncertainties in the parameterisation for heathland ecosystems (Van Hinsberg & Kros, 1999)
2160		Dunes with *Hippophaë rhamnoides*						28.3	28	average model result
2170		Dunes with *Salix repens* ssp. *argentea* (Salicion arenariae)						32.3	32	average model result
2180	Abe	Wooded dunes of the Atlantic, Continental and Boreal region	dry, *Quercus* - *Betula* dominated variant	G1.8	Acidophilous Quercus-dominated woodland	10-15	(#)	18.2	15	upper limit of empirical range, taking account of model result (b)
2180	Ao	Wooded dunes of the Atlantic, Continental and Boreal region	dry, variant with dominance of other tree species	G1.6	Fagus woodland	10-20	(#)	28.6	20	upper limit of empirical range, taking account of model result (c)
2180	B	Wooded dunes of the Atlantic, Continental and Boreal region	moist					31.3	31	average model result

habitat type	subtype and/or variant	description of Habitat type	description of subtype or variant	EUNIS type	description of EUNIS type	empirical range	relia-bility	simu-lated value	critical Load	explanation
2180	C	Wooded dunes of the Atlantic, Continental and Boreal region	inner dune fringe					25.3	25	average model result (d)
2190	Aom	Humid dune slacks	open water, oligo-mesotrophic	C1.16	Dune slack pools	10-20	(#)	14.0	14	model results according to Aquacid, fits within empirical range; model results according to SMART2-1 are not suitable for surface water (p)
2190	Ae	Humid dune slacks	open water, meso-eutrophic						30	expert opinion, based on similar situations in peat landscape (3150) and salt marshes (1330) (q)
2190	B	Humid dune slacks	calcareous	B1.8	Moist to wet dune slacks	10-20	(#)	19.5	20	average model result, fitting within empirical subrange. Subrange is 15-20 given the high base availability (see footnote b in B&H p.187)
2190	C	Humid dune slacks	non-calcareous	B1.8	Moist to wet dune slacks	10-20	(#)	18.6	15	upper limit of empirical subrange, taking account of model result. Subrange is 10-15 given the high base saturation (see B&H footnote on p. 187)

habitat type	**subtype and/or variant**	**description of Habitat type**	**description of subtype or variant**	**EUNIS type**	**description of EUNIS type**	**empirical range**	**relia-bility**	**simu-lated value**	**critical Load**	**explanation**
2190	D	Humid dune slacks	tall reed and sedge vegetation						> 34	expert opinion, based on sufficient buffer capacity and naturally weakly to moderately eutrophic conditions, the weakly-eutrophic forms are 'potentially sensitive' to the fertilizing effect of nitrogen (compare 2190A), however there is insufficient certainty about the suitability of SMART2-1 for this type of marsh vegetation
2310		Dry sand heaths with *Calluna* and *Genista*		F4.2	Dry heaths	10-20	##	10-20	15	average of model results according to Calluna (e) and fitting within empirical subrange. Subrange is 10-15 given: (1) average precipitation in NL for the area of the type, (2) water level is not relevant, and (3) sod cutting frequency which is low (otherwise it would be restoration management) (see B&H footnotes e and h on p. 187)
2320		Dry sand heaths with *Calluna* and *Empetrum nigrum*		F4.2	Dry heaths	10-20	##	10-20	15	average of model results according to Calluna (e) (f) and fitting within empirical subrange. Subrange is 10-15 (see 2310)

habitat type	**subtype and/or variant**	**description of Habitat type**	**description of subtype or variant**	**EUNIS type**	**description of EUNIS type**	**empirical range**	**relia-bility**	**simu-lated value**	**critical Load**	**explanation**
2330		Inland dunes with open *Corynephorus* and *Agrostis grasslands*		E1.94	Inland dune pioneer grasslands	8-15	(#)	10.4	10	model result fitting within empirical subrange. Subrange is 8-11 given the low base availability (see footnote b in B&H p.187)
3110		Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae)		C1.1	Permanent oligotrophic lakes, ponds and pools	3-10	##	5.9	6	median model result, fitting within empirical subrange. Subrange is 5-10 (r) given the Atlantic character (see B&H footnote c on p. 187)
3130		Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoëto-Nanojuncetea		C1.1	Permanent oligotrophic lakes, ponds and pools	3-10	##		8	expert opinion based on some more buffering than habitat type 3110, fitting within empirical subrange. Subrange is 5-10 (r) given the Atlantic character (see footnote c on B&H p. 187)
3140	hz	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.	on sandy soil						8	expert opinion; type occurs in same pools as 3130 (g)
3140	lv	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.	in peatland areas						30	expert opinion, see 3150

habitat type	subtype and/or variant	description of Habitat type	description of subtype or variant	EUNIS type	description of EUNIS type	empirical range	relia-bility	simu-lated value	critical Load	explanation
3140	az	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.	in former (now enclosed) marine basins						> 34	expert opinion, see 3150
3150	baz	Natural eutrophic lakes with Magnopotamion or Hydrocharition - type	outside former (now enclosed) marine basins						30	expert opinion, based on sufficient buffer capacity, so not sensitive to acidification, should not be nutrient-rich, and is therefore sensitive to nitrogen in combination with phosphorus (the type is phosphate-limited, but by the addition of P, which almost always takes place, the type becomes also sensitive to N); the value is as yet derived from the model results for floating mires that occur under similar environmental conditions
3150	az	Natural eutrophic lakes with Magnopotamion or Hydrocharition - type	in former (now enclosed) marine basins						> 34	expert opinion, based on sufficient buffering and naturally (moderately) eutrophic
3160		Natural dystrophic lakes and ponds		C1.4	permanent dystrophic lakes, ponds and pools	3-10	(#)		10	expert opinion based on eutrophying effect of N (u), upper limit of empirical subrange. Subrange is 5-10 (r) given the Atlantic character (see footnote c on B&H p. 187)

habitat type	subtype and/or variant	description of Habitat type	description of subtype or variant	EUNIS type	description of EUNIS type	empirical range	relia-bility	simu-lated value	critical Load	explanation
3260	A	Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation	*Ranunculus* subg. *Batrachium* spp.						> 34	expert opinion, based on sufficient buffer capacity and should not be rich in nutrients, but nitrogen supply by deposition is (at least up to 34 kg N / ha / y) sufficiently dissipated by water flow
3260	B	Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation	large *Potamogeton* spp.						> 34	expert opinion, based on sufficient buffer capacity and should not be rich in nutrients, but nitrogen supply by deposition is (at least up to 34 kg N / ha / y) sufficiently dissipated by water flow
3270		Rivers with muddy banks with Chenopodion rubri p.p. and Bidention p.p.							> 34	expert opinion, based on sufficient buffering and naturally (moderately) eutrophic conditions
4010	A	Northern Atlantic wet heaths with *Erica tetralix*	on sandy soil	F4.11	Erica tetralix dominated wet heath lowland	10-20	(#)	17-22	17	model results according to Berendse (1988) (h), fitting within empirical range. A subrange has not been used because: (1) the average precipitation in the Netherlands in the area of the type, (2) water level is high under optimal conditions, (3) low sod-cutting frequency (see B&H footnotes e and h on p. 187)

habitat type	subtype and/or variant	description of Habitat type	description of subtype or variant	EUNIS type	description of EUNIS type	empirical range	relia-bility	simu-lated value	critical Load	explanation
4010	B	Northern Atlantic wet heaths with *Erica tetralix*	in peatland areas	D2	Valley mires, poor fens and transition mires	10-15	#		11	average of the empirical subrange. Subrange is 10-12 (#) (see B&H footnote f on p. 187)
4030		European dry heaths		F4.2	Dry heaths	10-20	##	10-20	15	average of model results according to Calluna (e) and fitting within empirical subrange. Subrange is 10-15 (see 2310)
5130		*Juniperus communis* formations on heaths or calcareous grasslands		F4.2	Dry heaths	10-20	##	30.5	15	upper limit of empirical subrange, taking account of model result (i). Subrange is 10-15 (see 2310)
6110		Rupicolous calcareous or basophilic grasslands of the Alysso-Sedion albi		E1.26	Sub-Atlantic semi-dry calcareous grassland	15-25	##	20.1	20	model result, fitting within empirical range
6120		Xeric sand calcareous grasslands		E2.2	Low and medium altitude hay meadows	20-30	(#)	17.5	18	average model result, fitting within empirical range (j)
				E1.26	Sub-Atlantic semi-dry calcareous grassland	15-25	##			
6130		Calaminarian grasslands of the Violetalia calaminariae		E1.7	Closed non-Mediterranean dry acid and neutral grassland	10-15	##	14.7	15	model result, fitting within empirical range

habitat type	subtype and/or variant	description of Habitat type	description of subtype or variant	EUNIS type	description of EUNIS type	empirical range	relia-bility	simu-lated value	critical Load	explanation
6210		Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia)		E1.26	Sub-Atlantic semi-dry calcareous grassland	15-25	##	21.1	21	average model result, fitting within empirical range
6230	dka	Species-rich *Nardus* grasslands, on silicious substrates in mountain areas (and submountain areas in Continental Europe)	dry, non-calcareous variant	E3.52	Heath Juncus meadows and humid Nardus stricta swards	10-20	#	13.7	12	top of empirical subrange, taking account of model result. Subrange is 10-12 (see B&H footnote on p. 187)
6230	dkr	Species-rich *Nardus* grasslands, on silicious substrates in mountain areas (and submountain areas in Continental Europe)	dry, calcareous variant	E1.7	Closed non-Mediterranean dry acid and neutral grassland	10-15	##	12.2	12	model result, fitting within empirical subrange. Subrange is 12-15 (see footnote b in B&H p.187)
6230	vka	Species-rich *Nardus* grasslands, on silicious substrates in mountain areas (and submountain areas in Continental Europe)	moist, non-calcareous variant	E1.7	Closed non-Mediterranean dry acid and neutral grassland	10-15	##	9.6	10	bottom of empirical range, taking account of model results
6410		*Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae)		E3.51	Molinia caerulea meadows	15-25	(#)	10.9	15	bottom of empirical range, taking account of average model results

habitat type	**subtype and/or variant**	**description of Habitat type**	**description of subtype or variant**	**EUNIS type**	**description of EUNIS type**	**empirical range**	**relia-bility**	**simu-lated value**	**critical Load**	**explanation**
6430	A	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	*Filipendula ulmaria* dominant						> 34	expert opinion; model results are probably not usable because the surface water is the main nitrogen source and not the deposition
6430	B	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	*Epilobium hirsitum* dominant						> 34	expert opinion; model results are probably not usable because the surface water is the main nitrogen source and not the deposition
6430	C	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	dry forest fringe					26.1	26	expert opinion, derived from average model results of related vegetation under comparable environmental conditions
6510	A	Lowland hay meadows *(Alopecurus pratensis, Sanguisorba officinalis)*	*Arrhenaterum elatius* dominant	E2.2	Low and medium altitude hay meadows	20-30	(#)	19.4	20	bottom of empirical range, taking account of average model results
6510	B	Lowland hay meadows *(Alopecurus pratensis, Sanguisorba officinalis)*	*Alopecurus pratensis* dominant	E2.2	Low and medium altitude hay meadows	20-30	(#)	21.5	22	average model result, fitting within empirical range

habitat type	subtype and/or variant	description of Habitat type	description of subtype or variant	EUNIS type	description of EUNIS type	empirical range	relia-bility	simu-lated value	critical Load	explanation
7110	A	Active raised bogs	in bog landscape	D1	Raised and blanket bogs	5-10	##		7	midpoint of empirical range. A subrange is not used because of the low rainfall in the Netherlands in the peat area, while the water level is high under optimal conditions (see B&H e footnote on p. 187)
7110	B	Active raised bogs	in heathland landscape	D2	Valley mires, poor fens and transition mires	10-15	#		11	midpoint of empirical subrange. Subrange is 10-12 (#) (see B&H footnote f on p. 187)
7120	ah	Degraded raised bogs still capable of natural regeneration	target like 7110A						7	critical load of 7110A (v)
7120	vh	Degraded raised bogs still capable of natural regeneration	target like 4010A						17	critical load of 4010A (v)
7120	hb	Degraded raised bogs still capable of natural regeneration	target like 91D0						25	critical load of 91D0 (v)
7140	A	Transition mires and quaking bogs	quaking bog	D4.1	Rich fens	15-30	(#)	16.8	17	average model result, fitting within empirical range (k)
7140	B	Transition mires and quaking bogs	floating fen *(Phragmites* dominated)	D2	Valley mires, poor fens and transition mires	10-15	#	7.2	10	bottom of empirical range, taking account of model results

habitat type	**subtype and/or variant**	**description of Habitat type**	**description of subtype or variant**	**EUNIS type**	**description of EUNIS type**	**empirical range**	**relia-bility**	**simu-lated value**	**critical Load**	**explanation**
7150		Depressions on peat substrates of the Rhynchosporion		F4.11	Erica tetralix dominated wet heath lowland	10-20	(#)	17-22	20	top of empirical range, taking account of model results by Berendse (1988) (l). Subrange is 15-20 given (1) the average precipitation in the Netherlands on the area of the type, (2) the high water level, and (3) the fact that habitat type 7150 is a community of sod-cut patches (see B&H footnotes e and f on p. 187)
7210		Calcareous fens with *Cladium mariscus* and species of the Caricion davallianae		D4.1	Rich fens	15-30	(#)		22	midpoint of empirical range
7220		Petrifying springs with tufa formation (Cratoneurion)							<34?	expert opinion, given Bobbink & Lamers (1999) (m)
7230		Alkaline fens		D4.1	Rich fens	15-30	(#)	15.8	16	average model result, fitting within empirical range
9110		Luzulo-Fagetum beech forests		G1.6	Fagus woodlands	10-20	(#)	28.0	20	top of empirical range, taking account of model result
9120		Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus* in the shrublayer (Quercion robori-petraeae or Ilici-Fagenion)		G1.6	Fagus woodlands	10-20	(#)	28.7	20	top of empirical range, taking account of average model result

habitat type	subtype and/or variant	description of Habitat type	description of subtype or variant	EUNIS type	description of EUNIS type	empirical range	relia-bility	simu-lated value	critical Load	explanation
9160	A	Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli	on sandy soil	G1.A	Meso- and eutrophic Quercus, Carpinus, Fraxinus, Acer, Tilia, Ulmus and related woodland	15-20	(#)	30.3	20	top of empirical range, taking account of average model result
9160	B	Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli	on calcareous hills (like 9130)	G1.A	Meso- and eutrophic Quercus, Carpinus, Fraxinus, Acer, Tilia, Ulmus and related woodland	15-20	(#)	33.7	20	top of empirical range, taking account of average model result
9190		Old acidophilous oak woods with *Quercus robur* on sandy plains		G1.8	Acidophilous Quercus-dominated woodland	10-15	(#)	18.2	15	top of empirical range, taking account of model result
91D0		Bog woodland						27.5	25	expert opinion, given both the average model result and also the very low value for bog vegetation (see 7110)
91E0	A	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)	in river valleys, *Salix* and *Populus* dominated					33.8	34	average model result (n)

habitat type	**subtype and/or variant**	**description of Habitat type**	**description of subtype or variant**	**EUNIS type**	**description of EUNIS type**	**empirical range**	**relia-bility**	**simu-lated value**	**critical Load**	**explanation**
91E0	B	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)	in river valleys, *Fraxinus* and *Ulmus* dominated					28.0	28	average model result (n)
91E0	C	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)	in brook valleys					26.1	26	average model result (n)
91F0		Riparian mixed forests of *Quercus robur, Ulmus laevis* and *Ulmus minor, Fraxinus excelsior* or *Fraxinus angustifolia,* along the great rivers (Ulmenion minoris)						29.1	29	average model result (n)
Hs01		Permanent springs & Slow flowing headwaters							< 34	expert opinion, given Bobbink & Lamers (1999)
Hs02		Isolated meanders and peatland ditches						29.7	30	model result (o)

habitat type	subtype and/or variant	description of Habitat type	description of subtype or variant	EUNIS type	description of EUNIS type	empirical range	relia-bility	simu-lated value	critical Load	explanation
Hs03		Weakly buffered ditches							25	expert opinion taken from Bal et al. (2007): weakly buffered (compare habitat type 3130), but some supply of buffer substances from infiltration area and also some loss of N through outflow (therefore not "very sensitive") (t)
Hs04		Acidic moorland pools							17	critical load of habitat type 4010A (s)
Hs05		Caricion gracilis fens						23.5	24	average model result
Hs06		Calthion grasslands of brook valleys		E2.2	Low and medium altitude hay meadows	20-30	(#)	16.9	20	bottom of empirical range, taking account of average model results
Hs07		Calthion grasslands of peat and clay		E2.2	Low and medium altitude hay meadows	20-30	(#)	18.0	20	bottom of empirical range, taking account of average model results
Hs08		Wet, moderately nutrient-rich grasslands		E2.2	Low and medium altitude hay meadows	20-30	(#)	22.3	22	model result, fitting within empirical range
Hs09		Extremely dry oligotrophic grasslands		E1.7	Closed non-Mediterranean dry acid and neutral grassland	10-15	##	14.4	14	model result, fitting within empirical range

habitat type	subtype and/or variant	description of Habitat type	description of subtype or variant	EUNIS type	description of EUNIS type	empirical range	relia-bility	simu-lated value	critical Load	explanation
Hs10		Lolio-Cynosuretum and other grasslands of sand and peat landscape (habitat for meadow birds)		E2.2	Low and medium altitude hay meadows	20-30	(#)	18.9	20	bottom of empirical range, taking account of average model results
Hs11		Lolio-Cynosuretum and other grasslands of clay landscape (habitat for meadow birds)		E2.2	Low and medium altitude hay meadows	20-30	(#)	18.9	20	bottom of empirical range, taking account of average model results
Hs12		Dry dune forest fringes, edges and thickets						23.1	23	average model result
Hs13		Forests on poor sandy soils		G1.8	Acidophilous Quercus-dominated woodland	10-15	(#)	18.2	15	top of empirical range, taking account of model result
Hs14		Oak and beech forests on loamy sandy soils		G1.6	Fagus woodlands	10-20	(#)	28.7	20	top of empirical range, taking account of average model result

Footnotes:

a According to B&H this type is similar or related to low and middle salt marsh (A2.54 and A2.55). In the Netherlands, salt marshes are not considered as part of habitat type 1130 and are therefore this translation is ignored here.

b This is the nutrient-poor variant (Erico-Betuletum pubescentis); habitat type 2180 is not mentioned in B&H nor is the corresponding EUNIS class B1.7 (Coastal dune woods). Therefore, the translation to the corresponding forest type outside the dunes is used here. The value of 18.2 is given by Albers et al. (2001) for 'Forests of poor sandy soil'.

c This concerns the other dry dune forests (beech forests). 2180 is not mentioned in B&H nor is the corresponding EUNIS class B1.7 (Coastal dune woods).Therefore, the translation to the corresponding forest type outside the dunes is used here.

d No translation to EUNIS in B&H App. 1 and no comparable forests (the range proposed in 2008 for G1.2: Mixed riparian floodplain and gallery woodland has not been adopted here).

e Model CALLUNA (Heil & Bobbink 1993) used; model results according SMART2^{-1} are unusable because regular management is not taken into account (Van Hinsberg & Kros 1999).

f Strictly speaking CALLUNA is not applicable to heathland with *Empetrum* but given the ecological similarity (abtiotic environment, mosses) its results are used here.

g Translation to EUNIS C1.16 (Plankton communities of oligotrophic waters), as mentioned in B&H, is not relevant because that class is considered to be habitat type 2190 in the Netherlands.

h According to the ERICA model (Berendse 1988) the bottom of the management-dependent range (17-22) is used given the low intensity management to achieve the desired biodiversity. The lowering of the empirical range in B&H is an additional argument to use the bottom of the range. The utility of the average SMART2^{-1} result is limited by uncertainties in its parameterization for heathland ecosystems (Van Hinsberg & Kros, 1999).

i According to B&H App 1 related to habitat type 4030, which is defensible, given the similarity in undergrowth.

j The habitat type is a nutrient-poor form of the first-mentioned type, and is similar to the second type.

k According to B&H App 1 the entire habitat type 7140 is in D2: Valley mires, poor fens and transition mires. But research in Dutch quaking bogs supports the critical load for 'rich fens' (B&H p. 77) so the translation to D1.4 is used here.

l According to the ERICA model (Berendse 1988) the top of the management-dependent range (17-22) used because this vegetation is typical for sod-cut patches. The utility of the average SMART2^{-1} result is limited by uncertainties in its parameterization for heathland ecosystems (Van Hinsberg & Kros, 1999).

m Is D4.2: Montane rich fens according to B&H App1 , but C2.1: Springs, spring brooks and geysers according to the EUNIS database, which is more logical. This is not covered in B&H. For the calculation of critical load exceedences in specific locations, 2400 mol / ha / y should be used.

n This concerns G1.2: Mixed riparian floodplain and gallery woodland which is not covered in B&H (the range proposed in 2008 for G1.2: Mixed riparian floodplain and gallery woodland has not been adopted here).

o Cicuto-Caricetum pseudocyperi is the only vegetation type for which a model result is available, the abiotic conditions of this type are characteristic for this habitat, although by itself the type is not significant for the species concerned.

p Concerns vegetations belonging to the Charetum hispidae and the Litorellion

q Concerns vegetations belonging to the Charion vulgaris and the Potametea

r Is not really clear in B&H, but this is what was meant to during the symposium where the ranges were determined (pers. com. R. Bobbink).

s Unlike for habitat type 3160, the empirical range of C1.4: permanent dystrophic lakes, ponds and pools is not relevant for this habitat, which concerns the Little Grebe and the Black-necked Grebe. The effect on C1.4 (Increased algal productivity and a shift in nutrient limitation of phytoplankton from N to P) is not relevant for these species. Overgrowth of the banks is relevant, however, and these banks are similar to habitat type 4010 (subtype of sandy soil). Also severe acidification is relevant, but that only occurs at even higher deposition values.

t There are no empirical, nor modelled critical loads. This is a habitat for the floating water plantain, the ramshorn snail and the European bitterling. Bal et al. (2007) give 25.2 kg for a weakly buffered ditch (with floating water plantain) on the basis of expert opinion. The restoration strategy (Smits et al. in prep.) mentions that ditch cleaning may lead to a lower sensitivity for the floating water plantain, that for the ramshorn snail a critical load similar to habitat type 3150 (in which it also occurs) is conceivable and that 25.2 is relevant for the European bitterling "at a low N-load by other sources or high P-load" (also all expert opinion). Here the lowest of these values is used.

u In the past, acidic moorland pools were further acidified by a high nitrogen load in combination with high sulphur loads; currently the critical load is determined by the eutrophication effect.

v See text, chapter 3 last paragraph

Annex 2: Specification of model results used to derive critical loads

This table gives all habitat types, subtypes and variants together with the vegetation types they are composed of, and the critical load values of these types. Habitat types are indicated by codes, for their full names and descriptions see Annex 1. The translation of habitat types to vegetation types is according to http://www.synbiosys.alterra.nl/natura2000/gebiedendatabase.aspx?subj=habtypen&groep=0 and Smits et al. (in prep.).; vegetation type for which no critical load value is available have been omitted, a full list of corresponding vegetation types is found in Van Dobben et al. (2012), Bijlage 2.

Explanation of column headers:

habitat type	code for habitat type or habitat, corresponding to the first column of Annex 1
subtype and/or variant	code for subtype and/or variant, corresponding to the second column of Annex 1
vegetation type	name of corresponding vegetation type
soil type	code for soil type: CN: clay non-calcareous, CC: clay calcareous, SC: sand calcareous, SP: sand poor, SR: sand rich, L: loess, P: peat
CL according to SMART2^{-1}	critical load of soil / vegetation combination in Van Dobben et al. (2004), Appendix 2 (blank if no value is available)
reason not to use this CL	this reason may relate to the model outcome itself (ecologically implausible or too large uncertainty range), or to the soil or vegetation type (not typical or not relevant)
CL averaged over soil types	
CL averaged over vegetation types	
other model results	results of other models than SMART2^{-1}

Footnotes are indicated as (a), (b) etc. and explained after the table

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-1	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
1110	A							
1110	B							
1110	C							
1130								
1140	A							
1140	B							
1160								
1170								
1310	A	Salicornietum dolichostachyae	SC	23.0		23.0	22.9	
		Salicornietum brachystachyae	CN	22.5		22.7		
			CC	22.8				
		Suaedetum maritimae	CC	22.9		22.9		
			SC	22.9				
1310	B	Centaurio-Saginetum	SC	20.8		20.8	20.8	
1320		Spartinetum maritimae	CC	23.2		23.3	23.3	
			SC	23.3				
1330	A	Puccinellietum maritimae	CN	21.9		22.1	22.3	
			CC	22.3				
			SC	22.2				
		Plantagini-Limonietum	SC	22.0		22.0		
		Halimionetum portulacoides	CC	22.7		22.7		

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-1	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
		Puccinellietum distantis	CN	21.7		22.3		
			CC	22.8				
			SC	22.5				
		Juncetum gerardi	CN	20.9		21.0		
			CC	21.0				
			SC	21.0				
		Armerio-Festucetum litoralis	CC	21.5		21.5		
			SC	21.5				
		Atriplici-Elytrigietum pungentis	CC	23.0		23.1		
			SC	23.1				
		Oenantho lachenalii-Juncetum maritimi	CN	24.6		23.8		
			CC	25.8				
			SC	20.9				
1330	B	Puccinellietum maritimae	CN	21.9		22.1	22.3	
			CC	22.3				
			SC	22.2				
		Puccinellietum distantis	CN	21.7		22.3		
			CC	22.8				
			SC	22.5				
		Juncetum gerardi	CN	20.9		21.0		
			CC	21.0				
			SC	21.0				
		Armerio-Festucetum litoralis	CC	21.5		21.5		
			SC	21.5				

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-[1]	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
		Atriplici-Elytrigietum pungentis	CC	23.0		23.1		
			SC	23.1				
		Oenantho lachenalii-Juncetum maritimi	CN	24.6		23.8		
			CC	25.8				
			SC	20.9				
2110		Honckenyo-Agropyretum juncei	SC	23.6		23.6	23.6	
2120		Elymo-Ammophiletum	SC	21.2		21.2	21.2	
2130	A	Phleo-Tortuletum ruraliformis	SC	17.2		17.2	17.4	
		Sileno-Tortuletum ruraliformis	SC	16.9		16.9		
		Taraxaco-Galietum veri	SC	17.1		17.1		
		Anthyllido-Silenetum	SC	16.2		16.2		
		Polygonato-Lithospermetum	SC	19.7		19.7		
2130	B	Violo-Corynephoretum	SP	11.2		11.2	13.1	
		Ornithopodo-Corynephoretum	SP	14.0		14.0		
		Festuco-Galietum veri	SP	14.1		14.1		
2130	C	Botrychio-Polygaletum	SP	10.8		10.8	10.8	
2140	A	Empetro-Ericetum	SP	30.6	Implausible value			
2140	B	Carici arenariae-Empetretum	SP	29.2	Implausible value			
		Polypodio-Empetretum	SP	30.7	Implausible value			

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-[1]	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
		Salici repentis-Empetretum	SP	30.2	Implausible value			
		Pyrolo-Salicetum	SC	33.3	Implausible value			
			SP	31.2	Implausible value			
2150		Genisto anglicae-Callunetum typicum	SP	4.3	Implausible value			
		Carici arenariae-Empetretum	SP	29.2	Implausible value			
2160		Hippophao-Sambucetum	SC	29.0		29.0	28.3	
		Hippophao-Ligustretum	SC	28.0		28.0		
		Rhamno-Crataegetum	SC	27.9		27.9		
2170		Pyrolo-Salicetum	SC	33.3		32.3	32.3	
			SP	31.2				
2180	Abe	Betulo-Quercetum roboris	SP	10.5	very large uncertainty range			1300 mol of N / ha / year (= 18.2 kg N / ha / y) in Albers et al (2001) for ´forests on poor sandy soils´, comparable to Betulo-Quercetum roboris in the dunes
2180	Ao	Fago-Quercetum	SP	29.1		28.6	28.6	

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-[1]	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
			SR	28.1				
		Crataego-Betuletum pubescentis	SC	27.9	vegetation type is not typical for habitat type			
2180	B	Thelypterido-Alnetum	CN	28.5		32.5	31.2	
			P	36.5				
		Carici elongatae-Alnetum	P	36.4		33.6		
			SR	30.7				
		Carici curtae-Betuletum pubescentis	CN	26.9		30.9		
			P	34.8				
		Crataego-Betuletum pubescentis	SC	27.9		27.9		
2180	C	Violo odoratae-Ulmetum	SC	29.1		29.1	25.3	
		Fraxino-Ulmetum	CN	23.6		28.0		
			CC	32.3				
		Pruno-Fraxinetum	CN	24.5		18.7		
			SR	12.9				
		Crataego-Betuletum pubescentis	SC	27.9	vegetation type is not typical for habitat type			
2190	Aom	Eleocharitetum multicaulis	P	22.0	Implausible value			14.0 according Aquacid model applies to relatively large dune lakes)
			SP	21.1	Implausible value			
		Samolo-Littorelletum	SP	12.2	Implausible value			
2190	Ae	Eleocharito acicularis-	CC	22.1	Implausible value			

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-[1]	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
		Limoselletum	SR	21.8	Implausible value			
2190	B	Parnassio-Juncetum atricapilli	SC	17.7		17.7	19.5	
		Junco baltici-Schoenetum nigricantis	SC	17.8		17.8		
		Equiseto variegati-Salicetum repentis	CN	21.7		21.9		
		Equiseto variegati-Salicetum repentis	CC	22.0				
		Centaurio-Saginetum	SC	20.8		20.8		
2190	C	Caricetum trinervi-nigrae	P	26.9		19.4	18.6	
			SP	11.8				
		Carici curtae-Agrostietum caninae	P	18.1		17.8		
			SR	17.5				
		Empetro-Ericetum	SP	30.6	Implausible value			
2190	D	Cicuto-Caricetum pseudocyperi	P	29.7	Implausible value			
		Alismato-Scirpetum scirpetosum triquetri (f)	CN	22.4	Implausible value			
			CC	23.2	Implausible value			
			P	22.2	Implausible value			
			SR	22.3	Implausible value			
		Typho-Phragmitetum	CN	24.2	Implausible value			
			CC	25.7	Implausible value			
			P	21.1	Implausible value			
		Caricetum gracilis	CN	24.2	Implausible value			

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-[1]	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
			CC	25.9	Implausible value			
			P	20.5	Implausible value			
2310		Genisto anglicae-Callunetum	SP	4.3	Implausible value			10-20 according to CALLUNA model
2320		Genisto anglicae-Callunetum	SP	4.3	Implausible value			10-20 according to CALLUNA model
2330		Spergulo-Corynephoretum	SP	10.4		10.4	10.4	
		Ornithopodo-Corynephoretum	SP	14.0	vegetation type is not typical for habitat type			
		Festuco-Thymetum serpylli	SP	14.7	vegetation type is not typical for habitat type			
3110								4.9-14.0 (median value = 5.8) according to AquAcid model
3130		Eleocharitetum multicaulis	P	22.0	Implausible value			
			SP	21.1	Implausible value			
		Samolo-Littorelletum	SP	12.2	Implausible value			
3140	az							
3140	z							
3140	lv							
3150	az							
3150	baz							

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-1	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
3160		Sphagnetum cuspidato-obesi	P	33.1	Implausible value			4.9-14.0 (median value = 5.8) according to AquAcid model
			SP	31.1	Implausible value			
		Sphagno-Rhynchosporetum	P	28.9	Implausible value			
			SP	1.8	very large uncertainty range			
		Caricetum limosae	P	30.3	Implausible value			
			SP	30.8	Implausible value			
3260	A							
3260	B							
3270		Rumicetum maritimi	CN	30.6	Implausible value			
			CC	31.3	Implausible value			
			SC	23.3	Implausible value			
			P	22.5	Implausible value			
		Eleocharito acicularis-Limoselletum	CC	22.1	Implausible value			
			SR	21.8	Implausible value			
4010	A	Ericetum tetralicis	P	29.2	very large uncertainty range			17-22 according to the model in Berendse (1988)
			SP	14.1	very large uncertainty range			
4010	B	Sphagno palustris-Ericetum	P	32.9	Implausible value			
4030		Genisto anglicae-Callunetum	SP	4.3	Implausible value			10-20 according to CALLUNA model

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-[1]	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
5130		Roso-Juniperetum	SP	28.5		28.0	30.5	
			SR	27.4				
		Dicrano-Juniperetum	SP	33.0		33.0		
6110		Cerastietum pumili	CC	20.1		20.1	20.1	
6120		Sedo-Thymetum pulegioidis	SC	15.5		15.5	17.5	
		Medicagini-Avenetum pubescentis	CC	19.4		19.6		
			SC	19.7				
		Festuco-Thymetum serpylli	SP	14.7	vegetation type is not typical for habitat type			
		Bromo inermis-Eryngietum campestris	CC	20.8	vegetation type is not typical for habitat type			
			SR	21.0				
6130		Festuco-Thymetum serpylli	SP	14.7		14.7	14.7	
6210		Gentiano-Koelerietum	CC	20.6		20.6	21.1	
		Galio-Trifolietum	CC	21.6		21.6		
6230	dka	Galio hercynici-Festucetum ovinae	SP	13.7		13.7	13.7	
		Botrychio-Polygaletum	SP	10.8	vegetation type is not typical for habitat type			
6230	dkr	Betonico-Brachypodietum	SR	12.2		12.2	12.2	
6230	vka	Gentiano pneumonanthes-Nardetum	SP	9.6		9.6	9.6	
6410		Cirsio dissecti-	CN	17.2		13.5	10.9	

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-1	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
		Molinietum nardetosum	SP	9.8				
		Cirsio dissecti-Molinietum typicum	P	5.5	Implausible value	9.7		
			SP	9.7				
		Cirsio dissecti-Molinietum peucedanetosum	P	1.8	very large uncertainty range			
		Cirsio dissecti-Molinietum parnassietosum	SR	9.5		9.5		
		Crepido-Juncetum acutiflori	L	13.2	vegetation type is not typical for habitat type			
			P	1.8				
			SP	11.4				
6430	A	Valeriano-Filipenduletum	CC	21.8	Implausible value			
			SC	22.0	Implausible value			
			P	21.7	Implausible value			
6430	B	Valeriano-Senecionetum fluviatilis	CN	25.4	Implausible value			
			CC	25.9	Implausible value			
		Soncho-Epilobietum typicum	CN	28.7	Implausible value			
			CC	29.2	Implausible value			
			P	22.9	Implausible value			
		Oenantho-Althaeetum	CN	25.6	Implausible value			
			CC	25.6	Implausible value			
			SR	21.9	Implausible value			

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-1	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
6430	C (a)	Rubo-Origanetum typicum	CC	22.8		23.1 (b)	26.1	
		Rubo-Origanetum festucetosum arundinaceae	CC	23.4				
		Balloto-Arctietum	CC	24.5		23.9		
			SC	23.3				
		Echio-Verbascetum	SC	21.0		21.0		
		Rubetum grati	P	33.4		30.8		
			SP	29.5				
			SR	29.4				
		Rubetum silvatici	SP	30.2		29.7		
			SR	29.1				
		Pruno-Crataegetum	CN	23.7		27.9		
			CC	32.1				
6510	A	Arrhenatheretum elatioris	CC	23.7		19.4	19.4	
			SR	15.0				
6510	B	Fritillario-Alopecuretum pratensis	CN	21.4		21.5	21.5	
			CC	21.5				
7110	A	Carici curtae-Agrostietum caninae	P	18.1	CL only determined by Erico-Sphagnetum magellanici			
			SR	17.5	soil type not relevant			
		Sphagnetum cuspidato-obesi	P	33.1	CL only determined by Erico-Sphagnetum magellanici			

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-1	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
			SP	31.1	soil type not relevant			
		Sphagno-Rhynchosporetum	P	28.9	CL only determined by Erico-Sphagnetum magellanici			
			SP	1.8	soil type not relevant			
		Caricetum limosae	P	30.3	CL only determined by Erico-Sphagnetum magellanici			
			SP	30.8	soil type not relevant			
		Erico-Sphagnetum magellanici	P	26.4	Implausible value			
			SP	8.1	soil type not relevant			
		Salicetum auritae	P	36.7	CL only determined by Erico-Sphagnetum magellanici			
			SP	28.7	soil type not relevant			
		Erico-Betuletum pubescentis	P	32.4	CL only determined by Erico-Sphagnetum magellanici			
			SP	15.8	soil type not relevant			
		Carici curtae-Betuletum pubescentis	CN	26.9	soil type not relevant			
			P	34.8	CL only determined by Erico-Sphagnetum magellanici			
7110	B	Erico-Sphagnetum magellanici	P	26.4	very large uncertainty range			
			SP	8.1	Implausible value			
7120	a	Carici curtae-Agrostietum caninae	P	18.1	CL only determined by Erico-Sphagnetum magellanici			
			SR	17.5	CL only determined by Erico-Sphagnetum magellanici			
		Sphagnetum cuspidato-obesi	P	33.1	CL only determined by Erico-Sphagnetum magellanici			

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-[1]	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
			SP	31.1	CL only determined by Erico-Sphagnetum magellanici			
		Sphagno-Rhynchosporetum	P	28.9	CL only determined by Erico-Sphagnetum magellanici			
			SP	1.8	CL only determined by Erico-Sphagnetum magellanici			
		Caricetum limosae	P	30.3	CL only determined by Erico-Sphagnetum magellanici			
			SP	30.8	CL only determined by Erico-Sphagnetum magellanici			
		Lycopodio-Rhynchosporetum	SP	8.7	very large uncertainty range			
		Ericetum tetralicis sphagnetosum	P	27.2	CL only determined by Erico-Sphagnetum magellanici			
			SP	15.0				
		Erico-Sphagnetum magellanici	P	26.4	Implausible value			
			SP	8.1	very large uncertainty range			
		Erico-Betuletum pubescentis	P	32.4	CL only determined by Erico-Sphagnetum magellanici			
			SP	15.8	CL only determined by Erico-Sphagnetum magellanici			
		Carici curtae-Betuletum pubescentis	CN	26.9	CL only determined by Erico-Sphagnetum magellanici			
			P	34.8	CL only determined by Erico-Sphagnetum magellanici			
7120	v	Ericetum tetralicis	P	29.2	very large uncertainty range			
			SP	14.1	very large uncertainty range			

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-1	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
7120	b	Erico-Betuletum pubescentis	P	32.4		24.1	27.5	
			SP	15.8				
		Carici curtae-Betuletum pubescentis	CN	26.9		30.9		
			P	34.8				
7140	A	Carici curtae-Agrostietum caninae	P	18.1		17.8	16.8	
			SR	17.5				
		Scorpidio-Caricetum diandrae	P	15.8		15.8		
7140	B	Pallavicinio-Sphagnetum	P	7.2		7.2	7.2	
7150		Sphagno-Rhynchosporetum	P	28.9	Implausible value			
			SP	1.8	very large uncertainty range			
		Lycopodio-Rhynchosporetum	SP	8.7	very large uncertainty range			
7210								
7220	(c)							
7230		Equiseto variegati-Salicetum repentis	CN	21.7		21.9	15.8 (d)	
			CC	22.0				
		Cirsio dissecti-Molinietum typicum	P	5.5	Implausible value			
			SP	9.7		9.7		
		Cirsio dissecti-Molinietum parnassietosum	SR	9.5		9.5		
9110		Luzulo luzuloidis-Fagetum	SP	28.0		28.0	28.0	
9120		Fago-Quercetum	SP	29.1		28.6	28.7	

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-1	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
			SR	28.1				
		Deschampsio-Fagetum	SP	29.4		28.8		
			SR	28.2				
		Stellario-Carpinetum	CN	22.7	soil type not relevant			
			CC	37.8	soil type not relevant			
9160	A	Stellario-Carpinetum	CN	22.7		30.3	30.3	
			CC	37.8				
9160	B	Orchio-Cornetum	CC	37.1		37.1	33.7	
		Stellario-Carpinetum	CN	22.7		30.3		
			CC	37.8				
9190		Betulo-Quercetum roboris	SP	10.5	Implausible value			1300 mol of N / ha / year (= 18.2 kg N / ha / y) in Albers et al. (2001) for forests on poor sandy soils
91D0		Erico-Betuletum pubescentis	P	32.4		24.1	27.5	
			SP	15.8				
		Carici curtae-Betuletum pubescentis	CN	26.9		30.9		
			P	34.8				
91E0	A	Artemisio-Salicetum albae	CC	35.1		32.0	33.8	
			SC	28.9				
		Irido-Salicetum albae	CN	30.0		35.3		
			CC	40.6				

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-1	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
		Cardamino amarae-Salicetum albae	CN	29.0		34.1		
			CC	39.1				
91E0	B	Fraxino-Ulmetum	CN	23.6		28.0	28.0	
			CC	32.3				
91E0	C	Carici elongatae-Alnetum	P	36.4		33.6	26.1	
			SR	30.7				
		Pruno-Fraxinetum	CN	24.5		18.7		
			SR	12.9				
91F0		Violo odoratae-Ulmetum	SC	29.1		29.1	29.1	
Hs01		Pellio epiphyllae-Chrysosplenietum oppositifolii	SR	19.2	unreliable (e)			
Hs02		Cicuto-Caricetum pseudocyperi	P	29.7		29.7	29.7	
Hs03								
Hs04								
Hs05		Caricetum gracilis	CN	24.2		23.5	23.5	
			CC	25.9				
			P	20.5				
Hs06		Crepido-Juncetum acutiflori	L	13.2		12.3	16.9	
			P	1.8	very large uncertainty range			
			SP	11.4				
		Ranunculo-Senecionetum aquatici	CN	23.7		21.5		
			P	19.3				

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-[1]	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
Hs07		Rhinantho-Orchietum morionis	CN	17.6		14.5	18.0	
			SC	18.0				
			SP	11.1				
			SR	11.3				
		Ranunculo-Senecionetum aquatici	CN	23.7		21.5		
			P	19.3				
Hs08		Ranunculo-Alopecuretum geniculati	CC	22.4		22.3	22.3	
			SC	22.2				
Hs09		Ornithopodo-Corynephoretum	SP	14.0		14.0	14.4	
		Festuco-Thymetum serpylli	SP	14.7		14.7		
Hs10		Lolio-Cynosuretum	CN	21.1	soil type not relevant			
			P	18.0		17.8	17.8	
			SR	17.6				
Hs11		Lolio-Cynosuretum	CN	21.1		19.4	19.4	
			SR	17.6				
			P	18.0	soil type not relevant			
Hs12		Polygonato-Lithospermetum	SC	19.7		19.7	23.1	
		Balloto-Arctietum	CC	24.5		23.9		
			SC	23.3				
		Echio-Verbascetum	SC	21.0		21.0		
		Rhamno-Crataegetum	SC	27.9		27.9		

habitat type	subtype and/or variant	vegetation type used to derive CL	soil type	CL according to SMART2-1	reason not to use this CL	CL averaged over soil types	CL averaged over vege-tation types	other model results
Hs13		Leucobryo-Pinetum	SP	33.8	Implausible value			1300 mol of N / ha / year (= 18.2 kg N / ha / y) in Albers et al. (2001) for forests on poor sandy soils
		Betulo-Quercetum roboris	SP	10.5	Implausible value			
Hs14		Fago-Quercetum	SP	29.1		28.6	28.7	
			SR	28.1				
		Deschampsio-Fagetum	SP	29.4		28.8		
			SR	28.2				

Footnotes:

a no model results available, critical load values based on related vegetation under the same environmental conditions

b average of both subassociations

c no code for this vegetation, this concerns spring vegetation with *Brachythecium rivulare, Palustriella commutata* and/or *Cratoneuron filicinum*

d namely the average of the two subassociaties of Cirsio dissecti-Molinietum (9.6), and averaged with Equiseto variegati-Salicetum repentis: ((9.5 +9.7) / 2 + 21.9) / 2 = 15.8

e see van Dobben et al. (2004), p. 21

f this is the only subassociation with a model result