ENVIRONMENTAL RESEARCH OF THE
FEDERAL MINISTRY OF THE ENVIRONMENT,
NATURE CONSERVATION AND NUCLEAR SAFETY

Research Report 200 85 221

Texte 22/04

ISSN 0722-186X

The BERN Model: Bioindication for Ecosystem Regeneration towards Natural conditions

by

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Edited by: Section II 4.4
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Berlin, August 2004

Vorwort

Erhöhte Einträge von Stickstoffverbindungen in Ökosysteme und damit verbundene Eutrophierungserscheinungen sind ein wesentliches Problem im Zusammenhang mit ferntransportierten Luftschadstoffen. Ein Fokus der Wirkungsforschung liegt daher auf der zeit- und raumbezogenen Quantifizierung der Wirkung dieser Einträge mit dem Ziel, wichtige ökosystemare Prozesse der Modellierung zugänglich zu machen. Das hier vorgestellte BERN-Modell[1)] ermöglicht erstmals die Bioindikation von sich ändernden Bodenparametern mit Hilfe des beobachteten Wandels von natürlichen Pflanzengesellschaften. Zusammen mit vorgeschalteten prozessorientierten bodenchemischen Modellen lassen sich nun Prognosen über künftige Auswirkungen auf Ökosystemebene treffen, aber auch notwendige Maßnahmen und deren Wirksamkeit ableiten.
Das BERN-Modell ist im Auftrag des Umweltbundesamtes im Rahmen des FuE-Vorhabens *FKZ 200 85 212* von der Firma Ökodata[2)] entwickelt worden. Es soll auch international im Rahmen der Arbeiten des UN ECE Übereinkommens über den weiträumigen, grenzüberschreitenden Transport von Luftverunreinigungen auf Arbeitssitzungen vorgestellt, diskutiert und weiterentwickelt werden.

Foreword

The eutrophying effects resulting from increased deposition rates of reactive nitrogen to ecosystems are a major problem in the context of long range transported air pollution. Therefore, one focus of the related effects oriented research is to improve knowledge on time- and area-depending effects for modelling purposes. The presented BERN-model[1)] allows for the first time to model changes of major plant communities as bioindicators as a result of changes of soil parameters. In combination with existing process-oriented soil chemical models, prognoses on possible changes of ecosystems, the derivation of abatement measures and the evaluation of their effectiveness will be possible.
The BERN-model has been developed by Ökodata[2)] and is funded by the Federal Environmental Agency, Germany (FKZ-No. 200 85 212). It is aimed to present, discuss and further develop this approach also in the framework of the UNECE Convention on Long-range Transboundary Air Pollution.

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[1] **B**ioindication for **E**cosystem **R**egeneration towards **n**atural conditions / Bioindikatorische Ermittlung von regenerierungspotentialen naturnaher Ökosysteme

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The BERN Model: Bioindication for Ecosystem Regeneration towards Natural conditions

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1 Introduction

(A. Schlutow)

As a Signatory to the 1999 Gothenburg Protocol, Germany accepted extensive new environmental obligations. This Protocol, signed by 31 countries as the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, extends the 1979 Convention on Long-range Transboundary Air Pollution and aims to achieve its targets by 2010. Among Germany's responsibilities resulting from the Gothenburg Protocol there is also the obligation to contribute work-products towards the fulfillment of the medium-term work plan of the UNECE Working Group on Effects (WGE). At the last Critical Loads-Conference, which took place in Copenhagen in 1999, an overview of effect-oriented methodologies was presented, which demonstrated the connection between the rates of Critical Load exceedances and the observations of biological and ecological effects. One point of critique arising from the Copenhagen conference was that, in most cases, the Critical Load for air pollution was defined through the measurement of soil chemistry parameters. The challenge posed by that Conference was to include, in future models, more ecological indicators when establishing environmental Cause-Effect Relationships and determiningCritical Loads.

In order to better integrate ecosystematic connections, the BERN model was developed on the basis of empirical compilations, performed within a well monitored region of Germany.

Both the change within the vegetation structure and other biological reactions to long lasting air pollutant depositions (e.g., changes within the humus layer) can be recognized easily as indicators of ecological effects when one considers that the vegetation and the soil organism communities react in delayed sequence to the changing abiotic factors.

2 Background

(A. Schlutow)

Nearly all biological components in a natural or semi-natural ecosystem depend on a harmonious equilibrium within the nutrient cycle (fig. 1). In particular, there is a strong interdependence between the plant and soil organisms and their balanced relationship with the essential nutrients, which include nitrogen (N), phosphorus (P) and carbon (C), as well as base cations (Bc: sum of calcium [Ca], potassium [K] and magnesium [Mg]) and the supply of water and temperature. Where there is a lack of one of the nutrients, the biomass productivity decreases - even if other nutrients, energy, and water are still sufficiently present. The empirically determined reactions of plants and soil organisms to nutrient inputs (nitrogen eutrophication) and/or nutrient losses (leaching of base cations as a consequence of acidification) can only be interpreted reasonably where one determines the multiple correlations between C to N to Bc- considering water supply and temperature. The influence of phosphorus has still to be neglected in the BERN model because the interaction with the plant composition could not be verified satisfactorily by experimental evidence.
Both the "net primary productivity" of the plants and the "abating productivity" of the microorganisms which break down the humus may be empirical measures in evaluation of the harmonious material and energy equilibrium (fig. 1).

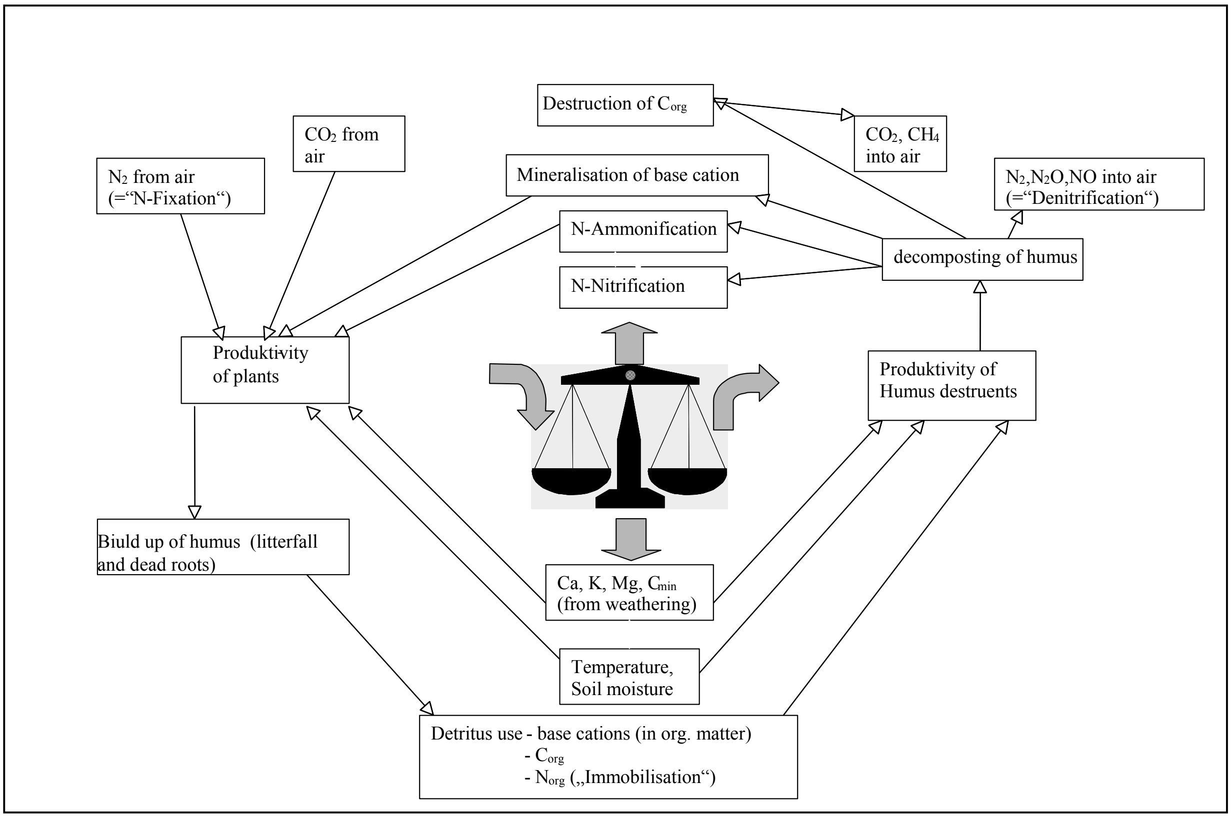


Fig. 1: Nutrient cycle in (semi)natural ecosystems (oder nutrient cycle)

Changes in the nutrient household as a consequence of anthropogenic influences often occur as a result of high depositions of nitrogen and sulphur. Both the endogenic chemical parameters in the soil solution and the exogenic exchange processes are changing between the upper soil and the atmosphere as well as the leaching into the ground water body (see BUTTERBACH-BAHL ET AL. 2001). Indicators of the endogenic changes are manifest within the productivity of plants and soil organisms and are also characterized by the changes of the vegetation structure and conversion of humus structure. The ELLENBERG (1991) system of "indicator values" for certain species represents values for the ecological optimum of the plant species. However, the system does not provide information on fundamental niche widths of the species. Also information about real niche in consideration of the competition power of the species are missing.

Plant communities contain the highest and most exact level of information. The plant community structure is characterized not only through the presence or absence of plant species, but also through the abundance of the respective populations and the steadiness of plant occurrence in the habitat type and the degree of coverage over the soil surface. From community structure, one can draw more exact information about the soil parameters than from the average of the optimum values of the plant species based on ELLENBERG (1991). On the other hand the ELLENBERG optimum values were of great value for the validation of our database by comparison.

In the presence of a harmonious equilibrium, (of nutrients, water, and energy) a so-called natural plant community spontaneously settles in. Disharmonious nutrient conditions, caused by soil-chemical processes in reaction to anthropogenic eutrophication and/or acidification, result in the reduction of the vitality and the ecosystematic functional efficiency- at first for single individuals, then later, up to and including the entire local population. The resulting consequence can be the local extinction of a specific plant species. Remaining behind after this extinction are those plant species with very large ecological niche widths- those capable of withstanding the changing site factors. If the local extinction of a plant species concerns the constant species with a high faithfulness to the natural plant community, the overall abundance decreases. Later, the natural plant community, as such, is no longer existent - only fragments and/or unsocial companies remain. Every now and then, plant species with very large niche widths immigrate to the competition-free areas. However, since these species are rare, only “few-species-compositions” develop, which can no longer build into plant association structures with typical composition of dominant and other constant species.

However, where nutrient input (e.g., with simultaneous nitrogen eutrophication and inputs of base cations from fly ash from coal combustion) achieves a new harmonious nutrient equilibrium at a higher level, there will still be the death of the primarily existing dominant and other constant plant species, but many other plant species will migrate in, which altogether can develop a new natural (or potentially natural) plant community typical for the habitat. The same occurrence has been known to occur with simultaneous acidification (with sulphur) and nitrogen deprivation.

If one uses the published taxonomy when labeling natural plant communities, one experiences difficulties with forest ecosystems. The difficulty lies in that the community name contains the names of the natural main tree species that are in reality hardly present in the current middle European forests. The spontaneous bush and ground vegetation, however, still matches the natural plant community. The constant bush or ground species are also contained in the community name. In the case of unspoiled habitats, forests contain mostly the natural main tree species due to regenerative processes in the ground and bush vegetation layer. Therefore the original taxonomy can be applied. Thus, when analyzing the current condition of forest sites, one must use the bush and ground vegetation as an indicator for the condition of the site rather than the trees themselves.

The difficulty involved with forest ecosystems, however, does not at all exist with plant communities of (semi)natural grassland, heaths or bogs. Thus, the natural plant communities in those habitats can be assigned directly to the scaled harmonious equilibrium classes.

3 Model concept

(A. Schlutow)

The conception of the model contains 4 stages:

- The determination of the primary-natural habitat parameters based on a) (quite) non changeable regular properties and b) easily changeable regular properties / allocation of typical plant communities to the classified regular habitat types
- The determination of the current conditions of the easily changeable soil parameters and their comparison with the original primary natural parameters of the regular habitat type.
- The determination of the regeneration target and regeneration potential.
- The combination of dynamic models based on soil-chemical parameters (e.g., ForSAFE) with the biological dynamic model BERN

3.1 Habitat classification based on the regular site properties and allocation of the typical plant communities

(A. Schlutow)

The north German lowlands and hilly area were chosen as the area of investigation for the purpose of a calibration and testing of the model. This area comprises nearly half of Germany's territory.
The site classification is based on a combination of typified (quite) non changeable regular site properties. This combination includes:

· type of hydromorphy (degree of water saturation)
· type of climatic region
· altitude zone
· relief type
· exposition type (degree of sun exposure)
· soil type group

The area under investigation includes the habitat types of both the planar sub oceanic and sub continental regions. The soil types, which are present in the north German lowlands were classified according to 33 groups of soil types. The forests, extensively used grassland, pastures and heaths including bogs and wet heaths were examined. For this area, 5218 vegetation and site observation releveés (OBERDORFER 1979; PASSARGE 1964; PASSARGE U. HOFMANN 1968; SCHLUTOW 1990-2002; SUCCOW U. JOOSTEN 2001, SCHMIDT, HEMPEL ET AL. 2000) were evaluated.

The 186 plant communities recorded in Northern Germany can be allocated to the following 239 regular site types (table 1)

Table 1: site parameter for classifying regular site types and for allocating their indicating plant community

altitude zone	Climate regional type	Hydromor-phic type	Relief type	Exposition type	quantity of soil-type groups and their allocated plant community in German Lowlands and hilly area			
					Wood-lands	Fens/ bogs	Natural meadows	Pastures, heathlands
lowland	azonal	high ground-water level	plane	no	9	18	-	-
	sub oceanic	groundwater in lower root-zone or below root-zone	plane	no	14	-	22	19
			medium slope	sunny site	14	-	8	9
				shade site	14	-	8	9
	sub continental		plane	-	14	-	22	19
			medium slope	sunny site	14	-	8	9
				shade site	14	-	8	9
colline/ submon-tane	azonal	high ground-water level	plane	no	14	25	-	-
	sub oceanic	groundwater in lower root-zone or below root-zone	plane, plateau	no	30	-	27	29
			slope	sunny site	18	-	23	22
				shade site	11	-	16	18
	sub continental		plane, plateau	-	27	-	27	29
			slope	sunny site	9	-	27	24
				shade site	16	-	18	22

The regular site types of German Northern low and hilly lands are defined after the following abiotic parameter (table 2 – 5).

Table 2: Relief types in the German Northern low and hilly lands

code	rise
plane	<5°
medium slope	mostly 4...9°, somewhere 9...16°
hardly slope	9...16°, somewhere >16°

Table 3: Exposition types of slopes in the German Northern low and hilly lands

code	Direction of slope surface	exposition of slope to sun (compass degree)
Sunny	South, east	45°-135°-225°
Shade	North, west	225°-315°-45°

Table 4: Hydromorphic types in the German Northern low and hilly lands

Code	Ground or stagnic water table under floor (dm)	Plant available water content in soil (%)	Moisture value after Ellenberg (1981)
Fare from groundwater dry	>20	<15	<2
Fare from groundwater medium dry	>20	15-20	3
Fare from groundwater fresh	>20	>20	4-5
Few influenced by groundwater	15-10	>20	5-6
medium influenced by groundwater	10-6		6-7
strongly influenced by groundwater	6-2		7-8
swampy	0-2		8-9
Few influenced by stagnic water	10-6		5-6
medium influenced by stagnic water	6-4		6-7
strongly influenced by stagnic water	<4		7-8

Table 5: Altitude/climate-zones in the German Northern low and hilly lands

Code	Altitude/climate-zone	Altitude NN (m)	Precipitition (mm/a)	Temperature (°C)
cUf	colline - suboceanic	100-500	570-900	6,5-8,7
cUt	colline - subcontinental	100-500	480-580	8,4-9,2
mHf	montane	650-850	850-1100	4,5-5,8
mKf	montane - oreal	800-1200	1000-1200	4,8
mMf	submontane-suboceanic	450-700	800-1000	5,2-7,0
mMm	submontane-subcontinental	450-700	650-800	6-7
sko	planar - subcontinental	0-150	450-560	8,5-9
soz	planar - suboceanic	0-150	550-700	8,5

For all regular site types, the typical natural (wood) and semi-natural (grassland) plant communities (with their wild-spontaneous species endowment) which were occurred before the hardly industrialization period in the 1960th are put into a database (fig. 2).

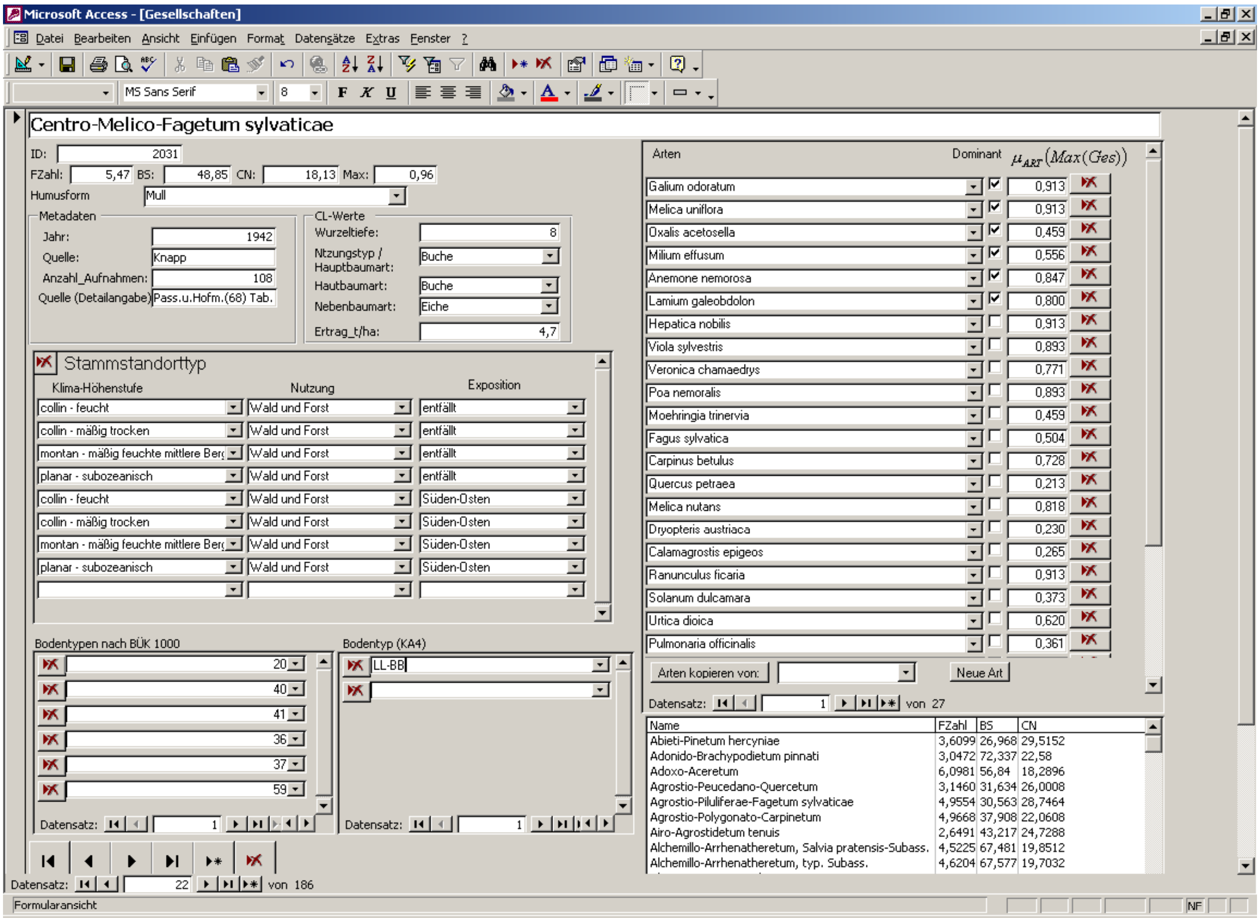


Fig. 2: Formular for entering the natural plant community´s information into the data base of BERN-model

To these plant communities have been assigned the regularly occurring constant dominant and other constant plant species.

The following definitions apply:

Plant Community: A regularly arising combination of plant species with a regular structure at a habitat site. This consists of constant dominant species, other constant species and unstable species. The size of the habitat of a plant community is determined on the basis of the homogeneity (=steadiness) of the distribution of the constant species.

Constant dominant species: A species that covers more than 15 percent of the habitat's soil and appears with a steadiness (= uniformity of their distribution over the entire habitat of the community) of over 60 percent.

Other constant species: A species with a degree of soil coverage below 15 percent and with a steadiness exceeding 60 percent.

Since the constant species of a plant community keep a high faithfulness to this community they are the relevant indicators for site factors which are preferred by this community.

Therefore for all 720 plant species retained in the database up to now, the ecological niche widths are indicated in regard to the easily changeable site properties (fig. 3). These include the parameters which follow:

· Soil moisture
· C/N-ratio
· Base saturation

A habitat is defined by the regular site type and by the three easily changeable parameters.

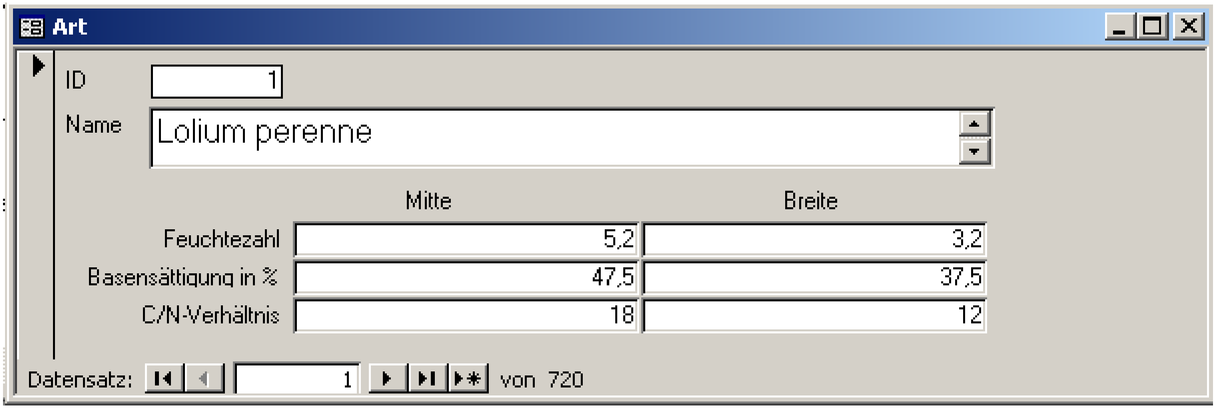


Fig. 3: Formular for entering the constant plant species of the natural plant communities and the additional information of fundamental niche widths (moisture value after Ellenberg 1981, base saturation in %, C/N-ratio in g/g) into the data base of BERN-model

3.2 Mathematical concept and equations

(P. Hübener)

Some authors (Burrows 1990, Glavac 1996, Dierschke 1994) have some arguments against using mathematical methods for describing relationships between site properties and plant occurrences. On the other hand it needs computing Critical Loads for plant sensitivity based on mathematic determined models.
Glavac 1996:49/198 called the relationship between site and plant composition "blurred relationship". Based on the fuzzy-logic a mathematical instrument is available for characterizing blurred relationships.
A great amount of knowledge is usable about the qualitatively relation between site properties and their plant communities (Ellenberg 1996, Klapp 1965, Oberdorfer1957, Passarge 1968, Pott 1994). The model BERN should result in a computer based ecosystem model using this knowledge. The approach is the blurred correlation of site types to plant species regarding empirical experiences about plant physiology and plant competition.

3.2.1 Blurred relation of site and plant

Relations describe correlations between objects. The classical algebra calls the correlating objects "Tupel". These tupel are elements of the kartesic products of the quantity of objects. Therefore the relation is a part of the object quantity. For a relation (R) which connects only 2 quantities of objects (X, Y) the following definition is valid:

$$R(X,Y) \subseteq X \times Y \qquad \text{eq. 1}$$

Which pairs (x, y) from X x Y belong to the relation R is determined by a condition or in the case of ending quantities by listing the included tupels. If the relation is determined by a blurred condition then the relation R is a blurred quantity and therefore R builds a blurred connection between the quantities X and Y. In the case of sharp quantities one object can be either an element or can not be an element, but in the case of blurred quantities the objects belong to the quantity with various degree of contribution. The blurred relation graduates the connection between the objects.
The mathematical approach bases on the definition of blurred relations between site properties and plant composition. Therefore it needs to produce the blurred condition determining the degree of contribution of a site/plant combination to the quantity of all actual regarded combinations.

The degree of keeping the blurred condition is called after ZADEH 1978 the possibility of variable x to keep the condition B. The degree of "x keeps B" is determined by a distribution function of possibilities (MVF) with the range 0...1.

3.2.2 Distribution function of possibilities as a model of ecological niches

If the variable x is standing for a site which is defined by the vector of site factors $x=(x_1, \ldots, x_n)$ and $\pi_y(x)$ is a MVF which determines the possibility of a plant species to exist on the site then the following equation valid:

$$\pi(x) \in \Re; x \in \Re^n \qquad \text{eq. 2}$$

with:

π = extention possibility of a plant species
x = site factor
n = number of site factors

This definition in accordance to the definition of ecological niche after Hutchenson (BURROWS 1990:115; SHUGART 1984:185) describes the ecological niche as a n-dimensionally hypervolume in the functional space of all site factors. The definition of MVF leads to a blurred hypervolume, a kind of hypercloud showing by BEGON ET AL. (1997), MARTIN (2002), DIERSCHKE (1994), BURROWS (1990).
WHITTAKER (IN ELLENBERG (1996) and BURROWS (1990)) differences fundamentally and really niches. The fundamentally niche corresponds with the hypervolume which is defined by the blurred conditions of plant adaptation to the exogenic site factors excluding the endogen competitive factor between the plant species.
DIERSCHKE (1994) calls the fundamentally niche also "possibility field" due to the functionally space defines the range of factor parameters in which the plant species can exist. This range of occurrence possibilities is determined by the physiological and genetic properties of the plant species and this is quite not changeable.

The really niche is a result of the social properties and is determined by the competitive power and reproductively fitness of the species in connection to all other existing species at the site.

While the fundamental niche is normally shown in a bell form of curve, the form of curve for the really niche could be very different. Especially species with a wide fundamentally niche which are not competitive enough could be displaced by other more competitive species in the middle range of niche around their niche optimum. An example is the Scottish pine (Pinus sylvetris) with 2 really niche optima in the driest and in the wettest soils respectively do to in the middle range of soil moisture the beech (Fagus sylvatica) is more competitive and displaces the pine.

Do to this difficulties describing displacing activities of different plant species at one site the BERN model describes in the first stage only the fundamental niches of the plant species. (Later in the second stage the really niche of the whole plant community will be modelled (see below)).

At first the blurred thresholds of the suitable site parameter for the plant species were determined and then they were combined with the operators of the fuzzy logic.

In order to model the really possibility of a species the points of dynamic competition equivalents between all species at one site had to be considered. But there is not enough knowledge about this equivalent points. On the other hand there is enough knowledge about natural plant communities in connection to their preferred site type because the natural plant community is the result of the stabile competition equivalence of all species depending on each other. To use this knowledge in the next stage the fundamental niches of all species building together a plant community were combined to determine the fundamental niche of the whole community. The combination of the fundamental niches of the plant species then shows the typical really parts of niches at one site type. In this way the problem of unknown competition equivalents points is solved by using known plant species combination.

3.2.3 Distribution of possibilities (MVF)

Usually the distribution function of possibilities (MVF) is defined in triangle or trapeze form (fig. 4). The reason is only the low speed for digital computing in former time. Now the fuzzy controller are available for which the correct curve of the contribution function is not of interest.

The BERN model uses the contribution function of the site types to the whole quantity of all suitable site types for the plant occurrence not for a fuzzy controller but for the possibility of the species to exist at the defined site. Therefore the contribution function determining the distribution function of possibilities has to be a plausible curve for which heuristically causes are to be founded because theoretically causes do not exist.

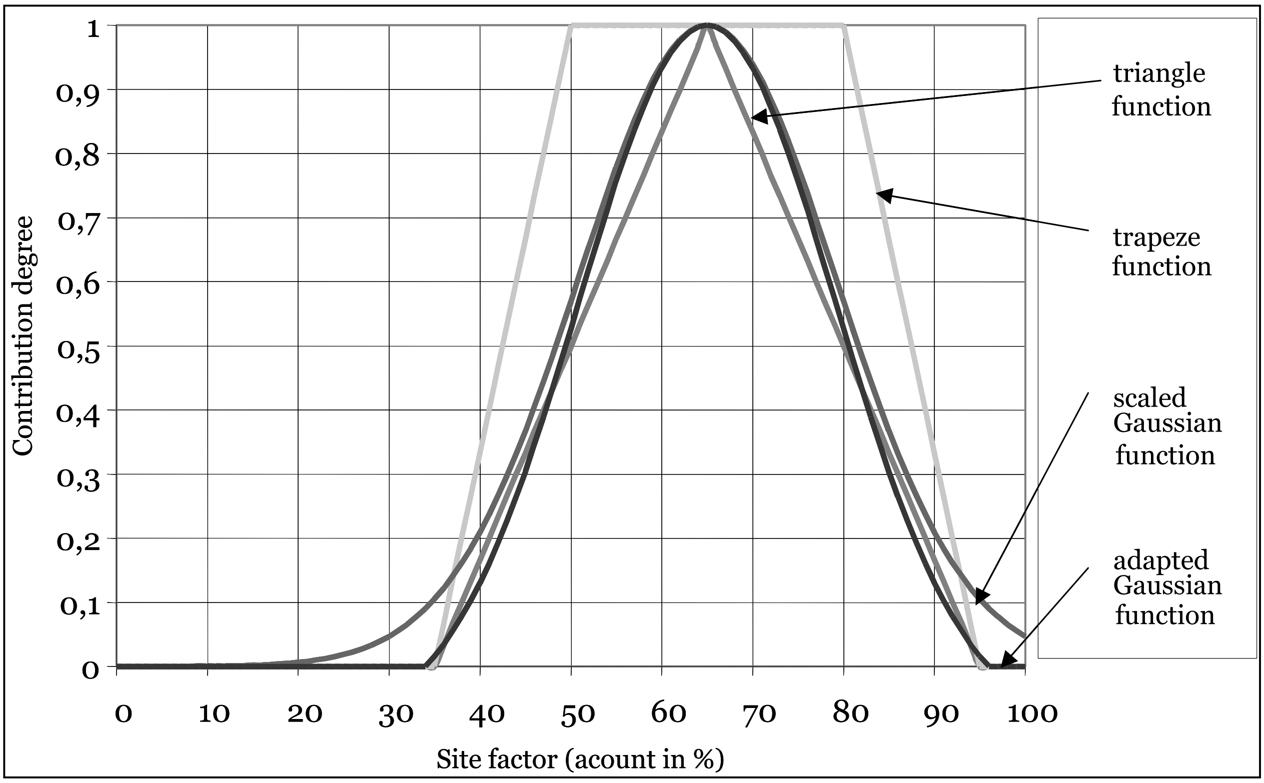


Fig. 4: Examples for potentially contribution function for the connection between a plant species and a site factor (hypothetic)

The trapeze curve form is not useable because of one optimum of a site parameter for a plant (in the medium also for the plant species) in principle exist, but not more then one. The triangle curve form is not useable because of the very small range around the optimum which is not true in natural conditions.

The ecological niche is commonly shown as a Gaussian normal distribution function also for different values of the function. BEGON ET AL. (1998) represents the survival ability by the function value of niches (1 - Mortality), BURROWS (1990) represents the biomass productivity, MARTIN (2002) represents the using frequents of resource and SCHUBERT (1991) represents the vitality. All these values could to be used as indicators for the possibility of a plant species to exist at a selected site. Therefore the DFP should have a similar curve.

Gaussian normal distribution function:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \cdot e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} \qquad \text{eq.3}$$

In order to use the Gaussian bell curve for the MVF should be made some adaptations. First the maximum of the function should have the value 1, second the width of the parameter range reflected by the function should have the same width like the ecological niche. Therefore the term for scaling the high of curve is to be set at 1 by definition and σ at 1/3 of half the ecological niche width. These though results in equation 4.

Scaled Gaussian function (see fig. 4):

$$\pi_a(x) := e^{-\frac{(x-m_a)^2}{(\frac{2}{3}b_a)^2}} \text{ ,} \qquad \text{eq. 4}$$

with:

$\pi_a(x)$ = possibility of a plant species to exist under the selected site parameter value x

m_a = optimum x for the plant species a

b_a = the range between ecological optimum and pessimum for the plant species a

The Gaussian function curve does not reach the value zero (no possibility for existing) but it decreases nearly to zero since increasing difference to the optimum. This is not plausible because there really exist some site parameter combinations at which some plant species are not able to exist. Therefore the Gaussian function curve had being been adapted to reach Zero while the function value out of the niche width was set to Zero (eq. 5).

Adapted conditions for the function curve:

$$\begin{aligned} \pi_a(x) &> 0 \forall\ x \in [m-b..m+b] \\ \pi_a(x) &= 0 \forall\ x \notin [m-b..m+b] \end{aligned} \qquad \text{eq. 5}$$

To consider equation 5 the amplitude of the function after equation 4 was enlarged onto 10 %, shifted up to 0.1, set all negative values to Zero and the width of function curve was adapted using an additional constant k. Equation 6 shows the finally form of the distribution function of possibilities for one plant species and one site factor.

Adapted Gaussian function curve with x-axes-touch (see fig. 4)

$$\pi_a(x_i) := \begin{cases} 1{,}1 \cdot e^{-\frac{(k(x_i-m_{a,i}))^2}{(\frac{2}{3}b_{a,i})^2}} - 0{,}1 \ \ \textit{für}\ x_i \in [m_{a,i}-b_{a,i}; m_{a,i}+b_{a,i}] \\ 0 \ \ \textit{für}\ x_i \notin [m_{a,i}-b_{a,i}; m_{a,i}+b_{a,i}] \end{cases} \qquad \text{eq. 6}$$

with *k* after equation 7:

Determination of constant k:

$$1{,}1 \cdot e^{-\frac{k^2}{(\frac{2}{3})^2}} - 0{,}1 = 0 \Rightarrow k = \frac{2}{3}\sqrt{-\ln\left(\frac{0{,}1}{1{,}1}\right)} = 1{,}032 \qquad \text{eq. 7}$$

The equation 6 gives the condition according to equation 5.

By that way a blurred qualitatively condition is given for the existence of a plant species depending of a site factor.

3.2.4 Contribution function for several site factors

A site factors mostly does not work independent on each other. Quite the combination of the site factors which influence the vegetation vitality results in a really possibility for plant existence. The real existing combinations of site factors are classified to site types.

In order to consider several factors the blurred conditions of the single factors were combined. This is necessary to declare the range of the functional n-dimensionally space in which the plant species exists. Therefore all site parameter ranges have to lay within the physiological niche width. The mathematical formula for this conditions are given in equation 8.

Condition for the existence of the species:

$$\vec{x} \in G \ \mathit{if} \ (x_1 \in G_1) \wedge (x_2 \in G_2) \wedge (x_3 \in G_3) \wedge ... \wedge (x_n \in G_n) \qquad \text{eq. 8}$$

with

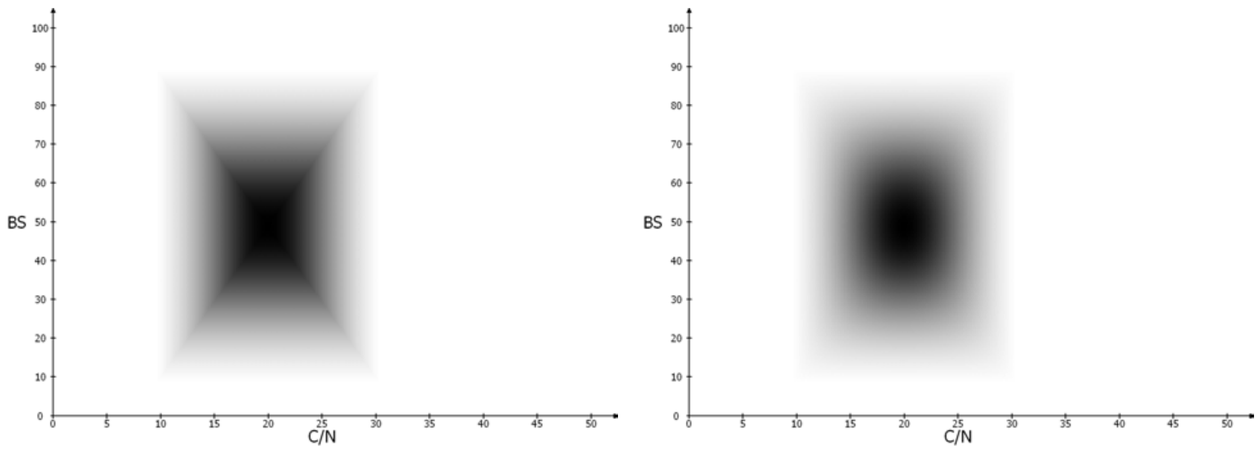
$\vec{x}$ = Vector for site factor (x_1,...x_n)

G = Quantity of sites which are suitable for a plant species

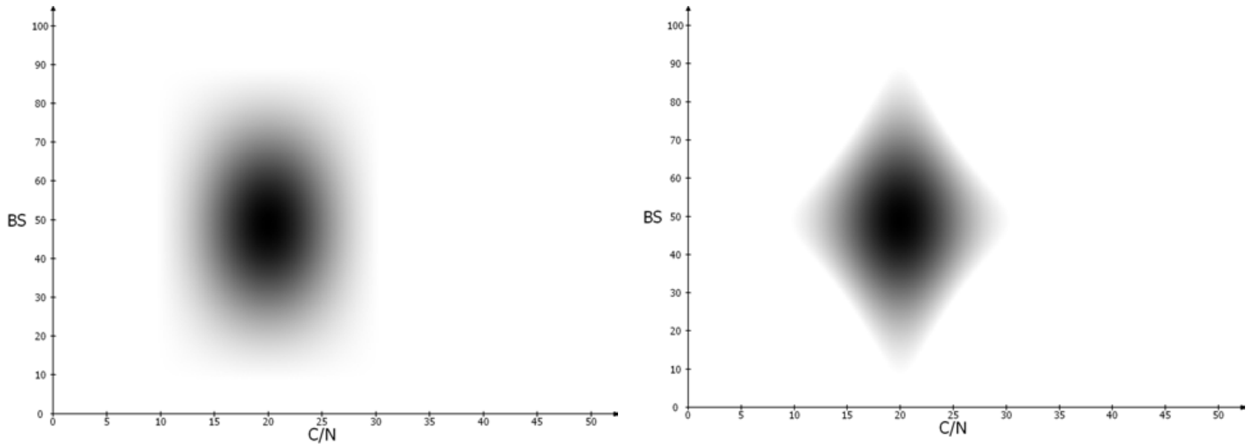
x_i = one site factor

G_i = Quantity of parameter values of site factor x_i which is suitable for a plant species

Within the fuzzy logic several operators exist for functioning as blurred operators. TILLI 1992 gives an overview of certain AND-operators. Fig. 5 shows the application of some operators for combining 2 site factors for one plant species. The parameters of 1-dimensionally distribution function of possibilities were taken from the data bank explaining below.



a) Minimum-Operator b) Hammacher-Operator



c) Product-Operator d) Bounded-Difference-Operator

Fig. 5: 2-dimensionally combination of the possibility values for the site factors base saturation and C/N ratio for the plant species Bellis perrenis applying different AND-operators (white: π_a=0, black:π_a=1)

As shown in fig. 5 the minimum-operator produces the highest and the product-operator produces the lowest possibility values. The elevation of the operator for combining some 1-dimensionally contribution functions has a meaning consequence. Applying the minimum-operator only the site factor with the lowest suitability for the selected plant species is decisive. Therefore apparently the plant species has the same vitality either at a site characterized by one less suitable factor and all other well suitable factors or at a site characterized by all less suitable factors.
Combining the functions by using the product-operator, apparently the plant species has a low vitality while all site factors have a middle suitability. The multiple stressing effect results in a higher loss of vitality then a single stress effect. But it does not exist enough knowledge based on statistics about these multiple effects at a lot of plant species. After ERNST (1978 IN: DIERSCHKE 1991), it is allowed to consider the effects of the factors separately.

The minimum-operator reduces the space of possibility at least, therefore it does not implement some non existing synergistic effects of several stress factors.
This is the reason for using the minimum-operator as AND-operator (eq. 9) within the BERN model with respect to the "Liebig´s rule of minimum-barrel" (see BÖRNER 1999, CHAPT. 2, P. 1F)

Definition of the minimum-operators:

$$\mu_{A\cap B}(x) = \min(\mu_A(x), \mu_B(x)) \qquad \text{eq. 9}$$

From equation 6 and equation 9 follows equation 10 as multivariate distribution function of possibilities of a plant species and as definition of the fundamental niche of this plant species.

The possibility value of a plant species at a given site

$$\pi_a(\vec{x}) = \min\begin{pmatrix} \pi_a(x_1) \\ \pi_a(x_2) \\ \dots \\ \pi_a(x_n) \end{pmatrix}, \text{with} \qquad \text{eq. 10}$$

$$\pi_a(x_i) := \begin{cases} 1{,}1 \cdot e^{-\frac{(k(x_i - m_{a,i}))^2}{(\frac{2}{3} b_{a,i})^2}} - 0{,}1 \;\; \textit{für}\; x_i \in [m_{a,i} - b_{a,i}; m_{a,i} + b_{a,i}] \\ 0 \;\; \textit{für}\; x_i \notin [m_{a,i} - b_{a,i}; m_{a,i} + b_{a,i}] \end{cases}$$

with:

x_i	=	value of the site factor i=[1..n]
$\vec{x}$	=	Vector of all site factors (x_1, ..., x_n)
n	=	number of regarded site factors
$m_{a,i}$	=	Optimum of the site factor i for the plant species a
$b_{a,i}$	=	niche width of the plant species a respecting the site factor i
$\pi_a(x_i)$	=	possibility of plant species a regarding site factor i
k	=	width scaling constant (see eq. 7)

3.2.5 Distribution function of possibilities of a plant community

The DFP for a plant community should be assessed in such kind that all plant species which mainly build up the plant community (all constant occurred plant species in a plant community) determine the DFP of the plant community. The DFP derivation is shown for example of Lolio-Cynosuretum cristati (table 6), a commonly plant community with less constant species.

Table 6: The constant species of the community Lolio-Cynosuretum cristati and their physiological optimum and their physiological niche width for site factor base saturation

species	m_{BS}	b_{BS}
Bellis perennis	49	39
Lolium perenne	47,5	37,5
Poa pratensis	55	45
Trifolium repens	50	40
Achillea millefolium	55	45
Cerastium caespitosum	49	39
Dactylus glomerata	45	35
Festuca pratensis	67,5	32,5
Leontodon autumnalis	49	39
Plantago lanceolata	50	40
Taraxacum officinalis	51,5	36,5
Trifolium dubium	60	28

The combination of the n-dimensionally DFP should be elevated in such kind that the possibility space of the plant community reaches the highest values at this point where the most constant species building up the community have their highest possibility values.

Few low values of some species should decrease the possibility of the whole community only a little. This kind of combination is not available using the classical fuzzy logic (AND-, OR-operators). Since these combinations are reasonable a lot of compensatively operators were assessed. Based on these operators the non convex algebraic gamma operator was elevated to combine the DFP of the constant plant species (eq. 11).

Algebraic compensatively operator A_γ

$$A_\gamma(x_1, x_2, \ldots x_n) = \left(\prod_{i=1}^{n} x_i\right)^{\gamma} \left(1 - \prod_{i=1}^{n}(1 - x_i)\right)^{1-\gamma} \qquad \text{eq. 11}$$

The reasons for this operator are the following:

- the operator is available for more then two blurred conditions, different to mostly others
- if the blurred quantity reaches the value Zero then the result is Zero too. I. e. if one of the constant plant species can not exist then the whole community is unable to exist
- the combination of convex fuzzy quantities results into a convex fuzzy quantity too
- Using the parameter y the dependence degree of the community on the possibility value of one constant species can be regulated.

The application of this operator is showing in fig. 6. This figure also shows the disadvantage of this operator: If more and more conditions were combined (e.g., if a lot of constant species are building up a community) the maximum value of the community decreases lower and lower.

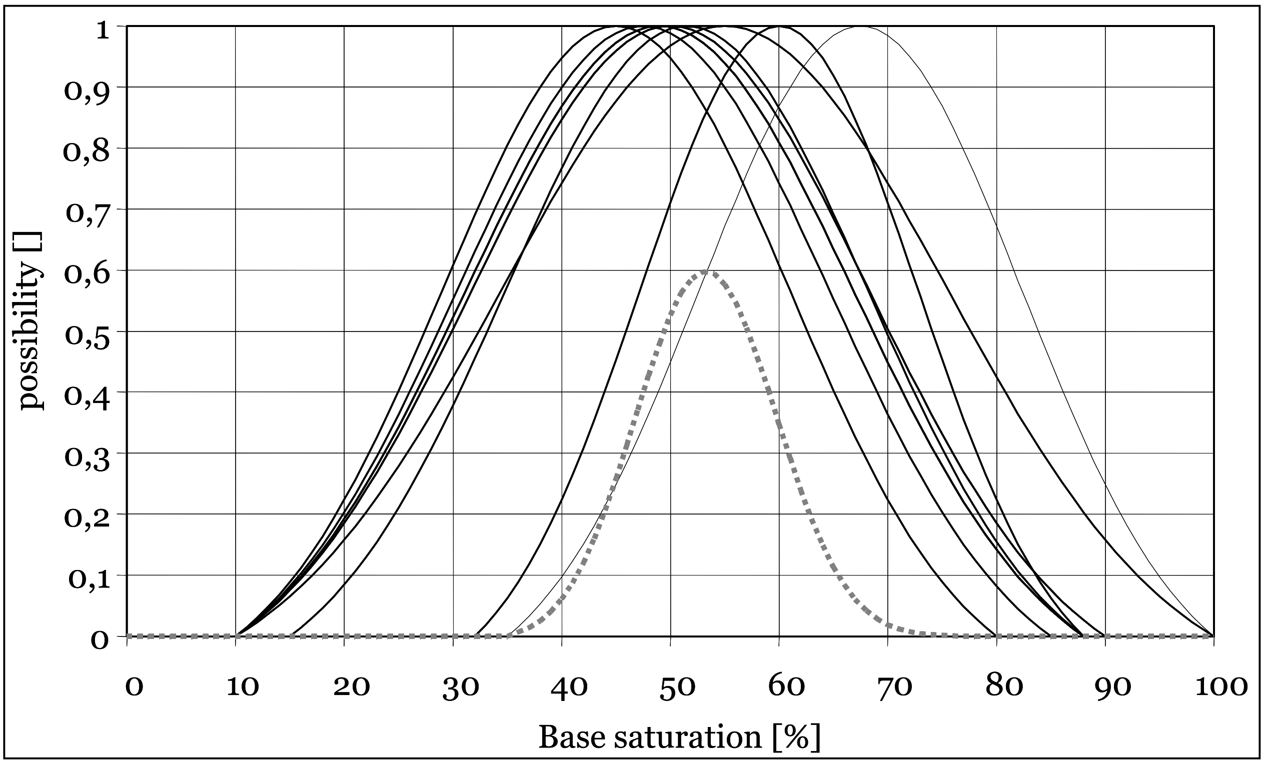


Fig. 6: Application of the A_γ-operators onto community Lolio-Cynosuretrum cristati

In order to equalize this fault the DFP of community will be normalized by applying the community's maximum (eq. 12).

$$\pi_{Ges} = \frac{A_\gamma\left(\pi_{Art\,1},\ldots,\pi_{Art\,n}\right)}{\sup\left(A_\gamma\right)} \Rightarrow \sup\left(\pi_{Ges}\right) = 1 \qquad \text{eq. 12}$$

Since the DFP of community is defined by DFP of plant species the function application on n-dimensionally vector of all relevant site factors of one site type is trivial. Figure 7 shows the DFP of community respecting two site factors.

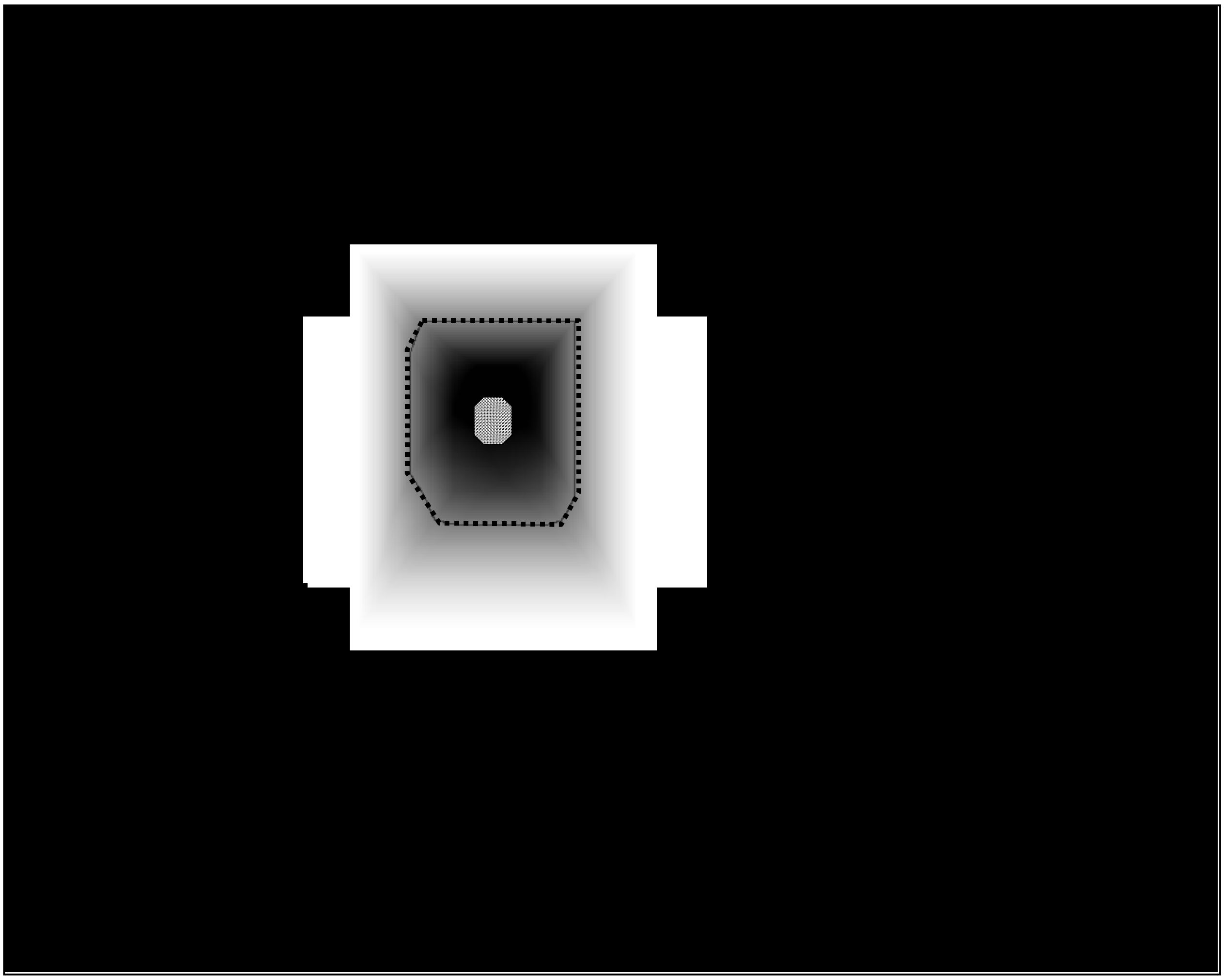


Fig.. 7: DFP of community Lolio-Cynosuretum cristati respecting two variable site factors (Base saturation and cabon:nitrogen-relationship in the upper soil layer) and constant soil moisture (Ellenberg-value) F=5,3 (white: π_{Ges}=0, confetti: π_{Ges}=1, pointed line: π_{Ges}=0,5)

The implementation into models using sharp boarded quantities needs to change the blurred quantity of suitable site factor for a plant community into a classical sharp quantity by assessing a so called α-level-quantity. Therefore a threshold of possibility has to be given. All elements which contribution values are laying over this threshold are elements of the α-level-quantity. In figure 7 the area inside the pointed line is signing the α-level-quantity with α = 0.5. One of the reasonable applications of this α-level-quantity is the determination of critical limits of site parameters for the vitality of plant communities (see Chapter 3.4).

Under the same procedure as was used to describe the union of fuzzy sets of all suitable communities in one regular habitat type with α = 0.5, the suitability curves are derived for the communities using the variable moisture degrees, the base saturation and the C/N relationship From the example of the habitat natural meadow that is situated in the planar-sub continental region with plane relief and a groundwater distance of 6 dm - all typical semi-natural grassland communities can be indicated (fig. 8).

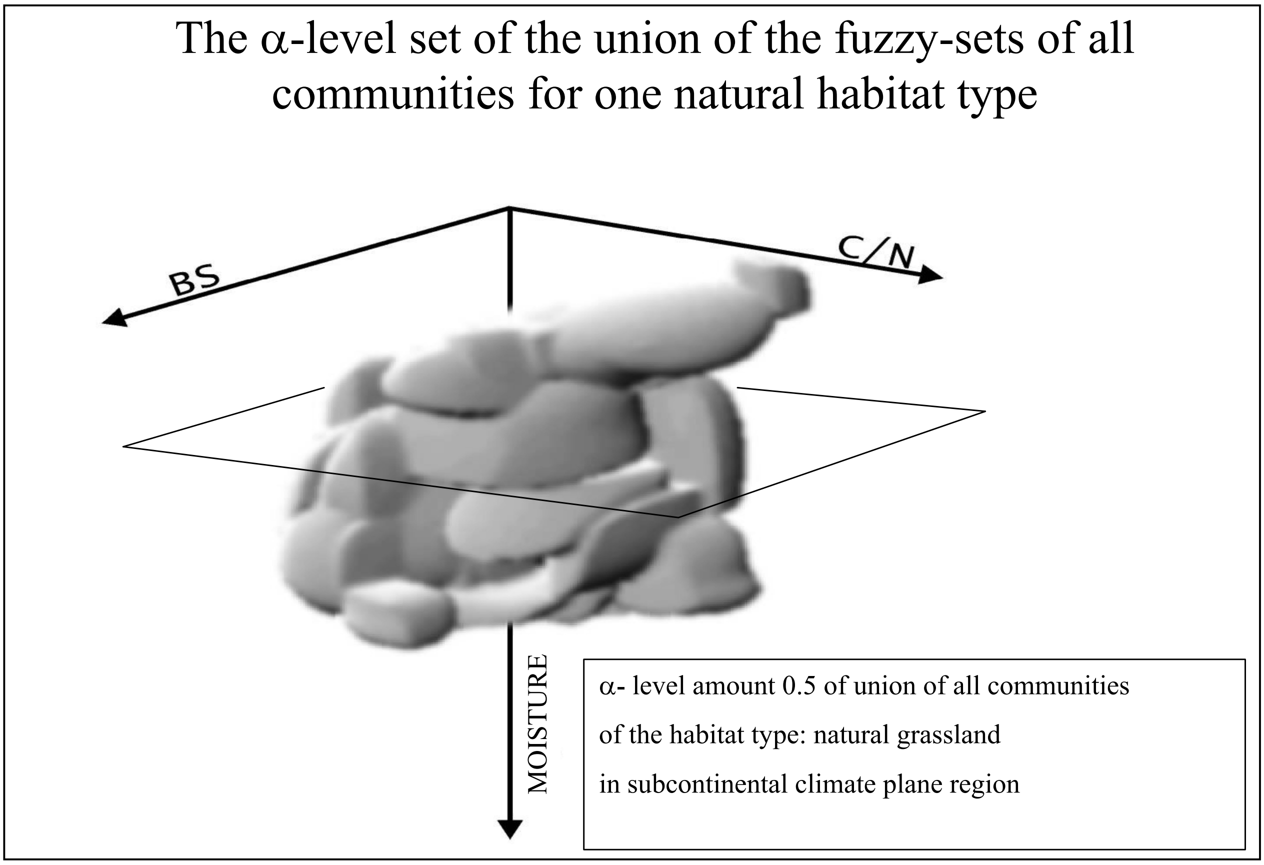


Fig. 8: α-level-set (with α = 0.5) of all typical semi-natural grassland communities from the example of the habitat natural meadow in the planar-sub continental region with plane relief and a groundwater distance of 6 dm

If one makes a slice through this 3-dimensional body of fuzzy sets regarding only the two parameter of interest in connection to air pollution effects (see cut plane in fig. 8) one gets a 2-dimensional graph of all typical semi-natural grassland communities at a constant (optimal) soil moisture value (fig. 9).

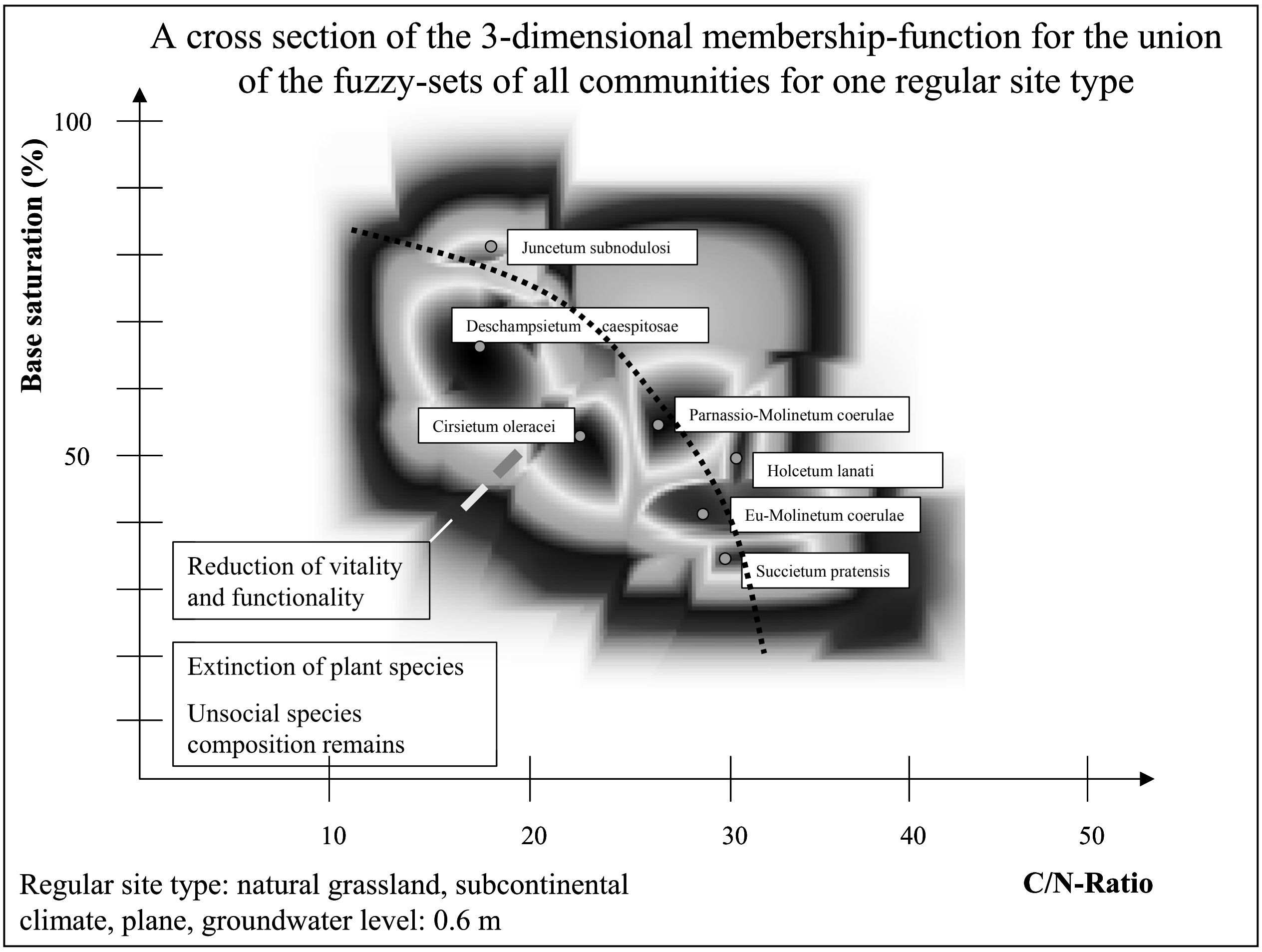


Fig. 9: Distribution of the suitability maxima of all plant communities of the habitat type: natural meadow in the planar- sub continental region with a plane relief, groundwater distance 6 dm (the grey points corresponds to the optima of the communities; the lightly grey lines around the optima demarcate the $\alpha = 0.5$; the 3 variable fat lines represent the reduction of the suitability degrees of the respective communities).

Shown (graphically) is an obviously regular arrangement of the natural plant communities, which demarcates an indirect proportional connection between the base saturation and C/N in the natural equilibrium (pointed line in fig. 9). This picture of the arrangement of the natural plant communities on an graph of the harmonious equilibrium of base saturation to C/N-ratio repeats itself for all regular site types and all natural (or semi-natural) plant communities.

Simultaneously, the overview of all natural plant communities of a regular site type shows the absence of the natural communities in the extremely disharmonious ranges, which are characterized by high nitrogen concentrations and low base content in the rooted soil. These areas are recognized here in figure 9 as white surfaces.

3.3 Derivation of Critical Limits

(A. Schlutow)

The lowest acceptable C/N-ratio is determined, by definition, for each natural plant community at the point which exhibits the furthest disharmonic relationship of base saturation to C/N-ratio on the Critical limit function f(BS;C/N)=0.5. This point is determined by drawing a straight line from the point of optimum of the primary-natural community to the origin of the coordinate system that presents the 0,0 point from base saturation and C/N-ratio (fig. 10).

The intersection of this straight line with the Critical limit function is, hence, the extreme disharmonious condition, in which the primary-natural plant community is just able to exist, meaning it exists with half vitality. In the following, this point is called $CN_{BS(crit)}$ and $BS_{CN(crit)}$ respectively.

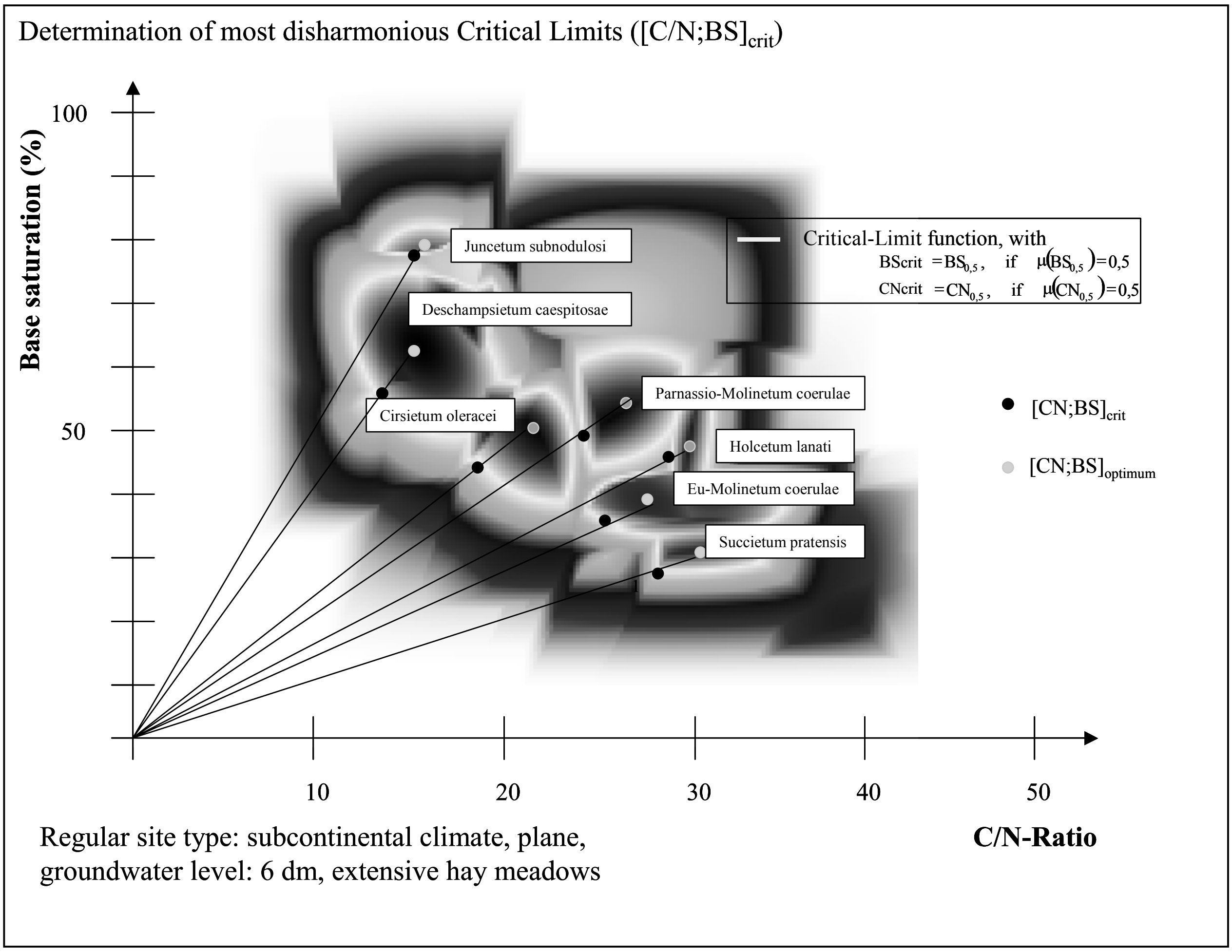


Fig. 10: Determination of most disharmonious Critical Limits ([CN;BS]crit) for natural plant communities

A harmonious site type is indicated simultaneously by a natural plant community and a harmonious humus form (Konopatzky und Kirschner 1997). Therefore, the Critical Limit-function for a natural community could be valid also for the harmonious humus form in this site type respectively. An example for the sequence of harmonious humus forms in a fen site type is given in figure 11.

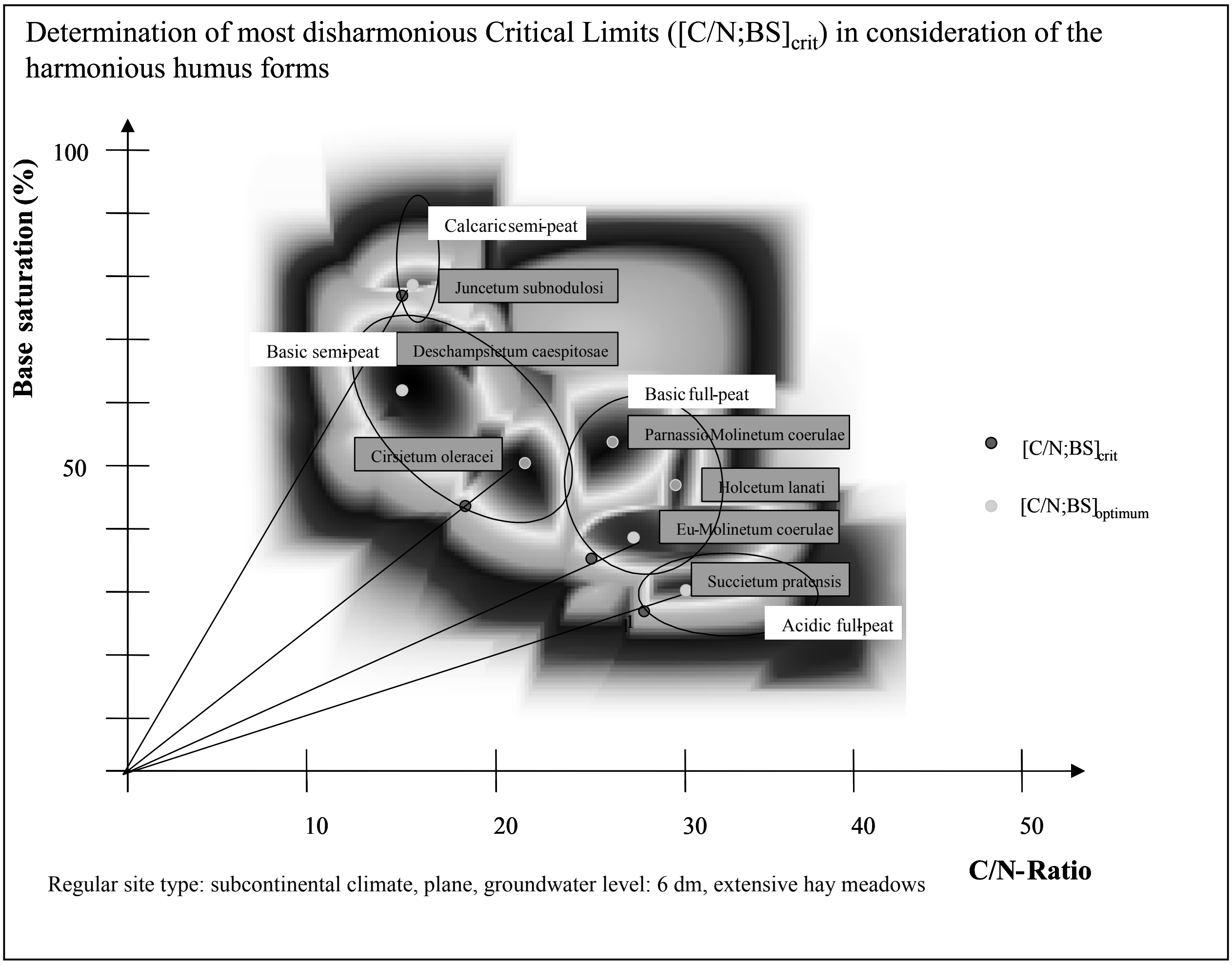


Fig. 11: Determination of most disharmonious Critical Limits ([CN;BS]crit) for harmonious humus forms

4 Applications and results

(A. Schlutow)

4.1 Derivation of Critical Loads (steady state) of natural plant communities

4.1.1 Critical Loads for acidification

In order to establish the connection between the threshold value for the C/N ratio (CN_{crit}) and base saturation (BS_{crit}) in the topsoil and the threshold value for the nutrient nitrogen input and the input of acidifying sulphur and nitrogen, we must adapt the Simple mass balance model (NAGEL AND GREGOR 1999).

For determining the Simple-Mass-Balance (SMB) that accounts for the source and sinks of Protons, the following model is being currently applied throughout Europe in accordance with the Method Manuel (UBA 1996).

$$CL(S+N) = CL(S) + CL(N) = BC_{dep} - Cl_{dep} + BC_w - Bc_u + N_i + N_u + N_{de} - ANC_{le(crit)} \quad \text{eq.13}$$

with:

CL	=	Critical Load
S	=	sulphur
N	=	nitrogen
BC_{dep}	=	Deposition of base cations
Cl_{de}	=	Deposition of chloride
BC_w	=	base cations weathering
Bc_u	=	base cations uptake and removal by biomass under steady-state conditions
N_i	=	immobilization rate of nitrogen in the humus layer
N_u	=	nitrogen uptake and removal by biomass under steady-state conditions
N_{de}	=	denitrification rate
$ANC_{le(crit)}$	=	critical leaching of acid neutralization capacity

The leaching of Acid Neutralizing Capacity (ANC) is illustrated by the following formula:

$$ANC_{le} = -H_{le} - Al_{le} = -PS \cdot ([H] + [Al]) \quad \text{eq. 14}$$

with:

PS	=	precipitation surplus (in m^3/ha/yr).
H^+_{le}	=	leaching of H^+-Ions [eq ha^{-1} a^{-1}]
Al^{3+}_{le}	=	leaching of Al^{3+}-Ions [eq ha^{-1} a^{-1}]

The critical criteria for plant communities CN_{crit} and BS_{crit} could be implemented into the above Simple Mass Balance equation in 2 ways:

(1) An overly high concentration of Al^{3+} can affect the plants of an ecological system toxically where there are insufficient base cations available at the same time in the soil solution.

Such base cations must be available in order that they can be alternatively absorbed by the plants.
The border-line criteria for the loss of acid neutralization capacity is described through the relationship of plant-available base cations: Bc=Ca+Mg+K to the Al^{3+}-Ions in the soil solution within the actual rooted zone.
The critical base cation/aluminium rate is the Critical Limit determining the critical leaching of acid neutralisation capacity. This critical Limit is specified according to the plant species sensibility.

The critical Aluminum concentration is reached when the Bc/Al ratio (for a plant community) arrives at a critical (first stage of toxicity) level. This level is determined as follows:

$$Al_{le(crit)} = 1.5 \cdot \frac{Bc_{le}}{(Bc/Al)_{crit}} \qquad \text{eq.15}$$

The factor 1.5 arises from the conversion of mols to equivalents (assuming that K is divalent). The base leaching, Bc_{le}, is determined through the mass, which follows:

$$Bc_{le} = Bc_{dep} + Bc_w - Bc_u \qquad \text{eq. 16}$$

with:

Bc_{le}	=	leaching of base cations [eq ha^{-1} a^{-1}]
Bc_{dep}	=	Deposition of base cations Ca+K+Mg [eq ha^{-1} a^{-1}]
Bc_w	=	base cations weathering [eq ha^{-1} a^{-1}]
Bc_u	=	base cations uptake and removal by biomass under steady-state conditions [eq ha^{-1} a^{-1}]

The Bc_{dep} values in uninfluenced sites with natural plant communities are nearly the Bc_{dep} values only in the seaspray. This values have to be calculated depending on the distance of the site to the next ocean coast. It can be assumed an averaged distance for the climate zones to the coast: suboceanic climate zone in Germany has an averaged distance to the North sea about 200 km, while the subcontinental zone has a distance of about 600 km, the colline regions of about 700 km and the eastern German mountain regions about 800 km. A widely used model for deriving this values is available (GAUGER ET AL. 2002).

The Bc_w values are calculated in dependence on the soil type which is preferred by the plant community (see Fig. 2) after Mapping Manual Revision (UBA in prep.).

The Bc_u values can be derived from community-specific biomass yields which will be harvested (see Fig. 2) multiplying with the plant specific contents of base cations in stems and bark (see Mapping Manual Revision, UBA in prep.).

Normally in the Simple mass balance the critical Bc/Al-ratio for the main tree species is used. But the BERN Model provides the critical Bc/Al-ratios also for natural plant communities. This value can be derived in the following way directly from the critical limit of base saturation BS_{crit} (see above):

$$BS_{CN(crit)} = \frac{Bc + Na^+}{Al^{3+}{}_{crit} + H^+{}_{crit} + Bc + Na^+} \cdot 100 \quad (in \quad \%) \qquad \text{eq. 17}$$

The portion of Na+ (fNa) within the total quantity of base cations (BC) amounts to 16% (fNa = 0.16) within sand-poor soils. In sand-rich soils, this quantity can reach around 24% (fNa = 0.24). According to NAGEL ET AL. (2000), the Na^+ proportion can be determined by the soil-type reference values of Central European soils. Thus, Na+ can be computed as follows:

$$Na^+ = fNa \cdot BC \quad \text{with} \quad Bc = BC - Na \qquad \text{eq. 18}$$

The next step is to transform the adsorbed cation value on the surface of the solid exchange complex to dissolved cation concentrations in the soil water phase. DE VRIES AND POSCH (2003) published an equation describing the equilibrium constant relationship of the base saturation in solid phase and the concentration of base cations in soil water, e. g. the GAPON-Coefficients (table 7).

For both the critical concentration $[H]_{crit}$ and $[Al]_{crit}$ can be found as a solution of the following equations:

$$[H]_{crit} = K_{Gap} \cdot \sqrt{[Bc] \cdot \left(\frac{1}{E_{Bc(crit)}} - 1 \right)} \quad with \quad K_{gap} = \frac{1}{k_{HBc} + k_{Albc} \cdot K^{\frac{1}{3}}_{gibb}} \qquad \text{eq. 19}$$

with:

k_{AlBc} = GAPON-Exchange-Coefficient Al against Ca+Mg+K
k_{HBc} = GAPON-Exchange-Coefficient H against Ca+Mg+K
[Bc] = concentration of base cations Ca+Mg+K in the soil solution can be derived from $[Bc] = Bc_{le} / PS$ (see eq. 16 and 14) eq. 20
$E_{BC(crit)}$ = $BS_{CN(crit)}$ /100 (#) eq. 21

The relationship between [H] and [Al] is described by an (apparent) gibbsite equilibrium:

$$[Al] = K_{gibb} \cdot [H]^3 \quad \text{or} \quad [H] = \left([Al]/K_{gibb}\right)^{1/3} \qquad \text{eq. 22}$$

K_{gibb} is set on 300 m^6/eq^2 (Manual, UBA 1996), therefore:

$$[Al]_{crit} = K_{gibb} \cdot K_{Gap}{}^3 \cdot [Bc]^{\frac{3}{2}} \cdot \left(\frac{1}{E_{Bc(crit)}} - 1 \right)^3 \qquad \text{eq. 23}$$

Transformed the resulting formulas are:

$$\frac{[Al]_{crit}}{[Bc]^{\frac{3}{2}}} = K_{gibb} \cdot K_{Gap}{}^3 \cdot \left(\frac{1}{E_{Bc(crit)}} - 1 \right)^3$$

$$\frac{[Bc]}{[Al]_{crit}} = \frac{1}{K_{gibb} \cdot K_{Gap}{}^3 \cdot \left(\frac{1}{E_{Bc(crit)}} - 1 \right)^3 \cdot \sqrt{[Bc]}} \qquad \text{eq. 24}$$

Table 7: GAPON-Exchange-Coefficients from Al and H against Ca+Mg+K for the soil depth of 0-100 cm (DE VRIES U. POSCH 2003)

kAlBc	**$(eq/m^3)^{1/6}$**			
	0-10 cm	**10-30 cm**	**30-60 cm**	**60-100 cm**
Sand	6,2729898	15,292362	20,439703	40,315735
Loess	4,8025797	7,4726489	7,5417925	7,6115759
Clay	1,5117312	1,0677623	0,1036274	0,0497135
Peat	1,3136346	1,1155129	0,5642539	0,4211866
kHBc	**$(eq/m^3)^{-1/2}$**			
	0-10 cm	**10-30 cm**	**30-60 cm**	**60-100 cm**
Sand	67,377516	150,49255	205,35959	328,48459
Loess	61,449025	77,716816	77,004304	76,298324
Clay	216,03046	86,599423	148,42771	212,08746
Peat	29,411353	24,519691	39,311082	47,589923

Note: These coefficients are derived empirically at sites in the Netherlands. In other European regions a site specific derivation of these exchange coefficients is needed. Therefore the given results for some plant communities in the annex have to be checked for various regions.

In order to compute the critical Bc/Al-ratio for the natural communities in the German northern low and hilly lands the specific GAPON-Exchange-Coefficients was applied for each horizon of the reference profile for the soil type preferred by the regarded plant community. Then the thickness weighted average was computed considering only the horizons within the actual rooted zone.

The Critical Load for acidic deposition is now computed with respect to the Bc/Al_{crit} ratio as a community-specific limiting criterion for the acid-neutralization-capacity-leaching-rate as follows:

$$CL(S+N) = CL(S) + CL(N) = BC^*_{dep} - Cl^*_{dep} + BC_w - Bc_u + N_u + N_i + N_{de} + \left(1{,}5 \cdot \frac{Bc_w + Bc_{dep} - Bc_u}{(Bc/Al)_{crit}}\right) + PS^{2/3} \cdot \left(1{,}5 \cdot \frac{Bc_w + Bc_{dep} - Bc_u}{(Bc/Al)_{crit} \cdot K_{gibb}}\right)^{1/3} \qquad \text{eq. 25}$$

or by implementing $[H]_{(crit)}$ and $[Al]_{(crit)}$ ditectly within equation 14.

For anthropogenic uninfluenced organic or moist mineral soils without significant aluminum weathering rates, apply (after Manual, UBA 1996) the formula for ground vegetation, deciduous and mixed stands as follows:

$$ANC = -0{,}5 \frac{Bc_{dep} + Bc_w - Bc_u}{(Bc/H)_{crit}} \qquad \text{eq. 26}$$

$$(Bc/H)_{crit} = 0{,}3 (Bc/Al)_{crit}$$

(2) If one sets as a goal the maintenance of a harmonious steady-state equilibrium as the target condition (even if such conditions are not identical with the primary existing nutrient balances), a change in the C/N-ratio must be permitted. Such a change reflects simultaneously adequate change in the base saturation in the soil along the series of the natural values within a site type.

This allowable change in the CN_{crit} parameter does however have a simultaneously modifying influence on the allowable Nitrogen immobilization rate. Consequently, the higher the C/N ratio, the higher will be the rate of immobilization (Gundersen et al., 1998) if the base saturation is simultaneously in a harmonious balance. One remembers, however, that the immobilization rate for Nitrogen is also dependent on the ground temperature (UBA 1996).

Therefore, the overall rate of Nitrogen immobilization is calculated through the temperature dependant rate of immobilization ($N_{i(T)}$) in addition to the clime of the N-value in the organic substance in dependence of the lowest acceptable C/N-ratio in steady state condition.

In Middle Europe, the temperature dependant rate of immobilization lies within the range of 1 kg N $ha^{-1}a^{-1}$ (at an average yearly temperature of 8°C) and 5 kg N $ha^{-1}a^{-1}$ (at a yearly average temperature of 5°C).

The net –value of N that may be immobilized is partially a directly linear function of the C/N-ratio and depends indirectly linear on the base saturation (fig. 12). The allowable N-value lies between the natural (and therefore allowable) values for a soil-type-dependent maximum, CN_{max}, and the corresponding minimum-C/N-ratio, CN_{min} , if a harmonious equilibrium with base saturation exists.

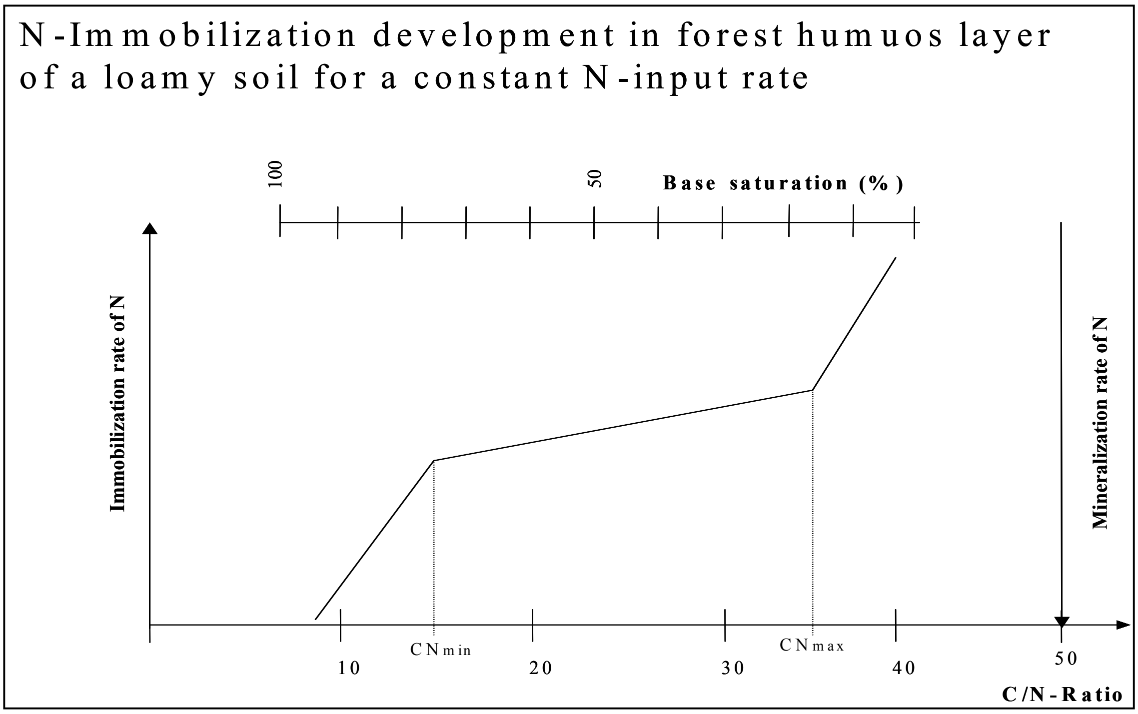


Fig. 12: normally N-immobilization rate development in the top soil (humus layer + ca. 10 cm of the upper mineral layer) of a loamy soil depending on C/N and base saturation effected by a continued N-input from atmosphere

In the referenced model, one should observe the lowest allowable border value for the C/N-ratio (for a given plant community) within a harmonious steady state condition. That border value, the determined Critical Limit $C/N_{BS(crit)}$, is being observed under the assumption that $CL(N)>N_u>N_{i(T)}$ as follows (POSCH AND DEVRIES 2004):

$$N_{i(acc)} = N_{i(T)} + \frac{CN_{BS(crit)} - CN_{\min}}{CN_{\max} - CN_{\min}}(CL(N) - N_u - N_{i(T)}) \qquad for \qquad CN_{\min} < CN_{BS(crit)} < CN_{\max}$$
$$N_{i(acc)} = CL(N) - N_u \qquad for \qquad CN_{BS(crit)} \geq CN_{\max} \qquad \text{eq.27}$$
$$N_{i(acc)} = N_{i(T)} \qquad for \qquad CN_{BS(crit)} \leq CN_{\min}$$

with:
$N_{i(acc)}$ = acceptable immobilization rate of nitrogen in topsoil
$N_{i(T)}$ = temperature depending immobilization rate of nitrogen in topsoil

The equation above conveys that the allowable annual N- immobilization rate equals the temperature dependent constant N-immobilization rate- if the C/N-relationship reaches a (predetermined) minimum.

When one applies this equation to the mass balance, one derives

CL(S+N) = CL(S)+ CL(N) =

$$BC^*_{dep} - Cl^*_{dep} + BC_w - Bc_u + N_u + N_{i(T)} + \frac{N_{de}}{1-(CN_{BS(crit)} - CN_{\min})/(CN_{\max} - CN_{\min})}$$
$$+\left(1{,}5 \cdot \frac{Bc_w + Bc_{dep} - Bc_u}{(Bc/Al)_{crit}}\right) + PS^{2/3} \cdot \left(1{,}5 \cdot \frac{Bc_w + Bc_{dep} - Bc_u}{(Bc/Al)_{crit} \cdot K_{gibb}}\right)^{1/3} \qquad \text{eq. 28}$$

According to KLAP et al. (1997) in the evaluation of the European-wide investigations, CN_{max} and CN_{min} are defined as follows (table 8):

Table 8: Critical Minimums and Maximums regarding the C/N-ratio ensuring immobilization within humus

soil type	CN_{min}	CN_{max}
Peat	15	40
coarse textured soils (sand/loam)	15	35
fine textured soils (clay)	10	25
volcanic soils	10	20
calcareous soils	10	20

The data base for the ecosystem-related determination of Bc_w , BC_w, N_u, N_{de} and $N_{le(acc)}$ in the German dataset for Critical Loads are derived from reference data (CCE 2001). PS, BC^*_{dep} and Cl^*_{dep} are consistently mapped by a data collection network, which are then verified by model and comprehensively interpolated (GAUGER ET AL. 2002). The N_{de} rate in future will be modeled by using the model PNET-N-DNDC (LI ET AL. 2000, STANGE ET AL. 2000, BUTTERBACH-BAHL ET AL. 2001).

4.1.2 Critical Loads for nitrogen eutrophication

According to the Manual (UBA 1996), the following equation is used as the model description of the mass balance method describing Nitrogen resources of ecological systems under conditions of harmonious balance:

$$CL_{nut}(N) = N_u + N_{i(acc)} + N_{le(acc)} + N_{de} \quad \text{eq. 29}$$

with:

$CL_{nut}(N)$ = the Critical Load for eutrophicating nitrogen input [kg ha^{-1} a^{-1}]
$N_{le(acc)}$ = the tolerable rate of nitrogen loss with the water seepage [kg ha^{-1} a^{-1}]

With the help of the BERN-Model, one is able to insert the plant-community-specific rate of immobilization within the SMB-Formula with respect to the $CN_{BS(crit)}$. This implementation is analog with the modeled determination of the Critical Load for acidifying Nitrogen (see Chapter 4.1)

It follows that:

$$CL_{nut}(N) = N_u + N_{de} + N_{i(T)} + \frac{N_{le(acc)}}{1-(CN_{BS(crit)} - CN_{\min})/(CN_{\max} - CN_{\min})} \quad \text{eq. 30}$$

$$N_{de} = f_{de}(CL_{nut} - N_u - N_i) \quad \text{eq. 31}$$

$$N_i = N_{i(T)} + f_i(CL_{nut}(N) - N_u - N_{le}) \quad \text{eq. 32}$$

$$f_i = \frac{CN_{BS(crit)} - CN_{\min}}{CN_{\max} - CN_{\min}} \quad for \quad CN_{\min} < CN_{BS(crit)} < CN_{\max} \quad \text{eq. 33}$$

$$f_i = 1 \quad for \quad CN_{BS(crit)} \geq CN_{\max}$$

$$f_i = 0 \quad for \quad CN_{BS(crit)} \leq CN_{\min}$$

$$CL_{nut} = N_u + N_{i(T)} \frac{N_{le}}{(1-f_{de})(1-f_i)} \quad \text{eq. 34}$$

with:

In the annex the f_i-Terms for the natural plant communities of the German northern low and hilly lands are given. These term is also applicable for computing Critical Loads for acidification due to eq. 32 and 33 are implemented in eq. 27.
The data base for the ecology-driven determination of N_u, N_{de} and $N_{le(acc)}$ could be derived from reference data (NAGEL ET AL 2000, CCE 2001).

4.1.3 Verifying the results and discussion

First, a statistical analysis was conducted with the empirical Critical Loads (= CL_{nut}(N)EMP) established from field observations of occurring species change and diversity loss in middle and northern Europe. The matrix (BOBBINK ET AL. 2003) designates Critical Load-ranges to the habitat types of the ecosystems: semi-natural grassland, heaths, and fens (after EUNIS classification). In a additional matrix, these Critical Load-ranges can be further differentiated - with consideration of abiotic site parameters (BOBBINK ET AL. A. 2003). With the help of these two matrixes a clear allocation of discrete CL_{nut}(N)EMP to the semi-natural plant communities of these ecological system types has been made possible.

The statistical analysis of the correlation from CL_{nut}(N)BERN to CL_{nut}(N)EMP is shown in the following table 9:

Table 9: Coefficient (r^2) of determination for correlation of resulting Critical Loads by modeling after BERN and by empirical determination

Coefficient of determination for correlation of parameter (r^2)	Grasslands, heaths, fens			
	total	sub continental	sub oceanic	azonal wet
CL_{nut}(N)EMP CL_{nut}(N)BERN	0.78	0.89	0.88	0.43

From this it can be concluded that both CL_{nut}(N)EMP and CL_{nut}(N)BERN are equally well-suited for the quantification of the Critical Load of natural plant communities. But on the one hand empirical Critical Loads are given for 10 differentiated ecosystem types by BOBBINK ET AL. (2003). On the other hand the BERN-Model gives out Critical Loads for 175 semi-natural plant communities up to now. But the model data base is not yet complete for Germany.

The BERN model permits a comprehensive calculation of the Critical Loads for natural and semi-natural ecosystems for a region, a country, or even for acontinent on the basis of the available published vegetation and location analysis. The advantage is that costly and time-intensive experiments and surveys become unnecessary.

Empirical Critical Loads for acidification in natural or semi-natural ecosystems are not published.

The comparison of CL(S+N)SMB with the results of the computation of CL(S+N)BERN results in a coefficient of determination with correlation of 0,93. There are however some notable deviations in some ecological system types.

For example, plant communities that are characterized by particularly acidic soil types (*Quercus robur, Betula pendula* and *Pinus sylvestris* dominated forests) exhibit a relatively high CL(S+N)BERN with a low CL(S+N)SMB. However, this apparent contradiction is explained by the differences in the objects being observed. Per the SMB model, exclusively three main tree species (*Quercus robur, Betula pendula* and *Pinus sylvestris*) are to be protected in their full vitality. However, the BERN model permits a drop in the vitality of the individual main tree species up to 50%, but only if at the same time other dominance species at these location types (such as *Vaccinium*, *Calluna, Nardus* etc..) exhibit a higher vitality. Thus, under BERN, the entire ecological system is protected, not only individual compartments.

4.2 Implementation into dynamic models for soil changes

The BERN model permits the points for the interface between the dynamic soil models and the biological response model to become a dynamic biological model for changes and recovery of the vegetation. The most suitable dynamic model for coupling with the BERN-model would be the ForSafe due to this model is the only one which considers the closely connection between acidifying and eutrophying effects. But BERN provides the interface points also to the "Very simple dynamic model – VSD" and to SAFE (see Mapping Manual Revision 2004 in preparation).

The interface points are:
Critical Limits $CN_{BS(crit)}$, $BS_{CN(crit)}$ and the parameter which are derived from these critical limit, especially critical Bc/Al-ratio, critical pH, acceptable immobilization rate.

In addition to the results of critical limits of the soil chemistry in the regarded time series the development of the vegetation (from community to community and in some cases to plant compositions without sociological connections) can be assessed (see fig. 13).

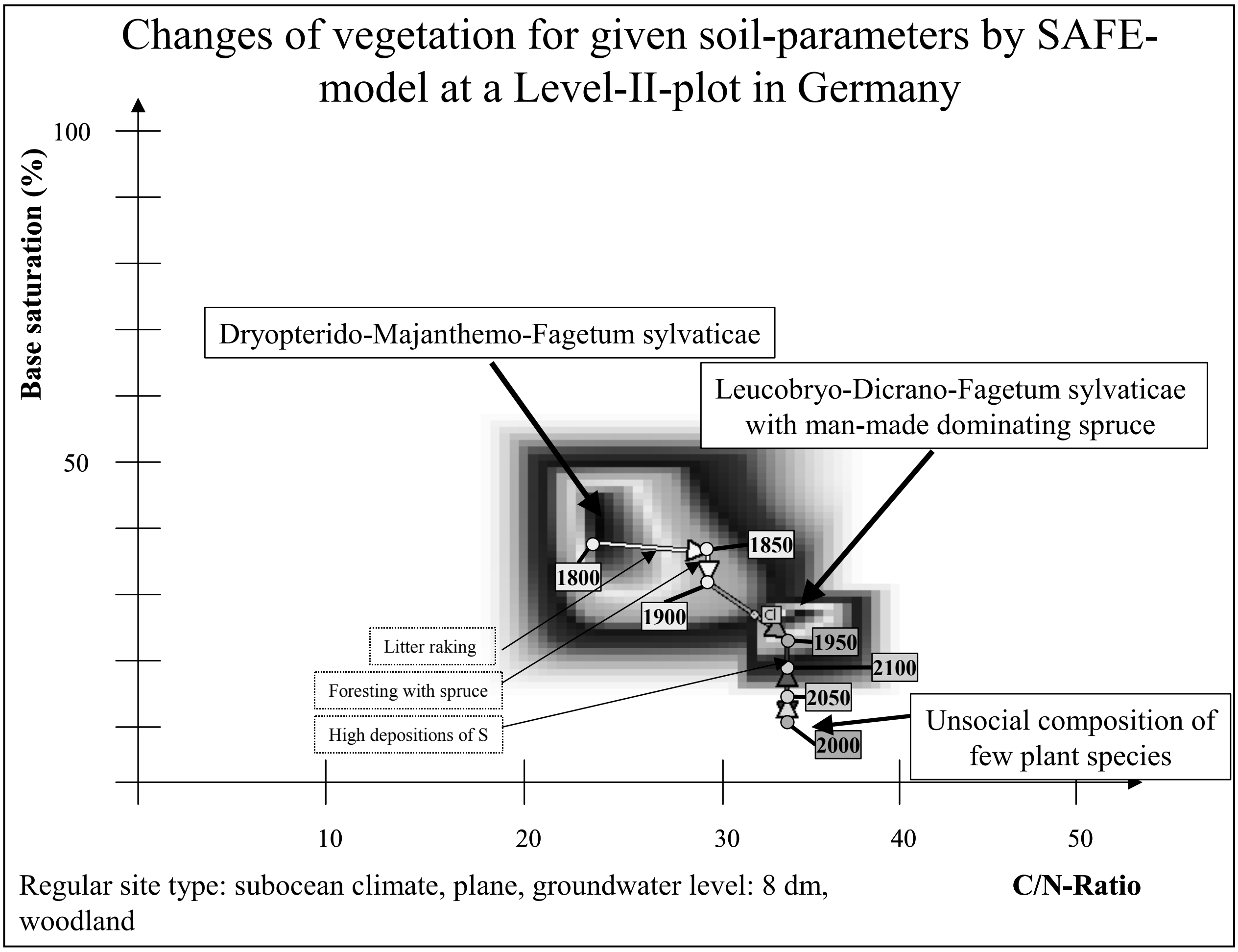


Fig. 13: dynamic modeling of vegetation changes using the SAFE-model for the changes of soil chemistry and coupling the BERN-model for an example of Level-II-plot "Heidelberg" in Germany

The time lag between an observed change in soil chemistry and the vegetation response is depending on a lot of factors and the interactions between these factors. Therefore it is not possible to model the recovery time for plant communities up to now. It would being be possible to generalize a lot of experiences in nature investigations after decreasing the depositions.

In the following chapters the possibilities for BERN dynamic model adaptation is given:

4.2.1 Determination of the actual habitat condition and comparison with the primary natural habitat parameters

There are two methods of determining the actual condition of a habitat

1. Determination of the soil parameter hydromorphy, base saturation and C/N-ratio through measurements or by recording the current humus form as an indicator of the soil parameter
2. Identification of the plant species present in the ground and bush vegetation of a homogeneous habitat

Because the second option is the more efficient one, this will be the method which is usually applied. Therefore, it is used to describe the following model. In principle, however, both variants can be inputted within the BERN model and lead to the same result.

The locally occurring plant species in a homogeneous habitat are entered into a database. Additionally, the surveyed habitat's main parameters are obtained - soil type, type of hydromorphy, type of climatic region, type of relief, and sun exposure. This is done either by site measurements or from large-scale maps.

From the database of plant species suitability values, the common ranges occupied by the current species together (minimum suitability curves for all current species) were determined. Such are calculated for the base saturation, the C/N relationship and for moisture.
The current condition of the habitat is assumed to be the middle of the common range as showcased in fig. 14 on the example of the forest Klever Reichswald near the border with the Netherlands. Simultaneously, the model provides the primary natural plant community from the inputted characteristics. The modeling software now produces the distance (=deviation) between the primary natural condition and the actual current condition.
According to the definition of the Critical Loads (UBA 1996), the maximum stress loads are met (but not exceeded) as long as no changes in the structure or/and function of the vegetation are registered. The biological determined Critical Load must result from a threshold value of the suitability function of the primary natural plant community.

A reasonable threshold value is the suitability degree of 0.5. At this value of the condition parameter (Critical Limit), the primary natural plant community has only the half possibility of its continued existence and only half of its vitality. At this point the option is given either to reproduce the full vitality or to reduce furthermore the vitality up to extinction of the community.

The current exceedance over the threshold value corresponds to the shortest span from the actual condition to the nearest point on the threshold bowl (fig. 14).

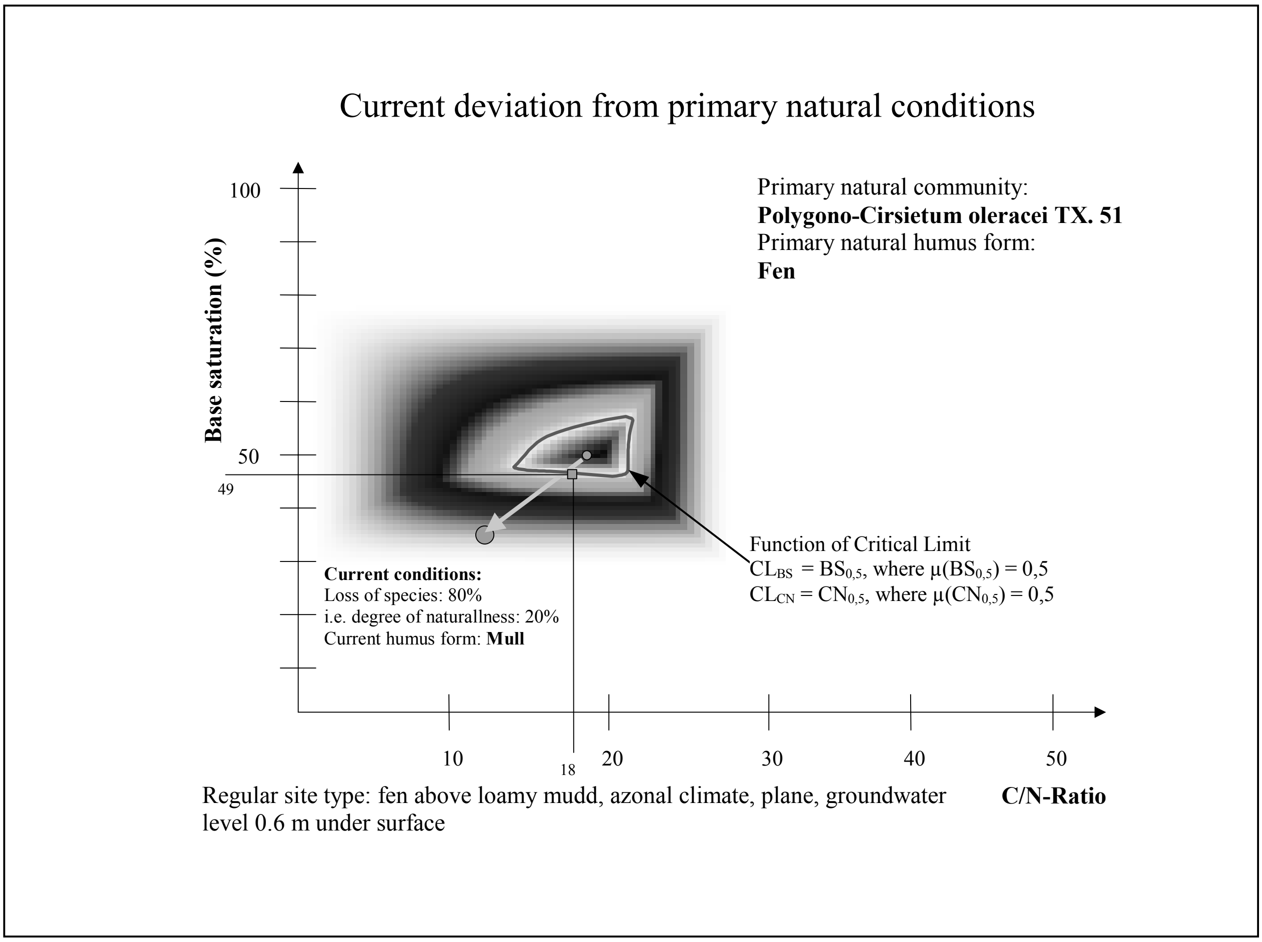


Fig. 14: Assessment of 1) the deviation between the current condition after acidification influences and eutrophication and the former natural condition, and 2) the line of the Critical Limit function.

To determine the deviation degrees, the rate of species loss is computed as a further parameter. The computation follows on the basis of the following definition:

Species Loss V_{akt} = portion of the non conforming species from the constant dominant species list (A_{prim}) of the primary natural plant community of the uninfluenced habitat, (determined from the type of soil, type of hydromorphy, climate zone and local sun exposure) compared to the current species list (A_{akt})

$$V_{akt} = \frac{A_{prim} - A_{akt}}{\sum A_{prim}} \cdot 100 \text{ (percent)} \qquad \text{eq. 13}$$

Similar to the determination of the degrees of deviation from the presently occurring plant species, one can obtain the degree of deviation from the current humus form in forests or bogs (fig. 14).

4.2.2 Determination of the recovery target and the current regeneration potential

If the actual condition lies not far from the primary natural condition (fig. 14), then, as a rule, populations of one or several constant dominant species of the primary natural plant community are present to a smaller or larger extent. With decreasing impairment inputs, these species could regain their full vitality, which would initialize the return of the primary natural plant community. This self regenerating process initiated by decreasing loads will lead to a return to the primary natural conditions within a short period of time.

If the current condition, however, lies far off from the primary natural condition (fig. 15), then, as a rule, every dominant constant species and other constant species of the primary natural plant community are extinct. Instead, new species (that are better adapted to the changed soil properties) have immigrated. One or several of the immigrant species, however, could be dominant species of a potentially natural plant community within a series of natural communities on the harmonious C/N- BS vector within a habitat regular type. When this is the case and the loads are decreasing towards a new level of harmonious nature-identical equilibrium, a new natural plant community can be developed, which, like the primary natural community, can exhibit high species diversity and high ecological functionality. Which, if either, of the natural plant community or the semi-natural plant community becomes the “target” of ecosystem management is (in the end) a political decision and depends on the preferred development targets. For example, in a protected area, fertilization would be completely excluded as a policy option whereas calcareous fertilization could be a meaningful measure in a forest where forestry takes place.

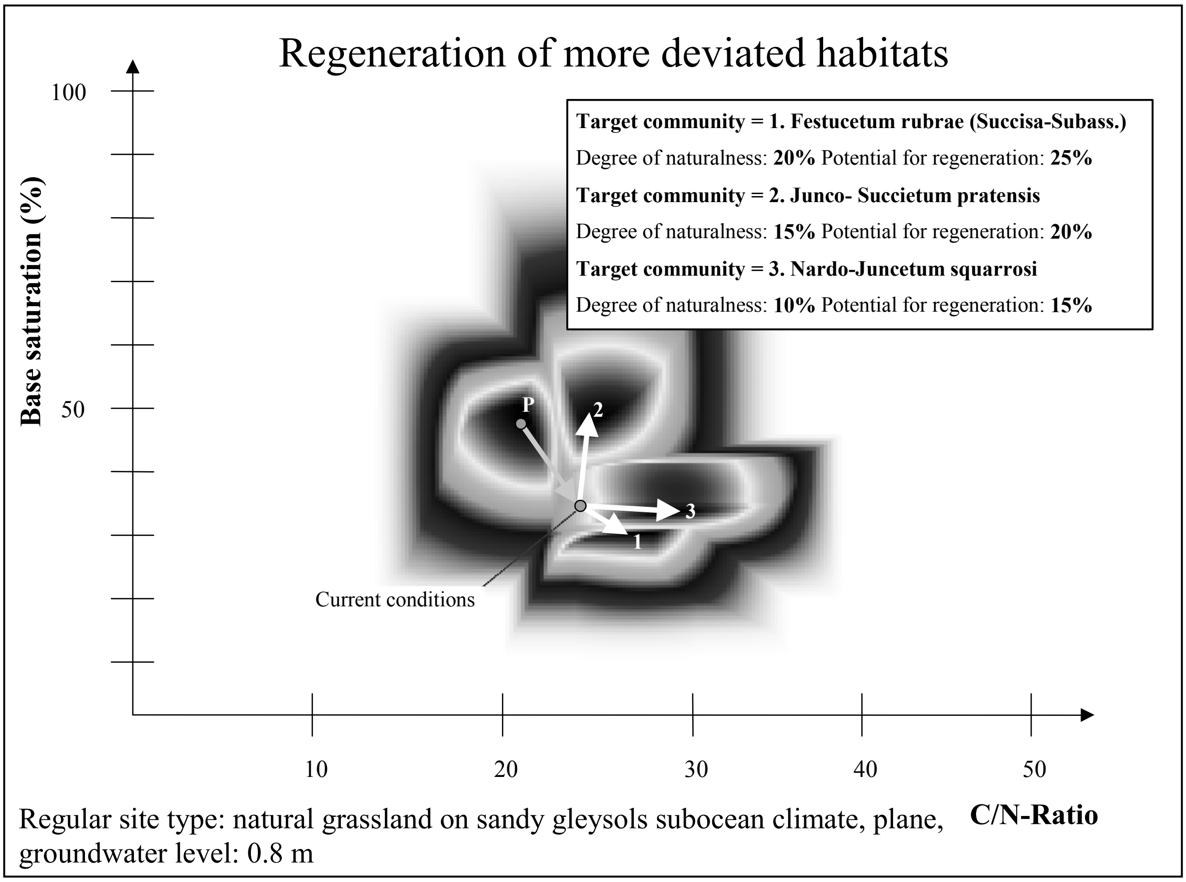


Fig. 15: Possible regeneration targets for a current habitat, which has greatly deviated from its primary natural condition.

The recovery time is a function of the current presence of species, which can develop their population to a dominant position in potential natural plant communities. By this one means a function of the presence of a reproductively capable gene-potential for the development of a new plant community in or near of the regarded habitat.

For the definition of the recovery target, one condition is the determination of the actually existing degree of remaining "naturalness" of the current species composition at the habitat in question.

The following definitions apply:

Degree of Naturalness N_{akt} = the proportion of actually occurring species (A_{akt}) of the list of dominant species ($A_{pot}{}^{D}$) of the natural plant community, to that which corresponds to the actual site parameters (indicated by actually observed species) that lie nearest the nature-identical harmonious equilibrium of BS and C/N. This nearest harmonious parameter combination should be the recovery target for the habitat. This target does not have to be identical with the primary uninfluenced condition.

The computation takes place based on the following equation:

$$N_{act} = \frac{M(A_{act} \cap A_{pot^D})}{M(A_{pot^D})} = \frac{\sum_{i=1}^{k} \frac{i}{i}[\forall i / a_{act_i} \in (A_{act_i} \wedge A_{pot^D})]}{l} \cdot 100 \qquad [in\%] \qquad \text{eq. 14}$$

$$A_{act} = \{a_{act_i} \wedge i = [1;k]\}$$

$$A_{pot^D} = \{a_{pot^D{}_j} \wedge j = [1;l]\}$$

where:

A_{act} = quantity of the actually occurring plant species at the habitat of the investigation
k = number of elements of the amount A_{act}
A_{potD} = quantity of dominant species of the potential natural plant community
l = number of elements of the amount A_{potD}

Regeneration potential R_{pot} = proportion of immigrating species to expect, which may arrive during the estimated recovery duration, compared with the total species list of the potential natural plant community (dominant and character species) at the recovery target A_{pot}. It is a function of the soil-chemical regenerative power and the propagation behavior of the potential dominant and character species.

Possible targets of recovery =

1. Target: (a slightly changed ecosystem): the primary natural habitat condition
2. Target: (a highly changed ecosystem): the re-establishment of the nearest balanced nature-identical equilibrium of N, C and Bc, which is appropriate for the current (disharmonic) condition - the most quickly reached by self-regeneration processes
3. Target: (an irreversible changed ecosystem): re-establishment of nearest balanced nature-identical equilibrium of N, C and Bc, which is appropriate for the current (disharmonic) condition – with the help of ecosystem management

A development target for a highly changed ecosystem - a target that would be reasonable under many criteria - should be, therefore, the re-establishment of a balanced nature-identical equilibrium in the nutrient, water, and energy balance. This can be the nearest equilibrium of N, C and Bc, which is appropriate for the current (disharmonic) condition (fig. 15). This condition of equilibrium would be the one reached the most quickly through self-regeneration processes, which would show a high species diversity with a high ecological functionality. A complete, independent return to the primary natural condition becomes, as a rule, a very long in coming proposition, or is completely impossible because of irreversible changes to the soil.

In particular, where the concentration of base cations in the soil solution (fig. 16) are strongly diluted and the dilution has already reached into deeper soil layers, one may no longer subsequently assume that sufficient base cations can be delivered from the weathering of parent material into the root-zone. On the one hand, the deep-rooted plant species which could carry the base cations to the surface (e.g., the trees in the forest or the grasses of the meadows and pastures), have experienced such a strong depression in their growth that this performance can hardly be completed. This growth depression is caused when a critical relationship of Bc/Al in the soil solution is reached. The plants, which themselves normally carry out the largest part of the recovery of a harmonious nutrient household in the soil, already are no longer productive or are already dead. On the other hand, soil-chemical processes have led to a destabilization of the soil content in the area of change- e.g., from aluminum to the iron buffer - which in extreme cases is no longer reversible.

In extreme cases, the nutrient household of some ecological systems is so strongly disharmoniously changed (usually through long and very strong acidification with simultaneous eutrophication) that the potential for self- regeneration to a nature-identical equilibrium has completely disappeared (fig. 16). The border of regenerative power is exceeded irreversibly. These ecosystems are characterized by the absence of species, which could function in any potential natural plant community as dominant constant species (degree of "Naturalness" = 0). In such sites, only species with very broad ecological niches occur. Such species can occur very irregularly in many communities of the regular site type. However, these can never arise to a dominant species of a potential natural plant community because they would not be competitive enough in the presence of many other species.

A characteristic of irreversibly changed habitats (with an extremely disharmonious nutrient household) is, in forests, the presence of the humus type "raw humus" with simultaneously high contents of N in the humus layer and of BS in the upper mineral soil layer of less than 10 percent.

It is thus necessary to obtain both 1) the maximum stress threshold (= Critical Limit function) in the sense defined so far (UBA 1996), and 2) the limit of regeneration ability, after which is exceeded, no more self-recovery takes place ("line of no return").

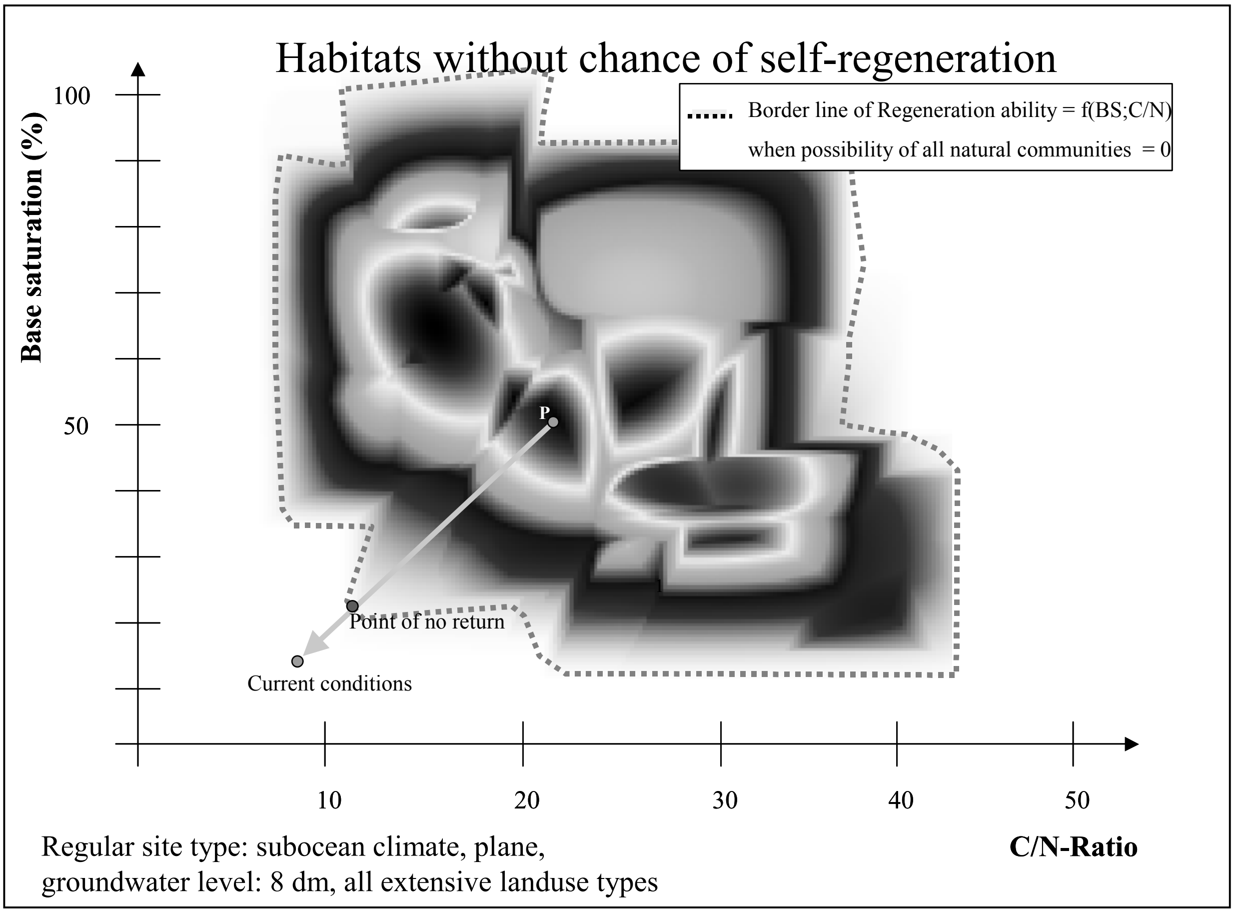


Fig. 16: Function of regeneration ability and a current highly changed habitat with no chance for self regeneration

5 Results, current state of the work and future outlook

Presently for all regular site types which represent country-wide the German Northern low and hilly lands results are determined for

- the allocated primary-natural plant communities (woodlands) and semi-natural communities (fens, heath and grassland vegetation) with their ecological Optima and possibility ranges regarding base saturation, C/N-ratio and moisture of the soil
- the constant plant species of these plant communities (720 plant species are in the data base up to now) with the optima and niche widths for the preferred soil moisture, base saturation and C/N-ratio ranges
- threshold values for these parameters at the most disharmonious point on the 0.5-Critical Limit-Function line for each plant community (Critical Limit of C/N according to the critical BS)
- the critical ratio of essential base cations to Aluminum-ions in the soil solution for the natural plant communities
- Critical Loads for acidification and N-eutrophication at the most disharmonious point on the 0.5-Critical Limit-Function line (empirical Critical Load N / Simple mass balance-Critical Load N)

The next future work will be

- to fulfill the data base for more and more regular site types in the whole German territory (for montanee, alpine and coast regions).
- in coupling the BERN-model to dynamic soil models like ForSAFE and VSD in order to become the BERN-model up to a dynamic model type
- to implement plant-specific (and at least community-specific) parameters for indicating the effects of climate change in natural habitats
- to implement management scenarios which will be support the recovery of nature-identical conditions in hardly loaded areas in prognoses by the dynamic BERN-model in future

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Annex: Results

*(Moisture value) **(FAOCode)

altitude/ climate zone	Relief	Expo-sition	Hydro-mor-phy*	soil type **	Using	plant community	EUNIS Code	BS Opti-mum	BS Crit	Bc/Al	CN Opti-mum	CN Crit	f imm
planar-suboceanic	slope	sunny	5,0	Rd	forest	Agrostio-Piluliferae-Fagetum sylvaticae	G1.61	31	28	0,47	29	26	0,69
	plane	no	6,9	Bg	forest	Anemono-Lysimachio-Quercetum roboris	G1.42	32	30	0,50	25	24	0,54
	slope	shade	6,9	Bg	forest	Anemono-Lysimachio-Quercetum roboris	G1.42	32	30	0,50	25	24	0,54
	slope	sunny	6,9	Bg	forest	Anemono-Lysimachio-Quercetum roboris	G1.42	32	30	0,50	25	24	0,54
	plane	no	7,7	J	forest	Athyrio-Alnetum glutinosae	G1.52	34	33	0,45	24	23	1,00
	slope	sunny	5,4	Bd, D	forest	Calamagrostio-Majanthemo-Fagetum sylvati-cae	G1.63	36	34	0,54	24	23	0,61
	slope	sunny	3,9	Ql	forest	Calamagrostio-Mnio-Fagetum sylvaticae	G1.61	34	31	0,51	24	22	0,67
	plane	no	5,1	B Ch Cl H L	forest	Centro-Asperulo-Fagetum sylvaticae	G1.63	44	42	0,73	19	18	0,45
	slope	shade	5,6	Ch Cl H L	forest	Centro-Carpino-Ulmetum scabrae	G1.A62	61	59	1,12	17	17	0,55
	slope	sunny	4,8	Rd	forest	Centro-Cladonio-Pinetum sylvaticae	G4.31	26	23	0,36	32	28	0,59
	plane	no	8,7	Oe	forest	Centro-Eriophoro-Pinetum sylvestris	G3.E2	17	16	0,17	34	32	0,15
	plane	no	7,5	G L	forest	Centro-Filipendulo-Alnetum	G1.213	43	40	0,67	19	18	0,87
	plane	no	7,4	J	forest	Centro-Filipendulo-Fraxinetum	G1.213	52	50	0,81	17	16	0,37
	plane	no	5,8	Cg	forest	Centro-Fraxino-Fagetum sylvaticae	G1.221	52	49	0,82	18	17	0,31
	slope	shade	5,8	Cg	forest	Centro-Fraxino-Fagetum sylvaticae	G1.221	52	49	0,82	18	17	0,31
	slope	sunny	5,8	Cg	forest	Centro-Fraxino-Fagetum sylvaticae	G1.221	52	49	0,82	18	17	0,31
	plane	no	5,4	Bd D	forest	Centro-Maianthemum-Fagetum sylvaticae	G1.63	37	34	0,55	24	22	0,63
	plane	no	5,5	B Ch Cl H L	forest	Centro-Melico-Fagetum sylvaticae	G1.63	49	47	0,87	18	17	0,51
	slope	sunny	5,5	BCh Cl H L	forest	Centro-Melico-Fagetum sylvaticae	G1.63	49	47	0,87	18	17	0,51
	plane	no	6,4	G	forest	Centro-Molinio-Fagetum sylvaticae	G1.61	33	29	0,44	28	25	0,49
	slope	shade	6,4	G	forest	Centro-Molinio-Fagetum sylvaticae	G1.61	33	29	0,44	28	25	0,49
	slope	sunny	6,4	G	forest	Centro-Molinio-Fagetum sylvaticae	G1.61	33	29	0,44	28	25	0,49
	plane	no	5,4	Rd	forest	Centro-Myrtillo-Fagetum sylvaticae	G1.61	33	30	0,51	29	27	0,67
	plane	no	5,4	Q	forest	Centro-Piluliferae-Fagetum sylvaticae	G1.61	33	30	0,52	28	26	0,47
	plane	no	7,3	Pg	forest	Centro-Pleurozio-Betuletum pubescentis	G3.E2	19	18	0,29	32	30	0,24
	slope	shade	7,3	Pg	forest	Centro-Pleurozio-Betuletum pubescentis	G3.E2	19	18	0,29	32	30	0,24
	slope	sunny	7,3	Pg	forest	Centro-Pleurozio-Betuletum pubescentis	G3.E2	19	18	0,29	32	30	0,24
	plane	no	4,4	B Bc L	forest	Cephalanthero-Mercuriali-Fagetum sylvaticae	G1.66	54	51	0,99	16	15	0,64
	slope	shade	4,4	B Bc L	forest	Cephalanthero-Mercuriali-Fagetum sylvaticae	G1.66	54	51	0,99	16	15	0,64
	slope	sunny	4,4	B Bc L	forest	Cephalanthero-Mercuriali-Fagetum sylvaticae	G1.66	54	51	0,99	16	15	0,64
	slope	shade	4,8	Bc Bv L	forest	Corydalido-Carpino-Ulmetum scabrae	G1.A62	61	59	1,11	17	17	0,55
	plane	no	5,3	Dd Ql	forest	Dactylido-Asperulo-Fagetum sylvaticae	G1.63	40	39	0,68	20	19	0,79
	slope	shade	5,5	De Lg	forest	Dryopterido-Asperulo-Fagetum sylvaticae	G1.63	43	40	0,64	20	18	0,44
	slope	shade	5,7	Bd D	forest	Dryopterido-Majanthemum-Fagetum sylvati-cae	G1.63	37	35	0,56	24	22	0,64
	slope	sunny	5,0	De Lg	forest	Festuco-Asperulo-Fagetum sylvaticae	G1.63	41	38	0,59	20	19	0,40
	slope	sunny	4,6	Dd L Ql	forest	Lathyrio-Asperulo-Fagetum sylvaticae	G1.63	41	39	0,68	19	18	0,83
	plane	no	5,0	Q	forest	Leucobryo-Dicrano-Fagetum sylvaticae	G1.61	29	26	0,42	32	28	1,00
	slope	shade	5,0	Q Anth	forest	Leucobryo-Dicrano-Fagetum sylvaticae	G1.61	29	26	0,42	32	28	1,00
	slope	sunny	5,0	Q Anth	forest	Leucobryo-Dicrano-Fagetum sylvaticae	G1.61	29	26	0,42	32	28	1,00
	plane	no	8,2	Pg	forest	Majanthemo-Sphagno-Betuletum pubescentis	G1.51	19	18	0,28	32	30	0,23
	plane	no	5,5	Bc	forest	Melico-Mercuriali-Fagetum sylvaticae	G1.66	52	49	0,81	18	17	0,55
	slope	sunny	5,3	Rd	forest	Mnio-Myrtillo-Fagetum sylvaticae	G1.61	30	27	0,45	30	27	0,64
	slope	shade	5,3	Q	forest	Mnio-Piluliferae-Fagetum sylvaticae	G1.61	30	27	0,46	29	27	0,42
	slope	shade	5,1	Rd	forest	Myrtillo-Vaccinio-Pinetum sylvaticae	G4.31	25	22	0,35	32	28	0,60
	slope	shade	5,1	Ql	forest	Oxalido-Mnio-Fagetum sylvaticae	G1.61	34	31	0,50	26	24	0,56
	plane	no	5,0	Rd	forest	Pleurozio-Cladonio-Pinetum sylvestris	G4.31	25	22	0,36	32	28	0,59
	plane	no	5,0	Ql	forest	Poo-Majanthemo-Fagetum sylvaticae	G1.63	36	34	0,57	25	23	0,60
	plane	no	8,4	Od	forest	Recurvi-Eriophoro-Betuletum pubescentis	G1.51	18	17	0,18	33	31	0,72
	slope	sunny	6,6	B Be C	forest	Remotae-Melico-Fagetum sylvaticae	G1.63	45	43	0,75	19	18	0,47
	plane	no	8,8	Bg	forest	Sphagno-Alnetum glutinosae	G1.52	28	27	0,44	26	25	0,48
	plane	no	8,6	G	forest	Symphyto-Irido-Alnetum glutinosae	G1.52	42	39	0,63	20	18	0,85
	plane	no	2,6	Be Cl	meadow	Airo-Agrostidetum tenuis	E1.72	43	37	0,59	25	21	0,27
	slope	shade	2,6	Be Cl	meadow	Airo-Agrostidetum tenuis	E1.72	43	37	0,59	25	21	0,27
	slope	sunny	2,6	Be Cl	meadow	Airo-Agrostidetum tenuis	E1.72	43	37	0,59	25	21	0,27
	plane	no	8,7	Od Pg	meadow	Caricetum diandrae	D2.32	42	39	0,50	21	20	0,00
	plane	no	8,9	Oe	meadow	Caricetum elatae (Comaro-Subass.)	D5.21	45	42	0,56	25	24	0,57
	plane	no	8,9	Bg G	meadow	Caricetum elatae (typ. Subass.)	D5.21	45	43	0,79	23	21	0,69
	plane	no	8,6	G	meadow	Caricetum gracilis	D5.21	60	55	1,10	20	18	0,84
	plane	no	8,2	J	meadow	Caricetum vulpinae	D4.1G	73	70	1,66	16	16	0,44
	plane	no	8,6	Cg L	meadow	Crepido-Juncetum subnudolosi	D4.1H	75	72	1,77	22	21	1,00

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planar-suboceanic	plane	no	5,2	Bd	meadow	Festucetum rubrae (Succisa-Subass.)	E1.72	33	30	0,47	27	25	0,51
	plane	no	4,6	Bd D De	meadow	Festucetum rubrae (typ. Subass.)	E1.72	31	29	0,43	26	24	0,54
	slope	shade	4,6	Bd D De	meadow	Festucetum rubrae (typ. Subass.)	E1.72	31	29	0,43	26	24	0,54
	slope	sunny	4,6	Bd D De	meadow	Festucetum rubrae (typ. Subass.)	E1.72	31	29	0,43	26	24	0,54
	plane	no	2,6	De Rd	meadow	Festuco-Koelerietum glaucae	E1.72	44	39	0,61	29	26	1,00
	slope	shade	2,6	De Rd	meadow	Festuco-Koelerietum glaucae	E1.72	44	39	0,61	29	26	1,00
	slope	sunny	2,6	De Rd	meadow	Festuco-Koelerietum glaucae	E1.72	44	39	0,61	29	26	1,00
	plane	no	5,1	L	meadow	Galio-Alopecuretum pratensi	E3.41	71	70	1,73	18	17	0,52
	plane	no	5,0	J	meadow	Heracleo-Arrhenatheretum elatioris (Alopecu-rus-Subass.)	E2.22	51	47	0,75	21	20	0,05
	plane	no	5,0	Ch Cl H L	meadow	Heracleo-Arrhenatheretum elatioris (typ. Subass.)	E2.22	51	48	0,77	21	19	0,38
	slope	shade	5,0	Ch Cl H L	meadow	Heracleo-Arrhenatheretum elatioris (typ. Subass.)	E2.22	51	48	0,77	21	19	0,38
	slope	sunny	5,0	Ch Cl H L	meadow	Heracleo-Arrhenatheretum elatioris (typ. Subass.)	E2.22	51	48	0,77	21	19	0,38
	plane	no	8,5	G Oe	meadow	Junco-Caricetum fuscae	D2.22	37	34	0,53	28	26	0,44
	plane	no	7,3	Bd Od	meadow	Junco-Molinietum	E3.51	34	32	0,51	27	26	0,46
	plane	no	6,9	Dg Pg	meadow	Loto-Brometum racemosae	E2.22	47	44	0,83	21	19	0,80
	plane	no	2,5	P Rd	meadow	Ornithopodo-Corynephoretum canescentis	E1.93	37	34	0,61	31	29	0,31
	slope	shade	2,5	P Rd	meadow	Ornithopodo-Corynephoretum canescentis	E1.93	37	34	0,61	31	29	0,31
	slope	sunny	2,5	P Rd	meadow	Ornithopodo-Corynephoretum canescentis	E1.93	37	34	0,61	31	29	0,31
	plane	no	8,3	De G	meadow	Phalaridetum arundinacae	E3.44	75	71	1,78	14	14	0,75
	plane	no	5,2	B Q	meadow	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	slope	shade	5,2	B Q	meadow	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	slope	sunny	5,2	B Q	meadow	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	plane	no	7,3	G L	meadow	Polygono-Cirsietum oleracei	E2.22	52	48	0,88	19	18	0,86
	plane	no	3,1	L	meadow	Potentillo-Brachypodietum pinnati	E1.23	72	71	1,78	22	22	1,00
	slope	shade	3,1	L	meadow	Potentillo-Brachypodietum pinnati	E1.23	72	71	1,78	22	22	1,00
	slope	sunny	3,1	L	meadow	Potentillo-Brachypodietum pinnati	E1.23	72	71	1,78	22	22	1,00
	plane	no	2,8	Dd Ql	meadow	Pulsatillo-Phleetum phleoides	E1.72	67	63	1,58	24	22	0,64
	slope	sunny	2,8	Dd Ql	meadow	Pulsatillo-Phleetum phleoides	E1.72	67	63	1,58	24	22	0,64
	plane	no	6,9	C G	meadow	Ranunculo-Deschampsietum caespitosae	E3.44	71	70	1,86	18	17	0,51
	plane	no	6,8	Ch J	meadow	Stachyo-Molinietum coeruleae	D4.13	60	58	1,08	27	26	1,00
	plane	no	2,1	P Rd	meadow	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,39	32	31	1,00
	slope	shade	2,1	P Rd	meadow	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,39	32	31	1,00
	slope	shade	2,1	P	meadow	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,42	32	31	0,22
	slope	shade	2,1	Rd	meadow	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,41	32	31	0,47
	slope	sunny	2,1	P Rd	meadow	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,39	32	31	1,00
	slope	sunny	2,1	P	meadow	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,42	32	31	0,22
	slope	sunny	2,1	Rd	meadow	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,41	32	31	0,47
	plane	no	2,6	Bd Ql	meadow	Thymo-Festucetum ovinae	E1.72	43	37	0,65	26	22	0,18
	slope	sunny	2,6	Bd Ql Anth	meadow	Thymo-Festucetum ovinae	E1.72	43	37	0,65	26	22	0,18
	slope	sunny	2,6	Bd	meadow	Thymo-Festucetum ovinae	E1.72	43	37	0,61	26	22	0,64
	slope	sunny	2,6	Ql	meadow	Thymo-Festucetum ovinae	E1.72	43	37	0,67	26	22	0,64
	plane	no	2,7	Bv De Lg	meadow	Thymo-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,01
	slope	sunny	2,7	Bv De Lg	meadow	Thymo-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,01
	slope	sunny	2,7	De	meadow	Thymo-Festucetum trachyphyllae	E1.29	57	55	1,04	26	25	0,01
	slope	sunny	2,7	Lg	meadow	Thymo-Festucetum trachyphyllae	E1.29	57	55	1,09	26	25	0,51
	plane	no	2,6	Be Cl	pasture	Airo-Agrostidetum tenuis	E1.72	43	37	0,58	25	21	0,27
	slope	shade	2,6	Be Cl	pasture	Airo-Agrostidetum tenuis	E1.72	43	37	0,58	25	21	0,27
	slope	shade	2,6	Cl	pasture	Airo-Agrostidetum tenuis	E1.72	43	37	0,63	25	21	0,27
	slope	sunny	2,6	Be Cl	pasture	Airo-Agrostidetum tenuis	E1.72	43	37	0,58	25	21	0,27
	plane	no	6,9	L	pasture	Alopecuretum geniculati	E3.44	64	59	1,17	17	15	0,65
	plane	no	8,7	Od Pg	pasture	Caricetum diandrae	D2.32	42	39	0,50	21	20	0,00
	plane	no	8,9	Oe	pasture	Caricetum elatae (Comaro-Subass.)	D5.21	45	42	0,56	25	24	0,57
	plane	no	2,8	P Q Rd	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,39	32	27	0,39
	slope	shade	2,8	P Q Rd	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,39	32	27	0,39
	slope	shade	2,8	Q	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,39	32	27	0,39
	slope	shade	2,8	Rd	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,38	32	27	0,64

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	slope	sunny	2,8	P Q Rd	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,39	32	27	0,39
planar-suboceanic	slope	sunny	2,8	Q	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,39	32	27	0,39
	slope	sunny	2,8	Rd	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,38	32	27	0,64
	plane	no	6,7	G	pasture	Festucetum arundinaceae	E3.44	61	57	1,18	13	12	0,00
	plane	no	4,8	Bd D De	pasture	Festuco-Cynosuretum	E2.11	33	30	0,47	22	20	0,73
	slope	shade	4,8	Bd D De	pasture	Festuco-Cynosuretum	E2.11	33	30	0,47	22	20	0,73
	slope	sunny	4,8	Bd D De	pasture	Festuco-Cynosuretum	E2.11	33	30	0,47	22	20	0,73
	plane	no	3,2	Bd Ql Rd	pasture	Genisto anglicae-Callunetum vulgaris	F4.22	28	26	0,39	29	27	0,42
	slope	shade	3,2	Bd Ql Rd	pasture	Genisto anglicae-Callunetum vulgaris	F4.22	28	26	0,39	29	27	0,42
	slope	sunny	3,2	Bd Ql Rd	pasture	Genisto anglicae-Callunetum vulgaris	F4.22	28	26	0,39	29	27	0,42
	plane	no	6,9	Dg Pg	pasture	Genisto-Juncetum squarrosi	E1.71	29	27	0,43	27	25	0,50
	plane	no	6,5	C G	pasture	Juncetum compressi	E1.65	63	59	1,32	13	12	0,84
	plane	no	8,5	G Oe	pasture	Junco-Caricetum fuscae	D2.22	37	34	0,52	28	26	0,44
	plane	no	4,2	Cl H L	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,86	22	19	0,37
	slope	shade	4,2	Cl H L	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,86	22	19	0,37
	slope	sunny	4,2	Cl H L	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,86	22	19	0,37
	plane	no	4,9	Bg	pasture	Lolio-Cynosuretum cristati (typ.-Subass.)	E2.11	55	45	0,89	21	17	0,91
	slope	shade	4,9	Bg	pasture	Lolio-Cynosuretum cristati (typ.-Subass.)	E2.11	55	45	0,89	21	17	0,91
	plane	no	7,0	Bd Dg Od Pg	pasture	Nardo-Juncetum squarrosi	E3.52	29	28	0,41	29	27	0,39
	plane	no	6,8	Ch J	pasture	Parnassio-Molinietum coeruleae	E3.51	60	59	1,12	32	31	1,00
	plane	no	4,7	B	pasture	Plantagini-Lolietum perennis	E2.11	58	53	1,06	14	13	0,81
	slope	shade	4,7	B	pasture	Plantagini-Lolietum perennis	E2.11	58	53	1,06	14	13	0,81
	plane	no	7,7	De G	pasture	Potentilla rep.-Inula britannica-Gesellschaft	E1.65	62	55	1,04	17	15	0,65
	plane	no	7,3	Bg G	pasture	Potentilla-Juncus inflexus	D4.1H	62	58	1,37	23	21	0,69
	plane	no	6,5	G	pasture	Potentilletum anserinae	E1.65	57	53	1,00	13	12	0,00
	plane	no	3,1	L	pasture	Potentillo-Brachypodietum pinnati	E1.23	72	71	1,77	22	22	1,00
	slope	shade	3,1	L	pasture	Potentillo-Brachypodietum pinnati	E1.23	72	71	1,77	22	22	1,00
	slope	sunny	3,1	L	pasture	Potentillo-Brachypodietum pinnati	E1.23	72	71	1,77	22	22	1,00
	plane	no	2,8	Dd Ql	pasture	Pulsatillo-Phleetum phleoides	E1.72	67	63	1,56	24	22	0,64
	slope	sunny	2,8	Dd Ql	pasture	Pulsatillo-Phleetum phleoides	E1.72	67	63	1,56	24	22	0,64
	plane	no	2,1	P Rd	pasture	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,39	32	31	1,00
	slope	shade	2,1	P Rd	pasture	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,39	32	31	1,00
	slope	sunny	2,1	P Rd	pasture	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,39	32	31	1,00
	plane	no	2,7	Bv De	pasture	Thymo-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,01
	slope	sunny	2,7	Bv De	pasture	Thymo-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,01
planar-sub-continental	slope	sunny	3,1	Bd	forest	Agrostio-Peucedano-Quercetum	G1.87	32	29	0,44	26	24	0,56
	plane	no	3,8	Q	forest	Dicrano-Quercetum	G1.87	26	23	0,36	31	27	1,00
	slope	shade	3,8	Q	forest	Dicrano-Quercetum	G1.87	26	23	0,36	31	27	1,00
	slope	sunny	3,8	Q	forest	Dicrano-Quercetum	G1.87	26	23	0,36	31	27	1,00
	slope	sunny	4,0	Dd Ql	forest	Filipendulo-Anemono-Quercetum roboris	G1.42	40	38	0,67	22	21	0,68
	slope	sunny	4,1	Bd D	forest	Poo-Peucedano-Quercetum	G1.87	31	29	0,45	27	25	0,52
	plane	no	4,2	B Ql	forest	Deschampsio-Potentillo-Quercetum petreae-roboris	G4.71	35	33	0,51	25	23	0,13
	slope	shade	4,2	B Ql	forest	Deschampsio-Potentillo-Quercetum petreae-roboris	G4.71	35	33	0,51	25	23	0,13
	plane	no	4,2	Dd Ql	forest	Primulo-Potentillo-Quercetum petreae-roboris	G4.71	39	37	0,63	21	20	0,74
	slope	shade	4,2	Dd Ql	forest	Primulo-Potentillo-Quercetum petreae-roboris	G4.71	39	37	0,63	21	20	0,74
	plane	no	4,3	Q	forest	Deschampsio-Agrostio-Quercetum roboris	G4.71	33	29	0,50	30	27	0,41
	slope	shade	4,3	Q	forest	Deschampsio-Agrostio-Quercetum roboris	G4.71	33	29	0,50	30	27	0,41
	slope	sunny	4,3	Q	forest	Festuco-Agrostio-Quercetum roboris	G4.71	32	29	0,49	31	28	0,36
	slope	sunny	4,4	Bc L	forest	Primulo-Merculiari-Carpinetum	G1.A16	60	59	1,10	18	17	0,52
	plane	no	4,5	Bc Bv L	forest	Centro-Merculiari-Carpinetum	G1.A16	54	49	0,79	18	16	0,59
	plane	no	4,5	Bd D	forest	Dactylido-Quercetum petreae-roboris	G4.71	35	32	0,51	25	23	0,61
	slope	shade	4,5	Bd D	forest	Dactylido-Quercetum petreae-roboris	G4.71	35	32	0,51	25	23	0,61
	slope	sunny	4,6	De Lg	forest	Primulo-Bromo-Carpinetum	G1.A16	60	59	1,18	18	17	0,51

altitude/ climate zone	Relief	Expo-sition	Hydro-mor-phy*	soil type **	Using	plant community	EUNIS Code	BS Opti-mum	BS Crit	Bc/Al	CN Opti-mum	CN Crit	f imm
	slope	shade	4,7	Bc Be L	forest	Corydalido-Carpino-Ulmetum carpinifoliae	G1.A61	61	59	1,12	17	16	0,59
planar-sub-continental	plane	no	4,7	Rd	forest	Deschampsio-Melampyro-Quercetum roboris	G4.71	30	26	0,42	31	27	0,66
	slope	shade	4,7	Rd	forest	Deschampsio-Melampyro-Quercetum roboris	G4.71	30	26	0,42	31	27	0,66
	slope	sunny	4,8	Rd	forest	Centro-Cladonio-Pinetum sylvaticae	G4.31	26	23	0,36	32	28	0,59
	slope	sunny	4,9	Rd	forest	Festuco-Melampyro-Quercetum roboris	G4.71	30	26	0,43	31	27	0,64
	slope	sunny	5,0	Ch Cl H L	forest	Agrostio-Polygonato-Carpinetum	G1.A16	38	36	0,51	22	21	0,26
	plane	no	5,0	Rd	forest	Pleurozio-Cladonio-Pinetum sylvestris	G4.31	25	22	0,36	32	28	0,59
	slope	shade	5,1	Rd	forest	Myrtillo-Vaccinio-Pinetum sylvaticae	G4.31	25	22	0,35	32	28	0,60
	plane	no	5,3	De Lg	forest	Centro-Bromo-Carpinetum	G1.A16	54	51	0,91	18	17	0,55
	plane	no	5,3	Ch Cl H L	forest	Centro-Polygonato-Carpinetum	G1.A16	39	36	0,52	21	20	0,31
	slope	shade	5,5	De Lg	forest	Dryopterido-Bromo-Carpinetum	G1.A16	51	46	0,78	18	17	0,56
	plane	no	5,7	C J	forest	Deschampsio-Stellario-Carpinetum	G1.A16	43	39	0,62	21	19	0,38
	slope	shade	5,7	C J	forest	Deschampsio-Stellario-Carpinetum	G1.A16	43	39	0,62	21	19	0,38
	slope	sunny	5,7	C J	forest	Deschampsio-Stellario-Carpinetum	G1.A16	43	39	0,62	21	19	0,38
	slope	shade	5,9	Ch Cl H L	forest	Centro-Carpino-Ulmetum carpinifoliae	G1.A61	61	59	1,13	17	16	0,59
	plane	no	6,4	Cg	forest	Centro-Sambuco-Quercetum roboris	G1.A17	56	53	0,93	17	16	0,42
	slope	shade	6,4	Cg	forest	Centro-Sambuco-Quercetum roboris	G1.A17	56	53	0,93	17	16	0,42
	slope	sunny	6,4	Cg	forest	Centro-Sambuco-Quercetum roboris	G1.A17	56	53	0,93	17	16	0,42
	plane	no	6,7	Dg	forest	Centro-Molinio-Quercetum roboris	G1.42	33	29	0,48	29	25	0,49
	slope	shade	6,7	Dg	forest	Centro-Molinio-Quercetum roboris	G1.42	33	29	0,48	29	25	0,49
	slope	sunny	6,7	Dg	forest	Centro-Molinio-Quercetum roboris	G1.42	33	29	0,48	29	25	0,49
	plane	no	6,9	Bg	forest	Anemono-Lysimachio-Quercetum roboris	G1.42	32	30	0,50	25	24	0,54
	slope	shade	6,9	Bg	forest	Anemono-Lysimachio-Quercetum roboris	G1.42	32	30	0,50	25	24	0,54
	slope	sunny	6,9	Bg	forest	Anemono-Lysimachio-Quercetum roboris	G1.42	32	30	0,50	25	24	0,54
	plane	no	7,1	Dg	forest	Centro-Pleurozio-Pinetum sylvestris	G3.E2	19	18	0,27	32	30	0,23
	slope	shade	7,1	Dg	forest	Centro-Pleurozio-Pinetum sylvestris	G3.E2	19	18	0,27	32	30	0,23
	slope	sunny	7,1	Dg	forest	Centro-Pleurozio-Pinetum sylvestris	G3.E2	19	18	0,27	32	30	0,23
	plane	no	7,5	G L	forest	Centro-Filipendulo-Alnetum	G1.213	43	40	0,67	19	18	0,87
	plane	no	7,7	J	forest	Athyrio-Alnetum glutinosae	G1.52	34	33	0,45	24	23	1,00
	plane	no	8,2	Pg	forest	Majanthemo-Sphagno-Betuletum pubescentis	G1.51	19	18	0,28	32	30	0,23
	plane	no	8,4	Od	forest	Recurvi-Eriophoro-Betuletum pubescentis	G1.51	18	17	0,18	33	31	0,72
	plane	no	8,6	G	forest	Symphyto-Irido-Alnetum glutinosae	G1.52	42	39	0,63	20	18	0,85
	plane	no	8,7	Oe	forest	Centro-Eriophoro-Pinetum sylvestris	G3.E2	17	16	0,17	34	32	0,15
	plane	no	8,8	Bg	forest	Sphagno-Alnetum glutinosae	G1.52	28	27	0,44	26	25	0,48
	plane	no	2,2	P Rd	meadow	Festuco-Sperguletum vernalis	E1.94	27	25	0,40	32	30	1,00
	slope	shade	2,2	P Rd	meadow	Festuco-Sperguletum vernalis	E1.94	27	25	0,40	32	30	1,00
	slope	sunny	2,2	P Rd	meadow	Festuco-Sperguletum vernalis	E1.94	27	25	0,40	32	30	1,00
	plane	no	2,6	De Rd	meadow	Festuco-Koelerietum glaucae	E1.72	44	39	0,61	29	26	1,00
	slope	shade	2,6	De Rd	meadow	Festuco-Koelerietum glaucae	E1.72	44	39	0,61	29	26	1,00
	slope	sunny	2,6	De Rd	meadow	Festuco-Koelerietum glaucae	E1.72	44	39	0,61	29	26	1,00
	plane	no	2,6	P Q Rd	meadow	Veronico-Corynephoretum canescentis	E1.93	33	31	0,54	31	29	0,31
	slope	shade	2,6	P Q Rd	meadow	Veronico-Corynephoretum canescentis	E1.93	33	31	0,54	31	29	0,31
	slope	sunny	2,6	P Q Rd	meadow	Veronico-Corynephoretum canescentis	E1.93	33	31	0,54	31	29	0,31
	plane	no	2,7	Bd Ql	meadow	Armerio-Festucetum ovinae	E1.72	42	41	0,74	30	29	1,00
	slope	sunny	2,7	Bd Ql	meadow	Armerio-Festucetum ovinae	E1.72	42	41	0,74	30	29	1,00
	plane	no	2,7	Bv De Lg	meadow	Armerio-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,00
	slope	sunny	2,7	Bv De Lg	meadow	Armerio-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,00
	plane	no	2,8	Ql	meadow	Potentillo-Stipetum capillatae	E1.27	71	70	2,04	24	24	0,57
	slope	sunny	2,8	Ql	meadow	Potentillo-Stipetum capillatae	E1.27	71	70	2,04	24	24	0,57
	plane	no	2,9	Be Cl	meadow	Armerio-Agrostidetum tenuis	E1.72	44	37	0,61	24	21	0,28
	slope	shade	2,9	Be Cl	meadow	Armerio-Agrostidetum tenuis	E1.72	44	37	0,61	24	21	0,28
	slope	sunny	2,9	Be Cl	meadow	Armerio-Agrostidetum tenuis	E1.72	44	37	0,61	24	21	0,28
	plane	no	3,0	L	meadow	Adonido-Brachypodietum pinnati	E1.23	72	71	1,79	23	22	1,00
	slope	shade	3,0	L	meadow	Adonido-Brachypodietum pinnati	E1.23	72	71	1,79	23	22	1,00
	slope	sunny	3,0	L	meadow	Adonido-Brachypodietum pinnati	E1.23	72	71	1,79	23	22	1,00
	plane	no	4,6	Bd D De	meadow	Festucetum rubrae (typ. Subass.)	E1.72	31	29	0,43	26	24	0,54

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	slope	shade	4,6	Bd D De	meadow	Festucetum rubrae (typ. Subass.)	E1.72	31	29	0,43	26	24	0,54
planar-sub-continental	slope	sunny	4,6	Bd D De	meadow	Festucetum rubrae (typ. Subass.)	E1.72	31	29	0,43	26	24	0,54
	plane	no	5,0	L	meadow	Filipendulo-Alopecuretum pratensis	E3.43	65	59	1,18	22	20	0,36
	plane	no	5,0	J Ch Cl H L	meadow	Pastinaco-Arrhenatheretum elatioris (Alopecurus-Subass.)	E2.23	51	47	0,76	21	20	0,04
	slope	shade	5,0	J Ch Cl H L	meadow	Pastinaco-Arrhenatheretum elatioris (typ. Subass.)	E2.23	50	46	0,73	22	20	0,34
	slope	sunny	5,0	J Ch Cl H L	meadow	Pastinaco-Arrhenatheretum elatioris (typ. Subass.)	E2.23	50	46	0,73	22	20	0,34
	plane	no	5,2	Bd	meadow	Festucetum rubrae (Succisa-Subass.)	E1.72	33	30	0,47	27	25	0,51
	plane	no	5,2	B Q	meadow	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	slope	shade	5,2	B Q	meadow	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	slope	sunny	5,2	B Q	meadow	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	plane	no	6,7	C G	meadow	Cnidio-Deschampsietum caespitosae	E3.44	72	70	1,87	16	15	0,66
	plane	no	6,8	Bd Od	meadow	Violo-Molinietum	E3.51	34	32	0,50	29	27	0,38
	plane	no	6,9	Ch J	meadow	Diantho-Molinietum coeruleae	D4.13	62	59	1,13	27	26	1,00
	plane	no	7,0	Dg Pg	meadow	Loto-Holcetum lanati	E2.23	48	44	0,84	20	18	0,83
	plane	no	7,2	G L	meadow	Thalictro-Cirsietum oleracei	E2.23	59	55	1,11	19	18	0,84
	plane	no	8,2	J	meadow	Caricetum vulpinae	D4.1G	73	70	1,66	16	16	0,44
	plane	no	8,3	De G	meadow	Phalaridetum arundinacae	E3.44	75	71	1,78	14	14	0,75
	plane	no	8,5	G Oe	meadow	Junco-Caricetum fuscae	D2.22	37	34	0,53	28	26	0,44
	plane	no	8,6	G	meadow	Caricetum gracilis	D5.21	60	55	1,10	20	18	0,84
	plane	no	8,6	Cg L	meadow	Crepido-Juncetum subnudolosi	D4.1H	75	72	1,77	22	21	1,00
	plane	no	8,7	Od Pg	meadow	Caricetum diandrae	D2.32	42	39	0,50	21	20	0,00
	plane	no	8,9	Oe	meadow	Caricetum elatae (Comaro-Subass.)	D5.21	45	42	0,56	25	24	0,57
	plane	no	8,9	Bg G	meadow	Caricetum elatae (typ. Subass.)	D5.21	45	43	0,79	23	21	0,69
	plane	no	2,2	P Rd	pasture	Festuco-Sperguletum vernalis	E1.94	27	25	0,40	32	30	1,00
	slope	shade	2,2	P Rd	pasture	Festuco-Sperguletum vernalis	E1.94	27	25	0,40	32	30	1,00
	slope	sunny	2,2	P Rd	pasture	Festuco-Sperguletum vernalis	E1.94	27	25	0,40	32	30	1,00
	plane	no	2,7	Bv De	pasture	Armerio-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,00
	slope	sunny	2,7	Bv De	pasture	Armerio-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,00
	plane	no	2,8	P Q Rd	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,39	32	27	0,39
	slope	shade	2,8	P Q Rd	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,39	32	27	0,39
	slope	sunny	2,8	P Q Rd	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,39	32	27	0,39
	plane	no	2,8	Ql	pasture	Potentillo-Stipetum capillatae	E1.27	71	70	2,05	24	24	0,57
	slope	sunny	2,8	Ql	pasture	Potentillo-Stipetum capillatae	E1.27	71	70	2,05	24	24	0,57
	plane	no	2,9	Be Cl	pasture	Armerio-Agrostidetum tenuis	E1.72	44	37	0,60	24	21	0,28
	slope	shade	2,9	Be Cl	pasture	Armerio-Agrostidetum tenuis	E1.72	44	37	0,60	24	21	0,28
	slope	sunny	2,9	Be Cl	pasture	Armerio-Agrostidetum tenuis	E1.72	44	37	0,60	24	21	0,28
	plane	no	3,0	L	pasture	Adonido-Brachypodietum pinnati	E1.23	72	71	1,78	23	22	1,00
	slope	shade	3,0	L	pasture	Adonido-Brachypodietum pinnati	E1.23	72	71	1,78	23	22	1,00
	slope	sunny	3,0	L	pasture	Adonido-Brachypodietum pinnati	E1.23	72	71	1,78	23	22	1,00
	plane	no	3,2	Bd Ql Rd	pasture	Genisto germanicae-Callunetum vulgaris	F4.22	30	28	0,41	28	26	0,47
	slope	shade	3,2	Bd Ql Rd	pasture	Genisto germanicae-Callunetum vulgaris	F4.22	30	28	0,41	28	26	0,47
	slope	sunny	3,2	Bd Ql Rd	pasture	Genisto germanicae-Callunetum vulgaris	F4.22	30	28	0,41	28	26	0,47
	plane	no	4,2	Cl H L	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,86	22	19	0,37
	slope	shade	4,2	Cl H L	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,86	22	19	0,37
	slope	sunny	4,2	Cl H L	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,86	22	19	0,37
	plane	no	4,7	B	pasture	Plantagini-Lolietum perennis	E2.11	58	53	1,06	14	13	0,81
	slope	shade	4,7	B	pasture	Plantagini-Lolietum perennis	E2.11	58	53	1,06	14	13	0,81
	plane	no	4,8	Bd D De	pasture	Festuco-Cynosuretum	E2.11	33	30	0,47	22	20	0,73
	slope	shade	4,8	Bd D De	pasture	Festuco-Cynosuretum	E2.11	33	30	0,47	22	20	0,73
	slope	sunny	4,8	Bd D De	pasture	Festuco-Cynosuretum	E2.11	33	30	0,47	22	20	0,73
	plane	no	4,9	Bg	pasture	Lolio-Cynosuretum cristati (typ.-Subass.)	E2.11	55	45	0,89	21	17	0,91
	slope	shade	4,9	Bg	pasture	Lolio-Cynosuretum cristati (typ.-Subass.)	E2.11	55	45	0,89	21	17	0,91
	plane	no	6,5	C G	pasture	Juncetum compressi	E1.65	63	59	1,32	13	12	0,84
	plane	no	6,5	G	pasture	Potentilletum anserinae	E1.65	57	53	1,00	13	12	0,00

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	plane	no	6,7	G	pasture	Festucetum arundinaceae	E3.44	61	57	1,18	13	12	0,00
planar-sub-continental	plane	no	6,8	Ch J	pasture	Parnassio-Molinietum coeruleae	E3.51	60	59	1,12	32	31	1,00
	plane	no	6,9	L	pasture	Alopecuretum geniculati	E3.44	64	59	1,17	17	15	0,65
	plane	no	7,0	Bd Dg Od Pg	pasture	Carici-Nardetum strictae	E1.71	30	27	0,40	28	25	0,51
	plane	no	7,3	Bg G	pasture	Potentilla-Juncus inflexus	D4.1H	62	58	1,37	23	21	0,69
	plane	no	7,7	De G	pasture	Potentilla rep.-Inula britannica-Gesellschaft	E1.65	62	55	1,04	17	15	0,65
	plane	no	8,5	G Oe	pasture	Junco-Caricetum fuscae	D2.22	37	34	0,52	28	26	0,44
	plane	no	8,7	Od Pg	pasture	Caricetum diandrae	D2.32	42	39	0,50	21	20	0,00
	plane	no	8,9	Oe	pasture	Caricetum elatae (Comaro-Subass.)	D5.21	45	42	0,56	25	24	0,57
colline-sub-oceanic	slope	sunny	2,8	P	forest	Cytiso-Quercetum	G4.71	26	25	0,41	27	26	0,45
	slope	sunny	3,1	Bd	forest	Agrostio-Peucedano-Quercetum	G1.87	32	29	0,44	26	24	0,56
	plane	no	3,3	P	forest	Luzulo-Quercetum	G4.71	27	26	0,43	27	26	0,46
	plane	no	3,8	Bd	forest	Vaccinio vitis-ideae-Quercetum	G1.42	24	23	0,34	34	33	0,10
	slope	shade	3,8	Bd	forest	Vaccinio vitis-ideae-Quercetum	G1.42	24	23	0,34	34	33	0,10
	slope	sunny	4,0	B Be	forest	Cynancho-Tilietum platyphyllis	G1.A45	58	55	1,13	18	17	0,51
	slope	sunny	4,2	B	forest	Deschampsio-Potentillo-Quercetum petreae-roboris	G4.71	35	33	0,51	25	23	0,13
	slope	sunny	4,2	Ql	forest	Deschampsio-Potentillo-Quercetum petreae-roboris	G4.71	35	33	0,54	25	23	0,60
	plane	no	4,4	Bd	forest	Luzulo-Querco-Fagetum	G1.61	34	33	0,52	27	26	0,47
	plane	no	4,4	B Bc L	forest	Cephalanthero-Mercuriali-Fagetum sylvaticae	G1.66	54	51	0,99	16	15	0,64
	slope	sunny	4,5	Bd	forest	Luzulo-Querco-Fagetum, Calamagrostis arundinacae-Subass.	G1.61	34	32	0,51	27	25	0,48
	plane	no	4,6	Dd L Ql	forest	Lathyrio-Asperulo-Fagetum sylvaticae	G1.63	41	39	0,68	19	18	0,83
	slope	sunny	4,6	Dd L Ql	forest	Lathyrio-Asperulo-Fagetum sylvaticae	G1.63	41	39	0,68	19	18	0,83
	slope	shade	4,7	Bd	forest	Luzulo-Querco-Fagetum, Athyrium-Subass.	G1.61	36	35	0,56	27	26	0,47
	slope	shade	4,8	Bc Bv	forest	Corydalido-Carpino-Ulmetum scabrae	G1.A62	61	59	1,11	17	17	0,55
	slope	shade	4,8	L	forest	Corydalido-Carpino-Ulmetum scabrae	G1.A62	61	59	1,19	17	17	0,55
	plane	no	5,1	Rd	forest	Myrtillo-Vaccinio-Pinetum sylvaticae	G4.31	25	22	0,35	32	28	0,60
	slope	shade	5,1	Rd	forest	Myrtillo-Vaccinio-Pinetum sylvaticae	G4.31	25	22	0,35	32	28	0,60
	slope	sunny	5,1	Rd	forest	Myrtillo-Vaccinio-Pinetum sylvaticae	G4.31	25	22	0,35	32	28	0,60
	plane	no	5,1	B Ch Cl H L	forest	Centro-Asperulo-Fagetum sylvaticae	G1.63	44	42	0,73	19	18	0,45
	plane	no	5,2	Bg G	forest	Luzulo-Querco-Fagetum, Carex brizoides-Subass.	G1.61	38	37	0,64	26	24	0,53
	plane	no	5,3	Rd	forest	Mnio-Myrtillo-Fagetum sylvaticae	G1.61	30	27	0,45	30	27	0,64
	plane	no	5,4	Bd D	forest	Centro-Maianthemum-Fagetum sylvaticae	G1.63	37	34	0,55	24	22	0,63
	plane	no	5,5	B Ch Cl H L	forest	Centro-Melico-Fagetum sylvaticae	G1.63	49	47	0,87	18	17	0,51
	slope	sunny	5,5	B Ch Cl H L	forest	Centro-Melico-Fagetum sylvaticae	G1.63	49	47	0,87	18	17	0,51
	slope	shade	5,5	De Lg	forest	Dryopterido-Asperulo-Fagetum sylvaticae	G1.63	43	40	0,64	20	18	0,44
	slope	shade	5,6	Bd	forest	Fraxino-Aceretum pseudoplatani	G1.A43	48	48	0,91	20	20	0,76
	plane	no	6,0	L	forest	Galio odorati-Fagetum, Carex brizoides-Subass.	G1.63	50	46	0,77	21	19	0,40
	slope	shade	6,0	L	forest	Galio odorati-Fagetum, Carex brizoides-Subass.	G1.63	50	46	0,77	21	19	0,40
	plane	no	6,1	B Jc	forest	Impatienti-Fagetum	G1.65	44	43	0,76	17	17	0,55
	slope	shade	6,1	G	forest	Adoxo-Aceretum	G1.7C3	57	55	1,12	18	18	0,48
	plane	no	6,6	L	forest	Fraxino-Ulmetum	G1.221	62	61	1,25	17	16	0,59
	plane	no	6,6	B Be C	forest	Remotae-Melico-Fagetum sylvaticae	G1.63	45	43	0,75	19	18	0,47
	slope	sunny	6,6	B Be C	forest	Remotae-Melico-Fagetum sylvaticae	G1.63	45	43	0,75	19	18	0,47
	plane	no	6,7	Dg	forest	Centro-Molinio-Quercetum roboris	G1.42	33	29	0,48	29	25	0,49
	plane	no	6,9	G	forest	Stellario-Alnetum	G1.52	48	48	0,88	21	21	0,71
	plane	no	6,9	Bg	forest	Anemono-Lysimachio-Quercetum roboris	G1.42	32	30	0,50	25	24	0,54
	plane	no	7,3	Pg	forest	Centro-Pleurozio-Betuletum pubescentis	G3.E2	19	18	0,29	32	30	0,24
	plane	no	7,4	J G L	forest	Centro-Filipendulo-Fraxinetum	G1.213	52	50	0,81	17	16	0,37
	plane	no	7,5	G	forest	Carici remotae-Fraxinetum	G1.213	60	59	1,26	20	20	0,35
	plane	no	7,7	J	forest	Athyrio-Alnetum glutinosae	G1.52	34	33	0,45	24	23	1,00
	plane	no	8,2	Pg	forest	Majanthemo-Sphagno-Betuletum pubescentis	G1.51	19	18	0,28	32	30	0,23
	plane	no	8,4	Od	forest	Recurvi-Eriophoro-Betuletum pubescentis	G1.51	18	17	0,18	33	31	0,72
	plane	no	8,6	Oe	forest	Carici elongatae-Alnetum betulosum	G1.52	28	27	0,31	26	25	0,51
	plane	no	8,6	G	forest	Symphyto-Irido-Alnetum glutinosae	G1.52	42	39	0,63	20	18	0,85

altitude/ climate zone	Relief	Expo-sition	Hydro-mor-phy*	soil type **	Using	plant community	EUNIS Code	BS Opti-mum	BS Crit	Bc/Al	CN Opti-mum	CN Crit	f imm
	slope	sunny	2,1	P Rd	meadow	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,39	32	31	1,00
colline-sub-oceanic	plane	no	2,2	Bc	meadow	Alysso alyssoidis-Sedetum albi	E1.27	64	61	1,22	23	22	0,22
	slope	sunny	2,2	Bc	meadow	Alysso alyssoidis-Sedetum albi	E1.27	64	61	1,22	23	22	0,22
	plane	no	2,3	Bd Be	meadow	Diantho gratianopolitani-Festucetum pallentis	E1.29	53	52	1,04	26	26	0,47
	slope	sunny	2,3	Bd Be	meadow	Diantho gratianopolitani-Festucetum pallentis	E1.29	53	52	1,04	26	26	0,47
	plane	no	2,5	Ch	meadow	Gageo saxatilis-Veronicetum dillenii	E1.26	53	52	0,90	26	26	1,00
	slope	shade	2,5	Ch	meadow	Gageo saxatilis-Veronicetum dillenii	E1.26	53	52	0,90	26	26	1,00
	slope	sunny	2,5	Ch	meadow	Gageo saxatilis-Veronicetum dillenii	E1.26	53	52	0,90	26	26	1,00
	plane	no	2,5	P Rd	meadow	Ornithopodo-Corynephoretum canescentis	E1.93	37	34	0,61	31	29	0,31
	plane	no	2,6	Bd Ql	meadow	Thymo-Festucetum ovinae	E1.72	43	37	0,65	26	22	0,18
	slope	shade	2,6	Bd Ql	meadow	Thymo-Festucetum ovinae	E1.72	43	37	0,65	26	22	0,18
	slope	sunny	2,6	Bd Ql	meadow	Thymo-Festucetum ovinae	E1.72	43	37	0,65	26	22	0,18
	plane	no	2,6	De Rd	meadow	Festuco-Koelerietum glaucae	E1.72	44	39	0,61	29	26	1,00
	slope	shade	2,6	De Rd	meadow	Festuco-Koelerietum glaucae	E1.72	44	39	0,61	29	26	1,00
	plane	no	2,7	Bv De Lg	meadow	Thymo-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,01
	slope	sunny	2,7	Bv De Lg	meadow	Thymo-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,01
	slope	shade	4,5	H L	meadow	Alchemillo-Arrhenatheretum, Salvia pratensis-Subass.	E2.22	67	62	1,22	20	18	0,46
	slope	sunny	4,5	H L	meadow	Alchemillo-Arrhenatheretum, Salvia pratensis-Subass.	E2.22	67	62	1,22	20	18	0,46
	plane	no	4,6	Bd D De	meadow	Festucetum rubrae (typ. Subass.)	E1.72	31	29	0,43	26	24	0,54
	slope	shade	4,6	Bd D De	meadow	Festucetum rubrae (typ. Subass.)	E1.72	31	29	0,43	26	24	0,54
	slope	sunny	4,6	Bd D De	meadow	Festucetum rubrae (typ. Subass.)	E1.72	31	29	0,43	26	24	0,54
	plane	no	4,6	Bg L	meadow	Alchemillo-Arrhenatheretum, typ. Subass.	E2.22	68	60	1,41	20	17	0,88
	slope	shade	4,6	Bg L	meadow	Alchemillo-Arrhenatheretum, typ. Subass.	E2.22	68	60	1,41	20	17	0,88
	slope	sunny	4,6	Bg L	meadow	Alchemillo-Arrhenatheretum, typ. Subass.	E2.22	68	60	1,41	20	17	0,88
	plane	no	5,1	Rc	meadow	Onobrychido-Brometum erecti	E1.26	78	78	2,29	24	24	0,09
	slope	sunny	5,1	Rc	meadow	Onobrychido-Brometum erecti	E1.26	78	78	2,29	24	24	0,09
	slope	shade	5,1	Rc	meadow	Polygalo amarae-Seslerietum variae	E1.26	78	77	2,26	24	24	0,09
	plane	no	5,1	L	meadow	Galio-Alopecuretum pratensi	E3.41	71	70	1,73	18	17	0,52
	plane	no	5,2	Bd	meadow	Festucetum rubrae (Succisa-Subass.)	E1.72	33	30	0,47	27	25	0,51
	plane	no	5,2	B Q	meadow	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	slope	shade	5,2	B Q	meadow	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	slope	sunny	5,2	B Q	meadow	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	plane	no	6,8	Ch J	meadow	Stachyo-Molinietum coeruleae	D4.13	60	58	1,08	27	26	1,00
	plane	no	6,9	Dg Pg	meadow	Loto-Brometum racemosae	E2.22	47	44	0,83	21	19	0,80
	plane	no	6,9	C G	meadow	Ranunculo-Deschampsietum caespitosae	E3.44	71	70	1,86	18	17	0,51
	plane	no	7,3	G L	meadow	Polygono-Cirsietum oleracei	E2.22	52	48	0,88	19	18	0,86
	plane	no	7,3	Bd Od	meadow	Junco-Molinietum	E3.51	34	32	0,51	27	26	0,46
	plane	no	7,9	G Od Pg	meadow	Sphagno-Caricetum lasiocarpae	D2.31	25	25	0,35	30	30	1,00
	plane	no	8,2	J	meadow	Caricetum vulpinae	D4.1G	73	70	1,66	16	16	0,44
	plane	no	8,3	De G	meadow	Phalaridetum arundinacae	E3.44	75	71	1,78	14	14	0,75
	plane	no	8,5	G Oe	meadow	Junco-Caricetum fuscae	D2.22	37	34	0,53	28	26	0,44
	plane	no	8,6	G	meadow	Caricetum gracilis	D5.21	60	55	1,10	20	18	0,84
	plane	no	8,6	Cg L	meadow	Crepido-Juncetum subnudolosi	D4.1H	75	72	1,77	22	21	1,00
	plane	no	8,7	Od Pg	meadow	Caricetum diandrae	D2.32	42	39	0,50	21	20	0,00
	plane	no	8,9	Oe Bg G	meadow	Caricetum elatae (Comaro-Subass.)	D5.21	45	42	0,56	25	24	0,57
	slope	sunny	2,1	P Rd	pasture	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,39	32	31	1,00
	plane	no	2,2	Bc	pasture	Alysso alyssoidis-Sedetum albi	E1.27	64	61	1,22	23	22	0,22
	slope	sunny	2,2	Bc	pasture	Alysso alyssoidis-Sedetum albi	E1.27	64	61	1,22	23	22	0,22
	plane	no	2,3	Bd Be	pasture	Diantho gratianopolitani-Festucetum pallentis	E1.29	53	52	1,04	26	26	0,47
	slope	sunny	2,3	Bd Be	pasture	Diantho gratianopolitani-Festucetum pallentis	E1.29	53	52	1,04	26	26	0,47
	plane	no	2,5	Ch	pasture	Gageo saxatilis-Veronicetum dillenii	E1.26	53	52	0,91	26	26	1,00
	slope	shade	2,5	Ch	pasture	Gageo saxatilis-Veronicetum dillenii	E1.26	53	52	0,91	26	26	1,00
	slope	sunny	2,5	Ch	pasture	Gageo saxatilis-Veronicetum dillenii	E1.26	53	52	0,91	26	26	1,00
	plane	no	2,5	P Rd	pasture	Ornithopodo-Corynephoretum canescentis	E1.93	37	34	0,61	31	29	0,31
	plane	no	2,6	De Rd	pasture	Festuco-Koelerietum glaucae	E1.72	44	39	0,62	29	26	1,00
	slope	shade	2,6	De Rd	pasture	Festuco-Koelerietum glaucae	E1.72	44	39	0,62	29	26	1,00
	plane	no	2,7	Bv De	pasture	Thymo-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,01
	slope	sunny	2,7	Bv De	pasture	Thymo-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,01

altitude/ climate zone	Relief	Expo-sition	Hydro-mor-phy*	soil type **	Using	plant community	EUNIS Code	BS Opti-mum	BS Crit	Bc/Al	CN Opti-mum	CN Crit	f imm
	plane	no	2,8	P Q Rd	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,39	32	27	0,39
	slope	shade	2,8	P Q Rd	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,39	32	27	0,39
colline-sub-oceanic	plane	no	3,1	Rc	pasture	Gentiano-Koelerietum pyramidatae	E1.26	72	71	1,70	23	22	0,20
	slope	sunny	3,1	Rc	pasture	Gentiano-Koelerietum pyramidatae	E1.26	72	71	1,70	23	22	0,20
	plane	no	3,2	Bd Ql Rd	pasture	Genisto anglicae-Callunetum vulgaris	F4.22	28	26	0,39	29	27	0,42
	slope	sunny	3,2	Bd Ql Rd	pasture	Genisto anglicae-Callunetum vulgaris	F4.22	28	26	0,39	29	27	0,42
	plane	no	4,2	Cl H L	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,86	22	19	0,37
	slope	shade	4,2	Cl H L	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,86	22	19	0,37
	slope	sunny	4,2	Cl H L	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,86	22	19	0,37
	plane	no	4,7	B	pasture	Plantagini-Lolietum perennis	E2.11	58	53	1,06	14	13	0,81
	slope	shade	4,7	B	pasture	Plantagini-Lolietum perennis	E2.11	58	53	1,06	14	13	0,81
	plane	no	4,8	Bd D De	pasture	Festuco-Cynosuretum	E2.11	33	30	0,47	22	20	0,73
	slope	shade	4,8	Bd D De	pasture	Festuco-Cynosuretum	E2.11	33	30	0,47	22	20	0,73
	slope	sunny	4,8	Bd D De	pasture	Festuco-Cynosuretum	E2.11	33	30	0,47	22	20	0,73
	plane	no	4,9	Bg	pasture	Lolio-Cynosuretum cristati (typ.-Subass.)	E2.11	55	45	0,89	21	17	0,91
	slope	shade	4,9	Bg	pasture	Lolio-Cynosuretum cristati (typ.-Subass.)	E2.11	55	45	0,89	21	17	0,91
	plane	no	5,1	Rc	pasture	Onobrychido-Brometum erecti	E1.26	78	78	2,23	24	24	0,09
	slope	sunny	5,1	Rc	pasture	Onobrychido-Brometum erecti	E1.26	78	78	2,23	24	24	0,09
	slope	shade	5,1	Rc	pasture	Polygalo amarae-Seslerietum variae	E1.26	78	77	2,21	24	24	0,09
	plane	no	5,1	L	pasture	Galio-Alopecuretum pratensi	E3.41	71	70	1,72	18	17	0,52
	slope	shade	5,1	L	pasture	Galio-Alopecuretum pratensi	E3.41	71	70	1,72	18	17	0,52
	plane	no	5,2	B Q	pasture	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	slope	shade	5,2	B Q	pasture	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	slope	sunny	5,2	B Q	pasture	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	plane	no	6,5	G	pasture	Potentilletum anserinae	E1.65	57	53	1,00	13	12	0,00
	plane	no	6,5	C G	pasture	Juncetum compressi	E1.65	63	59	1,32	13	12	0,84
	plane	no	6,7	G	pasture	Festucetum arundinaceae	E3.44	61	57	1,18	13	12	0,00
	plane	no	6,8	Ch J	pasture	Parnassio-Molinietum coeruleae	E3.51	60	59	1,12	32	31	1,00
	plane	no	6,9	L	pasture	Alopecuretum geniculati	E3.44	64	59	1,17	17	15	0,65
	plane	no	6,9	Dg Pg	pasture	Genisto-Juncetum squarrosi	E1.71	29	27	0,43	27	25	0,50
	plane	no	7,0	Bd Dg Od Pg	pasture	Nardo-Juncetum squarrosi	E3.52	29	28	0,41	29	27	0,39
	plane	no	7,7	De G	pasture	Potentilla rep.-Inula britannica-Gesellschaft	E1.65	62	55	1,04	17	15	0,65
	plane	no	7,9	G Od Pg	pasture	Sphagno-Caricetum lasiocarpae	D2.31	25	25	0,35	30	30	1,00
	plane	no	8,2	J	pasture	Caricetum vulpinae	D4.1G	73	70	1,70	16	16	0,44
	plane	no	8,5	G Oe	pasture	Junco-Caricetum fuscae	D2.22	37	34	0,52	28	26	0,44
	plane	no	8,7	Od Pg	pasture	Caricetum diandrae	D2.32	42	39	0,50	21	20	0,00
	plane	no	8,9	Oe	pasture	Caricetum elatae (Comaro-Subass.)	D5.21	45	42	0,56	25	24	0,57
colline-sub-continental	slope	sunny	2,8	P	forest	Cytiso-Quercetum	G4.71	26	25	0,41	27	26	0,45
	slope	sunny	3,1	Bd	forest	Agrostio-Peucedano-Quercetum	G1.87	32	29	0,44	26	24	0,56
	plane	no	3,3	P	forest	Luzulo-Quercetum	G4.71	27	26	0,43	27	26	0,46
	slope	shade	3,3	P	forest	Luzulo-Quercetum	G4.71	27	26	0,43	27	26	0,46
	plane	no	3,8	Bd	forest	Vaccinio vitis-ideae-Quercetum	G1.42	24	23	0,34	34	33	0,10
	slope	shade	3,8	Bd	forest	Vaccinio vitis-ideae-Quercetum	G1.42	24	23	0,34	34	33	0,10
	slope	sunny	4,2	B Ql	forest	Deschampsio-Potentillo-Quercetum petreae-roboris	G4.71	35	33	0,51	25	23	0,13
	plane	no	4,4	L	forest	Galio-Carpinetum, Sorbus torminalis-Subass.	G1.A16	56	55	1,02	21	20	0,32
	slope	shade	4,4	L	forest	Galio-Carpinetum, Sorbus torminalis-Subass.	G1.A16	56	55	1,02	21	20	0,32
	slope	sunny	4,4	Bc L	forest	Primulo-Merculiari-Carpinetum	G1.A16	60	59	1,10	18	17	0,52
	plane	no	4,5	Bc Bv L	forest	Centro-Merculiari-Carpinetum	G1.A16	54	49	0,79	18	16	0,59
	slope	shade	4,7	Bc Be L	forest	Corydalido-Carpino-Ulmetum carpinifoliae	G1.A61	61	59	1,12	17	16	0,59
	plane	no	4,8	L	forest	Galio-Carpinetum	G1.A16	54	54	1,00	20	20	0,34
	slope	shade	4,8	L	forest	Galio-Carpinetum	G1.A16	54	54	1,00	20	20	0,34
	plane	no	5,1	Rd	forest	Myrtillo-Vaccinio-Pinetum sylvaticae	G4.31	25	22	0,35	32	28	0,60
	slope	shade	5,1	Rd	forest	Myrtillo-Vaccinio-Pinetum sylvaticae	G4.31	25	22	0,35	32	28	0,60
	slope	sunny	5,1	Rd	forest	Myrtillo-Vaccinio-Pinetum sylvaticae	G4.31	25	22	0,35	32	28	0,60
	plane	no	5,4	De	forest	Holco mollis-Quercetum	G4.71	32	31	0,44	25	24	0,07

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	slope	shade	5,4	De	forest	Holco mollis-Quercetum	G4.71	32	31	0,44	25	24	0,07
	slope	sunny	5,4	De	forest	Holco mollis-Quercetum	G4.71	32	31	0,44	25	24	0,07
	plane	no	5,6	Bg	forest	Carici brizoides-Carpinetum	G1.A16	55	52	1,10	20	19	0,82
	plane	no	5,8	De	forest	Stachyo-Carpinetum	G1.A16	55	53	0,98	18	17	0,54
	slope	shade	5,8	De	forest	Stachyo-Carpinetum	G1.A16	55	53	0,98	18	17	0,54
	slope	sunny	5,8	De	forest	Stachyo-Carpinetum	G1.A16	55	53	0,98	18	17	0,54
colline-sub-continental	slope	shade	5,9	Ch Cl H L	forest	Centro-Carpino-Ulmetum carpinifoliae	G1.A61	61	59	1,13	17	16	0,59
	plane	no	6,0	Bd	forest	Selino-Quercetum	G4.71	58	58	1,25	22	22	0,64
	slope	shade	6,0	Bd	forest	Selino-Quercetum	G4.71	58	58	1,25	22	22	0,64
	slope	shade	6,1	G	forest	Adoxo-Aceretum	G1.7C3	57	55	1,12	18	18	0,48
	plane	no	6,6	L	forest	Fraxino-Ulmetum	G1.221	62	61	1,25	17	16	0,59
	plane	no	6,7	Dg	forest	Centro-Molinio-Quercetum roboris	G1.42	33	29	0,48	29	25	0,49
	plane	no	6,9	G	forest	Stellario-Alnetum	G1.52	48	48	0,88	21	21	0,71
	plane	no	7,3	Pg	forest	Centro-Pleurozio-Betuletum pubescentis	G3.E2	19	18	0,29	32	30	0,24
	plane	no	7,4	J	forest	Centro-Filipendulo-Fraxinetum	G1.213	52	50	0,81	17	16	0,37
	plane	no	7,5	G L	forest	Centro-Filipendulo-Alnetum	G1.213	43	40	0,67	19	18	0,87
	plane	no	7,5	G	forest	Carici remotae-Fraxinetum	G1.213	60	59	1,26	20	20	0,35
	plane	no	7,7	J	forest	Athyrio-Alnetum glutinosae	G1.52	34	33	0,45	24	23	1,00
	plane	no	8,2	Pg	forest	Majanthemo-Sphagno-Betuletum pubescentis	G1.51	19	18	0,28	32	30	0,23
	plane	no	8,4	Od	forest	Recurvi-Eriophoro-Betuletum pubescentis	G1.51	18	17	0,18	33	31	0,72
	plane	no	8,6	Oe	forest	Carici elongatae-Alnetum betulosum	G1.52	28	27	0,31	26	25	0,51
	plane	no	8,6	G	forest	Symphyto-Irido-Alnetum glutinosae	G1.52	42	39	0,63	20	18	0,85
	slope	sunny	2,1	P Rd	meadow	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,39	32	31	1,00
	slope	sunny	2,2	P Rd	meadow	Festuco-Sperguletum vernalis	E1.94	27	25	0,40	32	30	1,00
	plane	no	2,6	Bd Be	meadow	Thymo-Festucetum cinerae	E1.29	53	50	0,96	26	24	0,54
	slope	sunny	2,6	Bd Be	meadow	Thymo-Festucetum cinerae	E1.29	53	50	0,96	26	24	0,54
	plane	no	2,6	Bc	meadow	Alysso-Festucetum cinerae	E1.29	64	61	1,22	24	23	0,16
	slope	sunny	2,6	Bc	meadow	Alysso-Festucetum cinerae	E1.29	64	61	1,22	24	23	0,16
	plane	no	2,6	De Rd	meadow	Festuco-Koelerietum glaucae	E1.72	44	39	0,61	29	26	1,00
	slope	shade	2,6	De Rd	meadow	Festuco-Koelerietum glaucae	E1.72	44	39	0,61	29	26	1,00
	plane	no	2,6	P Q Rd	meadow	Veronico-Corynephoretum canescentis	E1.93	33	31	0,54	31	29	0,31
	plane	no	2,7	Bd Ql	meadow	Armerio-Festucetum ovinae	E1.72	42	41	0,74	30	29	1,00
	slope	shade	2,7	Bd Ql	meadow	Armerio-Festucetum ovinae	E1.72	42	41	0,74	30	29	1,00
	slope	sunny	2,7	Bd Ql	meadow	Armerio-Festucetum ovinae	E1.72	42	41	0,74	30	29	1,00
	plane	no	2,7	Bv De Lg	meadow	Armerio-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,00
	slope	sunny	2,7	Bv De Lg	meadow	Armerio-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,00
	plane	no	2,9	Ch Rc	meadow	Festuco rupiculae-Brachypodietum pinnati	E1.23	72	70	1,64	22	21	0,25
	slope	shade	2,9	Ch Rc	meadow	Festuco rupiculae-Brachypodietum pinnati	E1.23	72	70	1,64	22	21	0,25
	plane	no	3,1	Ch Rc	meadow	Festuco valesiacea-Stipetum capillatae	E1.22	71	70	1,63	24	24	0,09
	slope	shade	3,1	Ch Rc	meadow	Festuco valesiacea-Stipetum capillatae	E1.22	71	70	1,63	24	24	0,09
	slope	sunny	3,1	Ch Rc	meadow	Festuco valesiacea-Stipetum capillatae	E1.22	71	70	1,63	24	24	0,09
	slope	shade	4,6	H L	meadow	Dauco-Arrhenatheretum, Salvia pratensis-Subass.	E2.23	61	60	1,16	20	19	0,39
	slope	sunny	4,6	H L	meadow	Dauco-Arrhenatheretum, Salvia pratensis-Subass.	E2.23	61	60	1,16	20	19	0,39
	plane	no	4,6	Bd D De	meadow	Festucetum rubrae (typ. Subass.)	E1.72	31	29	0,43	26	24	0,54
	slope	shade	4,6	Bd D De	meadow	Festucetum rubrae (typ. Subass.)	E1.72	31	29	0,43	26	24	0,54
	slope	sunny	4,6	Bd D De	meadow	Festucetum rubrae (typ. Subass.)	E1.72	31	29	0,43	26	24	0,54
	plane	no	4,6	Bg Cl L	meadow	Dauco-Arrhenatheretum, typ. Subass.	E2.23	61	60	1,43	21	21	0,70
	slope	shade	4,6	Bg Cl L	meadow	Dauco-Arrhenatheretum, typ. Subass.	E2.23	61	60	1,43	21	21	0,70
	slope	sunny	4,6	Bg Cl L	meadow	Dauco-Arrhenatheretum, typ. Subass.	E2.23	61	60	1,43	21	21	0,70
	plane	no	5,0	L	meadow	Filipendulo-Alopecuretum pratensis	E3.43	65	59	1,18	22	20	0,36
	plane	no	5,2	Bd	meadow	Festucetum rubrae (Succisa-Subass.)	E1.72	33	30	0,47	27	25	0,51
	plane	no	5,2	B Q	meadow	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	slope	shade	5,2	B Q	meadow	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	slope	sunny	5,2	B Q	meadow	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	plane	no	6,7	C G	meadow	Cnidio-Deschampsietum caespitosae	E3.44	72	70	1,87	16	15	0,66
	plane	no	6,8	Bd Od	meadow	Violo-Molinietum	E3.51	34	32	0,50	29	27	0,38

altitude/ climate zone	Relief	Expo-sition	Hydro-mor-phy*	soil type **	Using	plant community	EUNIS Code	BS Opti-mum	BS Crit	Bc/Al	CN Opti-mum	CN Crit	f imm
	plane	no	6,9	Ch J	meadow	Diantho-Molinietum coeruleae	D4.13	62	59	1,13	27	26	1,00
	plane	no	7,0	Dg Pg	meadow	Loto-Holcetum lanati	E2.23	48	44	0,84	20	18	0,83
	plane	no	7,2	G L	meadow	Thalictro-Cirsietum oleracei	E2.23	59	55	1,11	19	18	0,84
	plane	no	7,9	G Od Pg	meadow	Sphagno-Caricetum lasiocarpae	D2.31	25	25	0,35	30	30	1,00
	plane	no	8,2	J	meadow	Caricetum vulpinae	D4.1G	73	70	1,66	16	16	0,44
	plane	no	8,3	De G	meadow	Phalaridetum arundinacae	E3.44	75	71	1,78	14	14	0,75
colline-sub-continental	plane	no	8,5	G Oe	meadow	Junco-Caricetum fuscae	D2.22	37	34	0,53	28	26	0,44
	plane	no	8,6	G	meadow	Caricetum gracilis	D5.21	60	55	1,10	20	18	0,84
	plane	no	8,6	Cg L	meadow	Crepido-Juncetum subnudolosi	D4.1H	75	72	1,77	22	21	1,00
	plane	no	8,9	Oe	meadow	Caricetum elatae (Comaro-Subass.)	D5.21	45	42	0,56	25	24	0,57
	plane	no	8,9	Bg G	meadow	Caricetum elatae (typ. Subass.)	D5.21	45	43	0,79	23	21	0,69
	slope	sunny	2,1	P Rd	pasture	Teesdalio-Sperguletum vernalis	E1.94	26	25	0,39	32	31	1,00
	slope	sunny	2,2	P Rd	pasture	Festuco-Sperguletum vernalis	E1.94	27	25	0,40	32	30	1,00
	plane	no	2,6	Bd Be	pasture	Thymo-Festucetum cinerae	E1.29	53	50	0,96	26	24	0,54
	slope	sunny	2,6	Bd Be	pasture	Thymo-Festucetum cinerae	E1.29	53	50	0,96	26	24	0,54
	plane	no	2,6	Bc	pasture	Alysso-Festucetum cinerae	E1.29	64	61	1,22	24	23	0,16
	slope	sunny	2,6	Bc	pasture	Alysso-Festucetum cinerae	E1.29	64	61	1,22	24	23	0,16
	plane	no	2,6	De Rd	pasture	Festuco-Koelerietum glaucae	E1.72	44	39	0,62	29	26	1,00
	slope	shade	2,6	De Rd	pasture	Festuco-Koelerietum glaucae	E1.72	44	39	0,62	29	26	1,00
	plane	no	2,6	P Q Rd	pasture	Veronico-Corynephoretum canescentis	E1.93	33	31	0,54	31	29	0,31
	plane	no	2,7	Bv De	pasture	Armerio-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,00
	slope	sunny	2,7	Bv De	pasture	Armerio-Festucetum trachyphyllae	E1.29	57	55	0,91	26	25	0,00
	plane	no	2,8	P Q Rd	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,39	32	27	0,39
	slope	shade	2,8	P Q Rd	pasture	Cladonio-Callunetum vulgaris	F4.262	28	24	0,39	32	27	0,39
	plane	no	2,9	Ch Rc	pasture	Festuco rupiculae-Brachypodietum pinnati	E1.23	72	70	1,65	22	21	0,25
	slope	shade	2,9	Ch Rc	pasture	Festuco rupiculae-Brachypodietum pinnati	E1.23	72	70	1,65	22	21	0,25
	plane	no	3,1	Ch Rc	pasture	Festuco valesiacea-Stipetum capillatae	E1.22	71	70	1,65	24	24	0,09
	slope	shade	3,1	Ch Rc	pasture	Festuco valesiacea-Stipetum capillatae	E1.22	71	70	1,65	24	24	0,09
	slope	sunny	3,1	Ch Rc	pasture	Festuco valesiacea-Stipetum capillatae	E1.22	71	70	1,65	24	24	0,09
	plane	no	3,2	Bd Ql Rd	pasture	Genisto germanicae-Callunetum vulgaris	F4.22	30	28	0,41	28	26	0,47
	slope	sunny	3,2	Bd Ql Rd	pasture	Genisto germanicae-Callunetum vulgaris	F4.22	30	28	0,41	28	26	0,47
	plane	no	4,2	Cl H L	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,86	22	19	0,37
	slope	shade	4,2	Cl H	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,86	22	19	0,37
	slope	shade	4,2	L	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,72	22	19	0,37
	slope	shade	4,2	Cl H	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,75	22	19	0,37
	slope	sunny	4,2	Cl H	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,86	22	19	0,37
	slope	sunny	4,2	L	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,72	22	19	0,37
	slope	sunny	4,2	Cl H	pasture	Lolio-Cynosuretum cristati (Ranunculus bulbosus-Subass.)	E2.11	51	45	0,75	22	19	0,37
	plane	no	4,7	B	pasture	Plantagini-Lolietum perennis	E2.11	58	53	1,06	14	13	0,81
	slope	shade	4,7	B	pasture	Plantagini-Lolietum perennis	E2.11	58	53	1,06	14	13	0,81
	plane	no	4,8	Bd D De	pasture	Festuco-Cynosuretum	E2.11	33	30	0,47	22	20	0,73
	slope	shade	4,8	Bd D De	pasture	Festuco-Cynosuretum	E2.11	33	30	0,47	22	20	0,73
	slope	sunny	4,8	Bd D De	pasture	Festuco-Cynosuretum	E2.11	33	30	0,47	22	20	0,73
	plane	no	4,9	Bg	pasture	Lolio-Cynosuretum cristati (typ.-Subass.)	E2.11	55	45	0,89	21	17	0,91
	slope	shade	4,9	Bg	pasture	Lolio-Cynosuretum cristati (typ.-Subass.)	E2.11	55	45	0,89	21	17	0,91
	plane	no	5,0	L	pasture	Filipendulo-Alopecuretum pratensis	E3.43	65	59	1,17	22	20	0,36
	slope	shade	5,0	L	pasture	Filipendulo-Alopecuretum pratensis	E3.43	65	59	1,17	22	20	0,36
	plane	no	5,2	B Q	pasture	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	slope	shade	5,2	B Q	pasture	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	slope	sunny	5,2	B Q	pasture	Polygalo-Nardetum strictae	E1.71	38	37	0,63	31	31	0,20
	plane	no	6,5	C G	pasture	Juncetum compressi	E1.65	63	59	1,32	13	12	0,84
	plane	no	6,7	G	pasture	Festucetum arundinaceae	E3.44	61	57	1,18	13	12	0,00
	plane	no	6,8	Ch J	pasture	Parnassio-Molinietum coeruleae	E3.51	60	59	1,12	32	31	1,00
	plane	no	6,9	L	pasture	Alopecuretum geniculati	E3.44	64	59	1,17	17	15	0,65

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	plane	no	7,0	Bd Dg Od Pg	pasture	Carici-Nardetum strictae	E1.71	30	27	0,40	28	25	0,51
	slope	shade	7,7	De G	pasture	Potentilla rep.-Inula britannica-Gesellschaft	E1.65	62	55	1,04	17	15	0,65
	plane	no	7,9	G Od Pg	pasture	Sphagno-Caricetum lasiocarpae	D2.31	25	25	0,35	30	30	1,00
	plane	no	8,5	G Oe	pasture	Junco-Caricetum fuscae	D2.22	37	34	0,52	28	26	0,44
	plane	no	8,7	Od Pg	pasture	Caricetum diandrae	D2.32	42	39	0,50	21	20	0,00
	plane	no	8,9	Oe	pasture	Caricetum elatae (Comaro-Subass.)	D5.21	45	42	0,56	25	24	0,57
montane	plane	no	3,6	B	forest	Abieti-Pinetum hercyniae	G3.13	27	26	0,39	30	29	0,32
	slope	shade	3,6	B	forest	Abieti-Pinetum hercyniae	G3.13	27	26	0,39	30	29	0,32
	slope	sunny	3,6	B	forest	Abieti-Pinetum hercyniae	G3.13	27	26	0,39	30	29	0,32
	slope	shade	4,0	B Be	forest	Cynancho-Tilietum platyphyllis	G1.A45	58	55	1,13	18	17	0,51
	plane	no	4,4	Bd	forest	Calamagrostio villosae-Piceetum	G3.1C	33	32	0,51	26	26	0,47
	slope	shade	4,4	Bd	forest	Calamagrostio villosae-Piceetum	G3.1C	33	32	0,51	26	26	0,47
	slope	sunny	4,6	P	forest	Vaccinio myrtilli-Piceetum	G3.1C	34	32	0,57	27	25	0,50
	plane	no	5,0	Bd	forest	Calamagrostio villosae-Fagetum	G1.65	39	38	0,63	25	24	0,55
	slope	shade	5,0	Bd	forest	Calamagrostio villosae-Fagetum	G1.65	39	38	0,63	25	24	0,55
	slope	sunny	5,0	Bd	forest	Calamagrostio villosae-Fagetum	G1.65	39	38	0,63	25	24	0,55
	plane	no	5,5	Bc	forest	Melico-Mercuriali-Fagetum sylvaticae	G1.66	52	49	0,81	18	17	0,55
	slope	sunny	5,5	Bc	forest	Melico-Mercuriali-Fagetum sylvaticae	G1.66	52	49	0,81	18	17	0,55
	slope	shade	5,6	Bd	forest	Fraxino-Aceretum pseudoplatani	G1.A43	48	48	0,91	20	20	0,76
	plane	no	5,7	B	forest	Dentario bulbiferae-Fagetum	G1.65	55	51	1,01	19	18	0,46
	slope	sunny	5,7	B	forest	Dentario bulbiferae-Fagetum	G1.65	55	51	1,01	19	18	0,46
	plane	no	5,8	Dg	forest	Calamagrostio villosae-Piceetum, Deschampsia caespitosa-Subass.	G3.1C	35	34	0,59	27	27	0,41
	plane	no	6,6	B	forest	Arici-Fagetum	G1.65	45	45	0,81	20	20	0,34
	plane	no	6,6	L	forest	Arunco-Alnetum	G1.52	47	46	0,78	21	21	0,28
	plane	no	6,6	Bd	forest	Leucobryo-Pinetum molinietosum	G3.E2	20	19	0,26	35	33	0,08
	plane	no	6,6	B Be C	forest	Remotae-Melico-Fagetum sylvaticae	G1.63	45	43	0,75	19	18	0,47
	slope	sunny	6,6	B Be C	forest	Remotae-Melico-Fagetum sylvaticae	G1.63	45	43	0,75	19	18	0,47
	plane	no	6,8	G	forest	Sphagno-Piceetum	G3.1C	23	23	0,32	34	33	1,00
	plane	no	7,1	Bg G	forest	Calamagrostio villosae-Piceetum, Equisetum sylvaticum-Subass.	G3.1C	34	33	0,56	25	24	0,56
	plane	no	7,5	G	forest	Carici remotae-Fraxinetum, Equisetum-Subass.	G1.213	61	58	1,22	19	18	0,47
	plane	no	7,5	L	forest	Carici remotae-Fraxinetum, Equisetum-Subass.	G1.213	61	58	1,15	19	18	0,47
	plane	no	7,6	G	forest	Salicetum albo-fragilis	G1.111	66	65	1,55	18	18	0,87
	plane	no	8,2	Od	forest	Vaccinio uliginosi-Pinetum rotundatae	G3.E2	19	19	0,21	38	38	0,55
	plane	no	8,2	Pg	forest	Majanthemo-Sphagno-Betuletum pubescentis	G1.51	19	18	0,28	32	30	0,23
	plane	no	8,5	G	forest	Caltha palustris-Alnus glutinosa-Gesellschaft	G1.213	31	31	0,47	23	23	0,61
	plane	no	3,6	B	forest	Abieti-Pinetum hercyniae	G3.13	27	26	0,39	30	29	0,32
	slope	shade	3,6	B	forest	Abieti-Pinetum hercyniae	G3.13	27	26	0,39	30	29	0,32
	slope	sunny	3,6	B	forest	Abieti-Pinetum hercyniae	G3.13	27	26	0,39	30	29	0,32
	slope	shade	4,0	B	forest	Cynancho-Tilietum platyphyllis	G1.A45	58	55	1,13	18	17	0,51
	slope	shade	4,0	Be	forest	Cynancho-Tilietum platyphyllis	G1.A45	58	55	1,11	18	17	0,88
	plane	no	4,4	Bd	forest	Calamagrostio villosae-Piceetum	G3.1C	33	32	0,51	26	26	0,47
	slope	shade	4,4	Bd	forest	Calamagrostio villosae-Piceetum	G3.1C	33	32	0,51	26	26	0,47
	slope	sunny	4,6	P	forest	Vaccinio myrtilli-Piceetum	G3.1C	34	32	0,57	27	25	0,50
	plane	no	5,0	Bd	forest	Calamagrostio villosae-Fagetum	G1.65	39	38	0,63	25	24	0,55
	slope	shade	5,0	Bd	forest	Calamagrostio villosae-Fagetum	G1.65	39	38	0,63	25	24	0,55
	slope	sunny	5,0	Bd	forest	Calamagrostio villosae-Fagetum	G1.65	39	38	0,63	25	24	0,55
	plane	no	5,5	Bc	forest	Melico-Mercuriali-Fagetum sylvaticae	G1.66	52	49	0,81	18	17	0,55
	slope	sunny	5,5	Bc	forest	Melico-Mercuriali-Fagetum sylvaticae	G1.66	52	49	0,81	18	17	0,55
	slope	shade	5,6	Bd	forest	Fraxino-Aceretum pseudoplatani	G1.A43	48	48	0,91	20	20	0,76
	plane	no	5,7	B	forest	Dentario bulbiferae-Fagetum	G1.65	55	51	1,01	19	18	0,46
	slope	sunny	5,7	B	forest	Dentario bulbiferae-Fagetum	G1.65	55	51	1,01	19	18	0,46
	plane	no	5,8	Dg	forest	Calamagrostio villosae-Piceetum, Deschampsia caespitosa-Subass.	G3.1C	35	34	0,59	27	27	0,41
	plane	no	6,6	B	forest	Arici-Fagetum	G1.65	45	45	0,81	20	20	0,34
	plane	no	6,6	L	forest	Arunco-Alnetum	G1.52	47	46	0,78	21	21	0,28
	plane	no	6,6	Bd	forest	Leucobryo-Pinetum molinietosum	G3.E2	20	19	0,26	35	33	0,08
	plane	no	6,6	B	forest	Remotae-Melico-Fagetum sylvaticae	G1.63	45	43	0,75	19	18	0,47
	plane	no	6,6	Be	forest	Remotae-Melico-Fagetum sylvaticae	G1.63	45	43	0,73	19	18	0,47
	plane	no	6,6	C	forest	Remotae-Melico-Fagetum sylvaticae	G1.63	45	43	0,70	19	18	0,47
	slope	sunny	6,6	B	forest	Remotae-Melico-Fagetum sylvaticae	G1.63	45	43	0,75	19	18	0,47
	slope	sunny	6,6	Be	forest	Remotae-Melico-Fagetum sylvaticae	G1.63	45	43	0,73	19	18	0,47
	slope	sunny	6,6	C	forest	Remotae-Melico-Fagetum sylvaticae	G1.63	45	43	0,70	19	18	0,47
	plane	no	6,8	G	forest	Sphagno-Piceetum	G3.1C	23	23	0,32	34	33	1,00

altitude/ climate zone	Relief	Expo-sition	Hydro-mor-phy*	soil type **	Using	plant community	EUNIS Code	BS Opti-mum	BS Crit	Bc/Al	CN Opti-mum	CN Crit	f imm
	plane	no	7,1	Bg	forest	Calamagrostio villosae-Piceetum, Equisetum sylvaticum-Subass.	G3.1C	34	33	0,56	25	24	0,56
	plane	no	7,1	G	forest	Calamagrostio villosae-Piceetum, Equisetum sylvaticum-Subass.	G3.1C	34	33	0,51	25	24	0,08
	plane	no	7,5	G	forest	Carici remotae-Fraxinetum, Equisetum-Subass.	G1.213	61	58	1,22	19	18	0,47
	plane	no	7,5	L	forest	Carici remotae-Fraxinetum, Equisetum-Subass.	G1.213	61	58	1,15	19	18	0,47
	plane	no	7,6	G	forest	Salicetum albo-fragilis	G1.111	66	65	1,55	18	18	0,87
	plane	no	8,2	Od	forest	Vaccinio uliginosi-Pinetum rotundatae	G3.E2	19	19	0,21	38	38	0,55
	plane	no	8,2	Pg	forest	Majanthemo-Sphagno-Betuletum pubescentis	G1.51	19	18	0,28	32	30	0,23
montane-oreal	plane	no	3,6	B	forest	Abieti-Pinetum hercyniae	G3.13	27	26	0,39	30	29	0,32
	slope	sunny	3,6	B	forest	Abieti-Pinetum hercyniae	G3.13	27	26	0,39	30	29	0,32
	plane	no	4,4	Bd	forest	Calamagrostio villosae-Piceetum	G3.1C	33	32	0,51	26	26	0,47
	slope	shade	4,4	Bd	forest	Calamagrostio villosae-Piceetum	G3.1C	33	32	0,51	26	26	0,47
	plane	no	4,6	Bd	forest	Luzulo-Abieto-Fagetum	G1.65	35	34	0,55	27	26	0,46
	slope	sunny	4,6	Bd	forest	Luzulo-Abieto-Fagetum	G1.65	35	34	0,55	27	26	0,46
	slope	sunny	4,6	P	forest	Vaccinio myrtilli-Piceetum	G3.1C	34	32	0,57	27	25	0,50
	slope	sunny	4,7	Bd	forest	Calamagrostio villosae-Piceetum, Sorbus aucuparia-Subass.	G3.1C	32	31	0,47	26	25	0,49
	slope	shade	5,0	Bd	forest	Luzulo-Abieto-Fagetum, Athyrio-Subass.	G1.65	37	36	0,58	26	25	0,49
	plane	no	5,4	Bd	forest	Calamagrostio villosae-Piceetum, Athyrium-Subass.	G3.1C	38	37	0,62	25	24	0,55
	slope	shade	5,4	Bd	forest	Calamagrostio villosae-Piceetum, Athyrium-Subass.	G3.1C	38	37	0,62	25	24	0,55
	slope	shade	5,6	Bd	forest	Fraxino-Aceretum pseudoplatani	G1.A43	48	48	0,91	20	20	0,76
	plane	no	5,7	B	forest	Dentario bulbiferae-Fagetum	G1.65	55	51	1,01	19	18	0,46
	slope	sunny	5,7	B	forest	Dentario bulbiferae-Fagetum	G1.65	55	51	1,01	19	18	0,46
	plane	no	5,8	Dg	forest	Calamagrostio villosae-Piceetum, Deschampsia caespitosa-Subass.	G3.1C	35	34	0,59	27	27	0,41
	plane	no	6,6	B	forest	Arici-Fagetum	G1.65	45	45	0,81	20	20	0,34
	plane	no	6,6	L	forest	Arunco-Alnetum	G1.52	47	46	0,78	21	21	0,28
	plane	no	6,6	Bd	forest	Leucobryo-Pinetum molinietosum	G3.E2	20	19	0,26	35	33	0,08
	plane	no	6,8	G	forest	Sphagno-Piceetum	G3.1C	23	23	0,32	34	33	1,00
	plane	no	7,1	Bg G	forest	Calamagrostio villosae-Piceetum, Equisetum sylvaticum-Subass.	G3.1C	34	33	0,56	25	24	0,56
	plane	no	7,6	G	forest	Salicetum albo-fragilis	G1.111	66	65	1,55	18	18	0,87
	plane	no	8,2	Od	forest	Vaccinio uliginosi-Pinetum rotundatae	G3.E2	19	19	0,21	38	38	0,55
	plane	no	8,2	Pg	forest	Majanthemo-Sphagno-Betuletum pubescentis	G1.51	19	18	0,28	32	30	0,23
	plane	no	8,5	G	forest	Caltha palustris-Alnus glutinosa-Gesellschaft	G1.213	31	31	0,47	23	23	0,61
	slope	shade	1,5	B	meadow	Rhizocarpetum alpicolae	E4.22	14	13	0,18	40	37	1,00
	plane	no	3,6	B	forest	Abieti-Pinetum hercyniae	G3.13	27	26	0,39	30	29	0,32
	slope	sunny	3,6	B	forest	Abieti-Pinetum hercyniae	G3.13	27	26	0,39	30	29	0,32
	plane	no	4,4	Bd	forest	Calamagrostio villosae-Piceetum	G3.1C	33	32	0,51	26	26	0,47
	slope	shade	4,4	Bd	forest	Calamagrostio villosae-Piceetum	G3.1C	33	32	0,51	26	26	0,47
	plane	no	4,6	Bd	forest	Luzulo-Abieto-Fagetum	G1.65	35	34	0,55	27	26	0,46
	slope	sunny	4,6	Bd	forest	Luzulo-Abieto-Fagetum	G1.65	35	34	0,55	27	26	0,46
	slope	sunny	4,6	P	forest	Vaccinio myrtilli-Piceetum	G3.1C	34	32	0,57	27	25	0,50
	slope	sunny	4,7	Bd	forest	Calamagrostio villosae-Piceetum, Sorbus aucuparia-Subass.	G3.1C	32	31	0,47	26	25	0,49
	slope	shade	5,0	Bd	forest	Luzulo-Abieto-Fagetum, Athyrio-Subass.	G1.65	37	36	0,58	26	25	0,49
	plane	no	5,4	Bd	forest	Calamagrostio villosae-Piceetum, Athyrium-Subass.	G3.1C	38	37	0,62	25	24	0,55
	slope	shade	5,4	Bd	forest	Calamagrostio villosae-Piceetum, Athyrium-Subass.	G3.1C	38	37	0,62	25	24	0,55
	slope	shade	5,6	Bd	forest	Fraxino-Aceretum pseudoplatani	G1.A43	48	48	0,91	20	20	0,76
	plane	no	5,7	B	forest	Dentario bulbiferae-Fagetum	G1.65	55	51	1,01	19	18	0,46
	slope	sunny	5,7	B	forest	Dentario bulbiferae-Fagetum	G1.65	55	51	1,01	19	18	0,46
	plane	no	5,8	Dg	forest	Calamagrostio villosae-Piceetum, Deschampsia caespitosa-Subass.	G3.1C	35	34	0,59	27	27	0,41
	plane	no	6,6	B	forest	Arici-Fagetum	G1.65	45	45	0,81	20	20	0,34
	plane	no	6,6	L	forest	Arunco-Alnetum	G1.52	47	46	0,78	21	21	0,28
	plane	no	6,6	Bd	forest	Leucobryo-Pinetum molinietosum	G3.E2	20	19	0,26	35	33	0,08
	plane	no	6,8	G	forest	Sphagno-Piceetum	G3.1C	23	23	0,32	34	33	1,00
	plane	no	7,1	Bg G	forest	Calamagrostio villosae-Piceetum, Equisetum sylvaticum-Subass.	G3.1C	34	33	0,56	25	24	0,56
	plane	no	7,6	G	forest	Salicetum albo-fragilis	G1.111	66	65	1,55	18	18	0,87
	plane	no	8,2	Od	forest	Vaccinio uliginosi-Pinetum rotundatae	G3.E2	19	19	0,21	38	38	0,55
	plane	no	8,2	Pg	forest	Majanthemo-Sphagno-Betuletum pubescentis	G1.51	19	18	0,28	32	30	0,23
	plane	no	8,5	G	forest	Caltha palustris-Alnus glutinosa-Gesellschaft	G1.213	31	31	0,47	23	23	0,61