Zur Homepage der Dissertation

Habitat models for plant functional groups with respect to soil parameters and management

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Ich widme diese Arbeit

meinen Eltern
Christine und Wolfgang Kühner,

meiner Schwester
Sophie Kühner

sowie

Hajo Voß
und
Thomas Schoof.

Ohne Euch hätte ich es nie geschafft!

DAnke ☺ !

The most banal pursuit
known to western educated man
is to try and make a piece of grass
to look like his dining room carpet.

Ted Green (2001)

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CHAPTER 1

GENERAL INTRODUCTION

Introduction

This chapter will give an elaborate overview on disturbances and grasslands as well as on the theoretical point of view about plant functional groups and habitat models. Furthermore, hypotheses and objectives as well as an outline of the presented thesis will be given.

Background

Disturbance ecology

Understanding ecosystems requires an understanding of their disturbance history. According to White & Pickett (1985) 'a disturbance is any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, or the physical environment'. Disturbances are a matter of scale and process, which need to be specified in each case. They are present in all ecosystems, occur over a wide range of temporal and spatial scales (Delcourt *et al.* 1983; White & Pickett 1985) and are continuous across all levels of ecological organisation (White & Pickett 1985). Disturbances have various effects on the affected systems; they may result in open space (e.g. Brokaw 1985; Runkle 1985), create patchiness (White & Pickett 1985; White & Jentsch 2001), can make resources more available (Canham & Marks 1985; White & Jentsch 2001) and influence competition and environment (White & Jentsch 2001).

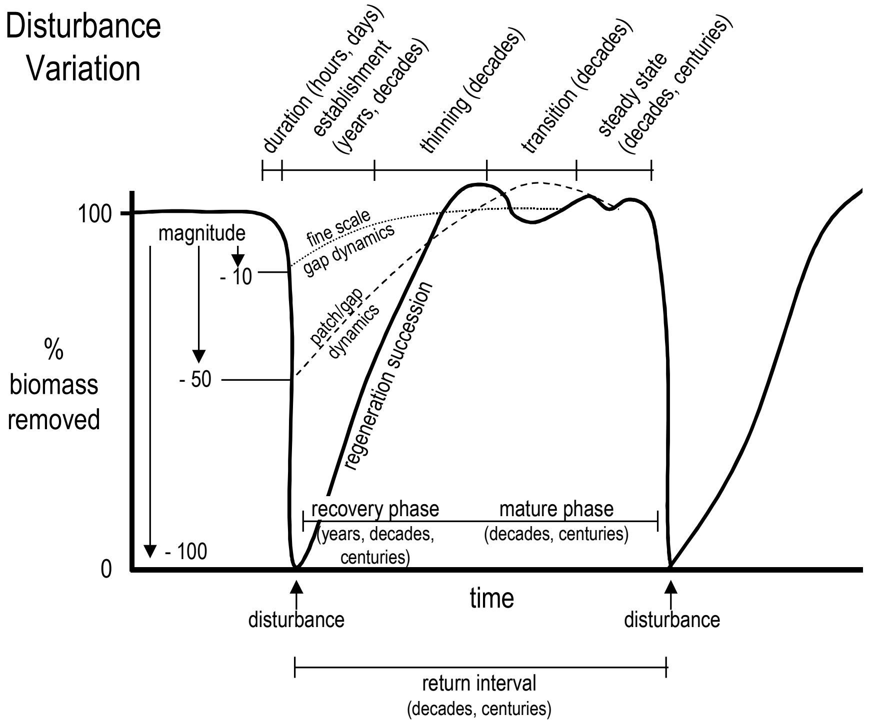

Figure 1.1: Vegetations dynamics have been classified according to the magnitude of the disturbance event (here relative to 100% of pre–disturbance biomass). Fine–scale dynamics occurs after low magnitude disturbance, patch or gap dynamics at moderate magnitudes, and regeneration succession at large magnitudes. (Van der Maarel 1996)

Human–induced disturbances affect biological diversity by directly influencing the disturbance rate and intensity (White & Jentsch 2001). Thereby, eliminating natural disturbances on one hand (e.g. floodings by canalisation of watercourses) allows succession and extends the return interval of disturbance events. On the other hand disturbance events become more frequent, e.g. intensified agricultural use. Land–use intensification or succession lead to a loss of heterogeneity of landscapes and the diversity of species and ecological processes (Kaule 1986; Jedicke 1994).

Disturbance regimes, some applied by humans over centuries, created various landscapes. According to Grebe *et al.* (1999) especially in Europe many endangered species now persist only where traditional land–management practices are being continued. Disrupting or abandoning traditional land–use may threaten the maintainance of biotic diversity and can change the abundances of many species (Tilman 1996; Beierkuhnlein 1998). Therefore, consideration of spatial and temporal dimension, magnitude and frequency of occurrence helps to comprehend the influence of disturbances (White & Jentsch 2001). Frequency is understood as the time interval at which disturbances re–occur. Magnitude includes the intensity or physical force of the disturbance itself and the severity of impacts to the ecosystem (White & Jentsch 2001). According to magnitude vegetation dynamics have been classified (Van der Maarel 1996) (Figure 1.1).

The main focus of the present study are semi–natural grasslands in north–eastern and southern Germany. Natural succession in temperate regions transforms open landscapes like grasslands into shrublands and forests (Lepš 1990; Briemle *et al.* 1991; Ellenberg 1996). Hence, there is evidence, that disturbance is required to maintain the typical species composition for the majority of grasslands. Within the last few decades intensification of grassland utilisation has resulted in a considerable loss of species in flora and fauna. Traditional extensive grazing and mowing were replaced by cheaper and more practical alternative management (disturbance) systems (Poschlod & Schumacher 1998). In the following paragraph I will take a closer look at grasslands and their management strategies.

Grasslands

According to Klapp (1971) the plant community of grasslands is a ‘permanent community’, maintaining an equilibrium by consistent management. It consists of permanent vegetation composed of numerous plant species with relatively dense coverage of grasses and herbs, and is kept open by more or less regular grazing and/or mowing using the biomass as forage or bedding for animals (Briemle *et al.* 1991). Most of the central European grasslands are man–made. Repeated direct and indirect disturbances by humans and their domestic animals caused the disappearance of extended forested areas (Briemle *et al.* 1991). There are only few naturally treeless landscapes such as lakes, swamps, dunes or rocky and alpine areas.

Up to the 18th century, cultivation of grasslands was determined by mowing once a year and grazing in spring (Briemle *et al.* 1991). When keeping of animals in stables was introduced, leading to less grazing, the grasslands were mowed twice a year. With increasing numbers of animals in stables more dung was available and therewith nutrient supply improved. Still, the biological diversity remained very high.

After the second World War technical progress allowed changes in water supply in larger areas. On one hand application of fertilisers increased, especially anorganic nitrogen compounds, and led to an enormous increase in productivity (Poschlod & Schumacher 1998). On the other hand, grasslands were afforested, leading to biotic depletion (Briemle *et al.* 1991).

Nowadays the use of agricultural areas with unfavourable natural conditions and/or situations (e.g. slopes, dry sites, cool low mountain ranges etc.) has become increasingly unprofitable and is often resulting in abandonment of these sites (Poschlod & Schumacher 1998; Poschlod & WallisDeVries 2002). Due to succession these landscapes will naturally be overgrown with shrublands or forest (Lepš 1990; Briemle *et al.* 1991; Ellenberg 1996). However, the time scale and manner are dependend on their 'initial' floristic composition as well as on humidity and nutrient conditions (Schiefer 1981).

Managing (or 'disturbing') grasslands

In central Europe semi–natural extensive grasslands are of high conservation value (Poschlod & Schumacher 1998) due to the fact that these grasslands are often inhabited by a specific flora and fauna. To preserve those diverse open landscapes nature conservation authorities need to manage these habitats. Management is associated with disturbance, as most management practices impose a change in biotic and/or abiotic conditions. In the following different possibilities to maintain grasslands shall be described.

Mowing: Today, annual mowing is the most common form of utilisation for nature conservation to maintain semi–natural open grasslands. Date and frequency of mowing, 'initial' floristic composition, and natural nutrient supply determine the nutrient status and the total diversity of grasslands (Schiefer 1984; Egloff 1986). Mowing removes the above–ground biomass and therewith prevents litter accumulation from dying plant biomass over years. It also is an effective method to reduce soil nutrient content. Nutrient–rich grasslands should be mowed early in the year since most plant species reallocate nutrients and minerals to their underground biomass in autumn (Briemle *et al.* 1991). In contrast, Briemle *et al.* (1991) state that under unfavourable nutrient and water conditions the first cut should take place in the beginning of summer to allow improvement of species diversity. Mowing enhances the availability of resources by the creation of new gaps (Rydgren 2001), but widely conserves a low and closed vegetation cover (Kleyer 1998). It leaves overall site potential unchanged and leads to a static equilibrium not giving consideration to the history of development and utilisation of most areas (cf. Schumacher *et al.* 1995; Poschlod *et al.* 1998). It should be noted that mowing is probably the most expensive option to preserve open landscapes, but at the same time one of the most effective since most grassland species (plants and animals) are functionally well–adapted to this old way of utilisation (Klapp 1971; Lepš 1990; Briemle *et al.* 1991; White & Jentsch 2001).

Grazing: In temperate grasslands moderate grazing is the major form of management (Bullock *et al.* 2001). Historically, it has been applied for centuries (Poschlod & Schumacher 1998), e.g. as transhumance and large sheep flock migrations (Poschlod & WallisDeVries 2002) or later on as more intensive animal husbandry. Today, its impact is a key issue for range management (Sternberg *et al.* 2000) and nature conservation (Collins *et al.* 1998), and it is recommended as an alternative to traditional mowing regimes on semi–natural grasslands (Bakker 1998; Pykälä 2000). Herbivores profoundly alter the spatial structure of the affected ecosystem implying changes in habitat diversity and in the diversity of other consumers (e.g. insects, Dennis *et al.* 1998). As an important stress factor grazing reduces the dominance of competitive species and by trampling creates germination niches in the bare soil (Grubb 1977). It therefore has a direct effect on the structure and organisation of plant communities (Noy-Meir *et al.* 1989; Sternberg *et al.* 2000) and furthermore, on a variety of ecosystem functions (Adler *et al.* 2001).

Various studies have provided evidence that grazing entails higher plant species diversity (e.g. Sala 1988; Bakker 1989; Milchunas & Lauenroth 1993; Sternberg *et al.* 2000). This is due to grazing being a selective agent (Hadar *et al.* 1999) in contrast to the general agents of clearcutting (Floret *et al.* 1992) and mowing which treat every part of an area the same. By spatially heterogeneous urine and dung deposition (Steinauer & Collins 1995) and feeding large herbivores typically create frequent, small–scale disturbances across the landscape (Shankar & Singh 1996) resulting in a small–scale mosaik or micro–pattern (Bakker 1998). However, it is mainly indirect effects of grazing, such as influencing light availability and the opportunities for germination and seedling establishment, affecting the structure of the vegetation canopy (Bakker 1998).

In grazed systems the herbivore type is important to plant species diversity. Terrain use and food habits (Bakker 1998) as well as body size, digestive system or utilisation of different parts of the vegetation (Gordon 1989a) influence plant composition. In the New Forest in Hampshire, England, Putman (1986) found cattle to show a relatively constant pattern of habitat use throughout the year. In contrast, ponies showed marked seasonality in their use of plant communities. Gordon (1989b) found goats to prefer heathland on the Isle of Rhum, Scotland, while cattle and ponies preferentially selected grassland communities. According to Briemle *et al.* (1991) goats are generally very effective in extremely shrubby areas. There are also differences in feeding behaviour. While cattle use their tongue to rupture plant parts (Klapp 1971), sheep are more selective as they have much smaller muzzles (Lutz 1990), and may select even single flowers or leaves. Horses are more selective than ruminants and can bite off plants directly at the soil surface (Klapp 1971). They are rather harmful to the plant community due to their narrow food range and impairing hoof effects (von Korn 1987). Considering these differences multi–species grazing may be of value to the management of plant communities (Bakker 1998).

Also, herbivore abundance shows different effects on plant species diversity and habitat quality. Intensive livestock farming may result in unselective grazing and can create erosive, detrimental soil disturbances (Milchunas *et al.* 1988). Plant diversity is reduced as only few tolerant species will survive. Increasing numbers of rosette plants indicate high grazing intensities (Van den Bos & Bakker 1990). Moderate grazing is advantageous for short–lived plants and grasses; it also promotes flat rosettes as well as species with high seed dispersal ability (Stammel *et al.* 2003). Generally, relatively low stocking densities result in 'random' and extensive grazing, i.e. not the entire annual production is utilised, and micro–patterns develop (Bakker 1998). Extensive grazing leads to variation in, amongst others, dung deposition, soil compaction and heterogeneous removal of plant material due to herbivore selectivity (Bakker 1998).

Compared to mowing it creates a higher structural diversity (Bakker 1998). However, it is of considerably less economical value than intensive husbandry (Briemle *et al.* 1991).

Roto–tilling: Roto–tilling is the profoundest impact on above– and below–ground components besides ploughing. The two methods can be distinguished by their impact depths. Whereas ploughing reaches down to 30 cm, roto–tilling influences only the upper 20 cm depending on soil conditions. It disturbs plants at their hypocotyls, and even kills individuals or units/modules. Roto–tilling has destructive effects on the top soil layer and the vegetation cover and causes changes in the population structure. The treatment is repeated within longer time periods (e.g. every 3–5 years, Kleyer 1998) which leads to natural succession and shifting competitive relationships among plant species but also gives sufficient time to many tolerant grassland species to regrow from their hypocotyl buds (Kleyer 1998). The creation of gaps (Aguilera & Lauenroth 1995; Jutila & Grace 2002) due to the destruction of biomass and perturbation down to the root horizon also activates germination from the soil seed bank (Leck *et al.* 1989; Bakker *et al.* 1991; Bazzaz 1996; Jentsch 2004).

Kleyer (1998) considers mechanical cultivation in the form of roto–tilling to be an alternative management strategy compared to annual mowing as the above mentioned facts of ecological importance reason a successful management of species–rich semi–natural grasslands. Also, roto–tilling has an economical advantage as it has to be re–applied only after longer time periods (e.g. every 3–5 years, Kleyer 1998).

Mulching: Even though mulching is significantly cheaper compared to mowing (Kahmen *et al.* 2002), it should only be used as a temporary solution (Briemle *et al.* 1991). However, it still is an appropriate method to maintain and regenerate species–rich grassland communities (Briemle *et al.* 1991; Kahmen *et al.* 2002). According to Schiefer (1981) and Schmidt (1981) mulching once or twice a year enhances plant species that are light demanding, low–growing and poorly competitive, as well as plant species of economically used grasslands. Compared to natural succession or intensive utilisation, plant species diversity increases (Schiefer 1981; Schmidt 1981). Compared to mowing Kahmen *et al.* (2002) found that removing or leaving the plant material made only a minor difference to sward composition after 25 years.

Controlled burning: For open grasslands burning is an inappropriate management strategy as it causes a decrease in plant individual numbers and it reduces the overall habitat diversity (Briemle *et al.* 1991). Also Kahmen *et al.* (2002) do not recommend regular burning as they found species composition to shift to a variant that very much resembled the herbaceous layer of fallow grasslands.

For maintainance and protection of semi–natural grassland there is a need for management strategies which are less costly and more flexible. The question is, however, if there is an ‘optimal management’ in the sense of a best possible way to preserve a diverse species composition at the lowest possible costs? In the past decades quite a few studies have been conducted to answer this question (e.g. Schreiber 1977; Kapfer 1988; Bakker 1989; Noy-Meir 1995; Bertiller 1996; Huhta & Rautio 1998; Humphrey & Patterson 2000). Poschlod & WallisDeVries (2002) suggest conservationists to be open for unusual and controversial management.

Plant functional groups

One of the greatest challenges for today's ecology and biogeography is to replace the description of individual cases by general principles and models (Keddy 1992; Shugart 1997). It is impossible to develop models for every single ecosystem and species within it, therefore it makes sense to reduce the number of predicting variables and therewith the complexity of models (Woodward & Cramer 1996; Gitay & Noble 1997; McIntyre *et al.* 1999a). This advocates the use of (plant) functional groups. Functional classifications go beyond traditional taxonomic classification as taxonomically closely related species often show more differences in their reaction to environmental factors than do unrelated species (e.g. Box 1981a; Woodward 1987; Pugnaire & Valladares 1999). The quality of this classification is, that it consists of non–phylogenetic groups. These species groups are defined as *plant functional groups* (PFGs) if they exhibit similar biological traits and respond in similar ways to multiple environmental factors (Gitay & Noble 1997; Lavorel *et al.* 1997).

There have been a number of concepts on a classification according to plant traits (e.g. Warming 1909; Raunkiær 1934; Odum 1963; MacArthur & Wilson 1967; Grime 1974; Westoby 1998). However, it is only the system of Raunkiær (1934), that is widely used to date. The latest two important ideas have been developed by Grime (1974) and Westoby (1998). Grime (1974) introduced the concept of the **CSR–types**. This theory classifies plants into functional groups considering their responses to gradients of productivity and disturbance. There are three main functional groups: **c**ompetitors, **s**tress-tolerators and **r**uderals. According to Grime *et al.* (1997b) it is possible to scale up these types from individual species to communities and regional floras both in Britain and western Europe. Westoby (1998) and Weiher *et al.* (1999) doubted this theory and Westoby (1998) introduced another model: the **LHS–model**. As a plant ecology strategy schemes it categorises plant species according to their ecological attributes, and should allow the positioning of any species world–wide within it. The LHS–model is based on the quantitative 'soft traits' of leaf area, canopy height and seed weight, and is supposed to be applicable world–wide. Westoby considers the advantage of his model in defining the axes through a 'single readily measured variable' (compared to the multi–trait axes of Grime's CSR–system). This would outweigh the disadvantage that capturing as much strategy variation as with Grime's categories is impossible.

Especially after considering Westoby's LHS–model the question arises if there are indeed any 'key characteristics' which determine plant response to environmental conditions, competitive interactions, and eventually their distribution in time and space. An overview was given by Smith *et al.* (1993) on different approaches for defining those key traits, but the discussion is still ongoing (e.g. Thompson *et al.* 1993; Noble & Gitay 1996; Días & Cabido 1997; Westoby 1998; Weiher *et al.* 1999; McIntyre & Lavorel 2001; Lavorel & Garnier 2002; Cornelissen *et al.* 2003).

According to Gitay & Noble (1997) there are 3 different approaches to identify functional groups: subjective, deductive and data–defined. For the subjective approach, observations are made assuming that functional groups exist and that they can be defined inductively. The deductive approach is derived from the assumption that particular processes or properties are of importance to the functioning of an ecosystem. Multivariate techniques are used for the data–defined approach, seeking clusters of species based on a set of characters.

It still is discussed controversially, if there is a ‘universal functional classification of organisms’ or if it is rather appropriate to seek for context dependent classifications. Heal & Grime (1991) argue in favour of the existence of this universal functional classification. Gitay & Noble (1997) came to the conclusion that these classifications depend on the context (cf. also Smith *et al.* 1993; Mooney 1997; Walker 1997). However, Westoby & Leishman (1997) were optimistic that plant functional classifications can be found ‘that (1) differentiate plant species for purposes of several different questions at the same time, and (2) covered more than one region or continent’.

The concept of PFGs can be applied at a range of spatial scales (Duckworth *et al.* 2000): from plant communities, through ecosystems and landscapes, and eventually at the global system. However, an important question is whether the knowledge about these groups can be transferred from a lower spatial level to a higher level. According to Duarte *et al.* (1995) it is more likely for broad–scale comparisons to reveal important patterns as they capture more functional variance and are more likely to be applicable to a wider range of ecosystems and habitats. The process of transforming the sampling frame from small– to large–scale is called ‘scaling–up’ (Atkinson 1997; Grace *et al.* 1997). Grace *et al.* (1997) distinguish two types of scaling–up: (1) simple scaling, which only allows multiplying up a phenomenon observed in a small plot or sample, and (2) hierarchical scaling, where it is possible to move between levels of organisation. Simple scaling can be understood as bottom–up approach *sensu* Cramer (1997) and Leemans (1997), whereas hierarchical scaling equals bottom–up as well as top–down approach *sensu* Cramer (1997) and Leemans (1997). The bottom–up approach has been applied by most scientists dealing with functional classifications (e.g. Grime 1979; Gitay & Noble 1997; Grime *et al.* 1997a; Westoby 1998). Cramer (1997) and Leemans (1997) used a top–down orientated derivation of PFGs describing vegetation patterns in terms of their environmental requirements. For now the two approaches still complement each other but in the future they ideally should merge (Cramer 1997).

The above–mentioned approaches suggest that scaling–up (and down) is generally possible. Marshall *et al.* (1997) give an elaborate overview on variability and scaling, inferring that there are no general recipes for scaling. ‘The nature of the phenomenon itself dictates the scaling properties of the system, and the way in which it should be observed’ (Marshall *et al.* 1997).

Identifying functional groups raises the question if they are consistent. Gitay & Noble (1997) defined and tested four criteria which have to apply to discuss consistency: uniqueness, repeatability, congruency and convergence. Concerning uniqueness, analytical techniques should be as similar as possible. Obviously, there is some evidence of repeatability, but little evidence of congruency (with exceptions). The authors could not test for convergence.

The characteristics to distinguish PFGs are species–specific biological traits. When looking at the same plant species, certain traits can be developed differently (e.g. leaf mass), differ in size (e.g. canopy height) or vary in quantitative traits (e.g. seed number) (Kleyer 1999; McIntyre *et al.* 1999b; Semenova & van der Maarel 2000).

Generally, PFGs are designed around morphological, reproductive, developmental and physiological traits. Theoretically one species could belong to one functional group classified by one trait or to another grouped by another trait, and therewith ecologically important trait combinations could exceed the number of species.

According to several authors, e.g. Mooney & Godron (1983) and Chapin (1993), however, this will not be the case as a lot of traits are interrelated and thus represent a 'syndrome of responses' to a given resource base. Mooney (1997) suggests that there will be a limited number of trait combinations among a pool of co–occurring species.

There are two different types of traits that can be distinguished: so–called 'hard traits' and 'soft traits'. 'Soft traits' such as leaf area are easy to record. Ideally, they are used as substitutes for those attributes, that are hard to determine but usually more directly related to certain ecosystem functions ('hard traits' such as photosynthetic activity) (cf. Hodgson *et al.* 1999; Weiher *et al.* 1999; Poschlod *et al.* 2000; Cornelissen *et al.* 2003). A trait is called functional if it is strategically important for a species or crucial considering the adaptation to certain environmental conditions (McIntyre *et al.* 1999b).

One of the most important objectives in research on the applicability of PFGs is to identify a minimum set of traits under a minimum budget of time and money, to describe the functional variation and at the same time to retain maximum discriminatory power (e.g. Weiher *et al.* 1999; Duckworth *et al.* 2000). In the future it could be possible to dynamically model changes in vegetation, e.g. caused by environmental changes, and to create a basis for connecting models on different scales (Smith *et al.* 1993; Duckworth *et al.* 2000). Therefore, PFGs are an important tool for understanding ecological and biogeographical processes, as well as for the prediction of changes. However, Duckworth *et al.* (2000) argue that perhaps it might be more realistic to understand them as complementary to species–based approaches.

Habitat models

Natural or anthropogenically induced changes in abiotic conditions such as soil parameters or utilisation can cause changes in species composition. Modelling empirical data allows predicting the effects of these changes on one or several species occurring in the studied areas. In this manner, models abstract reality and reduce complexity. By means of models it is easier to describe complex systems (i.e. reduction of systems) and new systems can be created (cf. Schröder 2000). *Habitat models* are one example of such a model. They formalise the relationship between single species or groups and their habitat, and quantify this relationship from the species' point of view (Morrison *et al.* 1998). They connect species and landscape according to the species' or group's perception of the given landscape. Hence, habitat models allow to create management plans to preserve protected species as well as to predict the effects of certain management strategies (e.g. Lindenmayer *et al.* 1993; Richter *et al.* 1997). Furthermore, it is possible to assess biotopes concerning their habitat suitability for certain species (Schröder & Richter 1999/2000).

The term 'habitat suitability index model' was first used by the U.S. Fish & Wildlife Service in 1981. These models were based on expertise and general statements on the habitat preference of a concerned species (Kleyer *et al.* 1999/2000; Schröder 2000). Later on, multivariate statistical methods were used (Morrison *et al.* 1998) while nowadays logistic regression is applied to create these models (cf. Schröder 2000).

Besides the prediction of incidences habitat models allow the analysis of the importance of certain habitat factors and requirements to explain spatial distributions of species (e.g. Lindenmayer *et al.* 1991; Kleyer *et al.*

1999/2000). Habitat models are statistical models, which means that they are non–dynamic. To be able to create a habitat model, presence/absence of a species (plant or animal) need to be recorded along with relevant habitat attributes (cf. Schröder 2000). Generally, habitat models are used in habitat suitability maps or utilisation scenarios (Schröder 2000; Vogel 2002), or to predict incidences of species or species groups (Kleyer 1997; Leftwich 1997; Kleyer 1999; Kleyer 2002), both for plant and animal species.

It should be noted, however, that there are limits to habitat models. One of them is that, for instance, interactions between plants (i.e. enhancement or inhibition of growth and development) can reduce their predictive capability as some plants have modifying effects on the micro–scale climate (e.g. shading, water availability) (Cramer 1997). This may cause a change in species composition and/or abundance, which might not be possible to predict by means of habitat models. Another problem is the transferability of habitat models to unstudied areas, which is doubtful. According to Schröder & Richter (1999/2000) habitat models created with data from a single investigation area only have limited validity. As long as transferability has not been tested and verified it is only possible to make statements on spatio–temporal aspects for those data the model is based on (Fielding & Haworth 1995). For example, Leftwich (1997) studied the fish of the North Fork Holston River, Virginia (USA) and stated that habitat models are not transferable to Little River which is located within the same river system. Kleyer (2002) studied the transferability of habitat models for PFGs for an agricultural and an urban landscape. He found a few models that sufficiently predicted the incidence of certain groups for the agricultural as well as for the urban landscape. He also stated that a successful transferability depended mainly on similar habitat conditions in both landscapes. In case the conditions are different, the concerned PFGs are landscape specific, i.e. significant for only one landscape.

Having created habitat models for a certain investigated area the question arises on the possibility of transferring the models to a regional or even to the landscape scale. The availability of Geographical Information Systems (GIS) plays a vital role for this so–called scaling–up. According to Kleyer *et al.* (1999/2000) there are two approaches: (1) Habitat models are developed using random sampling across the investigated area, or (2) habitat models using GIS functionality to produce the data basis. Habitat models using random sampling are eventually transferred to the whole landscape. For this purpose all independent habitat factors used for the models need to be available for every single partial area. An area–wide collection of the abiotic and biotic fundaments determining species incidences is essential. By using the model function it is now possible to produce an area–wide map of predicted habitat quality. The second approach, using GIS to produce the data basis for habitat models, includes, for instance, the inclination taken from digital elevation models, or the vegetation structure from vegetation maps, or soil data from soil maps. Presence/absence data of a certain species in a certain site can be overlaid with maps of habitat factors. This results in the data basis for the overall model.

An avowed objective of habitat models is to use them as an instrument for impact planning and to predict the effects of planning on the environment. Habitat models can also be applied in nature conservation, in the case of preserving biotopes (e.g. by certain management strategies), or for restoring or creating new habitats in the course of compensatory measures. According to Kleyer *et al.* (1999/2000) there are two possible ways to do so: (1) developing habitat models with data collected in the concerned area, and (2) using habitat models created for different landscapes and transferring them to the concerned area. However, for the latter transferability in space and time needs to be verified.

Objectives and hypotheses

Two management systems for preserving open grasslands will be tested as alternatives to regular mowing. ‘Random grazing’ (Bakker 1989) in *permanent grazing systems with low stocking densities* will create a spatio–temporally *uncontrolled small–scale mosaic* reaching from open grasslands to shrubby areas. In contrast, *massive cyclic disturbances* (e.g. roto–tilling) will create a spatio–temporally *controlled large–scale mosaic* reaching from exposed soils over grasslands to copses. Both, regular massive disturbances at longer time periods (e.g. every 5 years) as well as permanent grazing systems at low stocking densities allow limited natural succession. The two investigated management alternatives are suggested to lead to a coexistence of different successional stages resulting from changing habitat qualities. Consequently, they are expected to create a mosaic–like character of the landscape. Thereby, the local species pools vary, possibly including local extinctions. However, creating and accepting the resulting mosaic cycle with its continuously changing habitat qualities is the key to eventually preserve the regional species pool. That means, that the alternative management strategies do not result in a higher risk of extinction for the typical flora of semi–natural grasslands as species occupy special niches within the mosaic cycle, depending on resource availability and disturbance. Biologically similar plant species respond in a similar way to the environmental conditions within the mosaic cycle (i.e. PFGs).

The **objective** of this thesis is to determine the local potential species pool under equilibrium conditions. According to their biological traits the species are arranged into biological groups of which the ecological optimum was determined considering their response to environmental conditions and disturbance regime (i.e. PFGs). The created habitat models for the PFGs are of considerable importance to the planning practice. They allow the automated realisation of predictions into maps of Geographical Information Systems (GIS). The models can be used by conservation authorities as an instrument by which means it is possible to predict the impacts of environmental changes on species composition (e.g. changing management practice), and to eventually protect and preserve the considered semi–natural grasslands and their typical flora and fauna.

As investigations were carried out in two different natural areas underlying different concepts of management, **hypotheses** have to be considered separately.
For the *grazed system* it is hypothesised that:

- Natural succession depends on grazing intensity.
- Grazing intensity depends on soil resource availability.
- Grazing suppresses or even inverts natural succession predominantly in the winter months.
- Plant traits show a strong functionality to grazing intensity.
- There is a most parsimonious set of functional traits representing the PFGs along the environmental gradients.

For the *roto–tilled system* it is hypothesised that:

- Natural succession mainly depends on the various disturbance parameters, i.e. disturbance frequency, disturbance magnitude and disturbance date.
- Plant traits show a strong functionality to these disturbance factors.
- There is a most parsimonious set of functional traits representing the PFGs along the environmental gradients.

Generally, it is hypothesised that:

- The two alternative management systems allow limited natural succession and at the same time are capable of preventing the extinction of plant species typical to semi–natural grasslands.

Recording the local species pool together with environmental factors and disturbance regime allows the statistical determination of potential species presences and absences within the habitats of the mosaic cycle. Potential and real occurrences are identic if species are able to re–colonise habitats. Species unable to do so will become extinct in the long run.

Outline of the thesis

This thesis is part of the MOSAIK–project funded by the German Federal Ministery of Education and Research (BMBF) under FKZ 01 LN 0007. The project tests two alternative management strategies for their capacity to replace mowing as widely practiced to date, and evaluates their efficiency for nature conservation to preserve semi–natural grasslands, which are threatened by intensification and abandonment. The alternatives are namely (1) low stock density grazing all year round, investigated in a long–term grazing experiment at the eastern shore of the lake Müritz in north–eastern Germany (Mecklenburg – Western Pomerania), and (2) roto–tilling as a new form of below–ground disturbance within the Hassberge in southern Germany (Lower Franconia, Bavaria).

This thesis works with plant functional groups (PFGs) which are abstracts of species with similar biological traits showing similar responses to multiple environmental factors (Gitay & Noble 1997; Lavorel *et al.* 1997). Habitat models are created to show the probability of co–occurrence of species of one PFG and to visualise the groups' demands on their environment, i.e. natural resources and disturbances. The PFGs and their habitat models were created and interpreted separately for the two different landscapes (Chapter 3 and 4). Chapter 5 focuses on the synthesis of the species, habitat and disturbance factors in both investigation areas. PFGs and habitat models were created for the whole data set. Box 1 aims to identify the primary and secondary trade–offs within the whole species x trait – data set for both investigation areas.

All parts of the extensive field work were carried out by myself (to some extend with the dedicated help of my family and students!). The articles (chapters) and short communications (box) are designed by myself. I am myself responsible for the data analysis and writing up of the manuscript drafts. Chapter 3 – 5 were carried out together with the co–author. The SAS–Macro to identify the PFGs and conduct stepwise logistic regression was written by Prof. Dr. Michael Kleyer, Landscape Ecology Group, Carl–von–Ossietzky University Oldenburg, Germany.

CHAPTER 2

INTRODUCTION TO STUDY SITES AND EXPERIMENTAL DESIGN

Study sites

To test the transferability of habitat models for PFGs two study areas were chosen. The sites are situated in north–eastern and southern Germany (Figure 2.1).

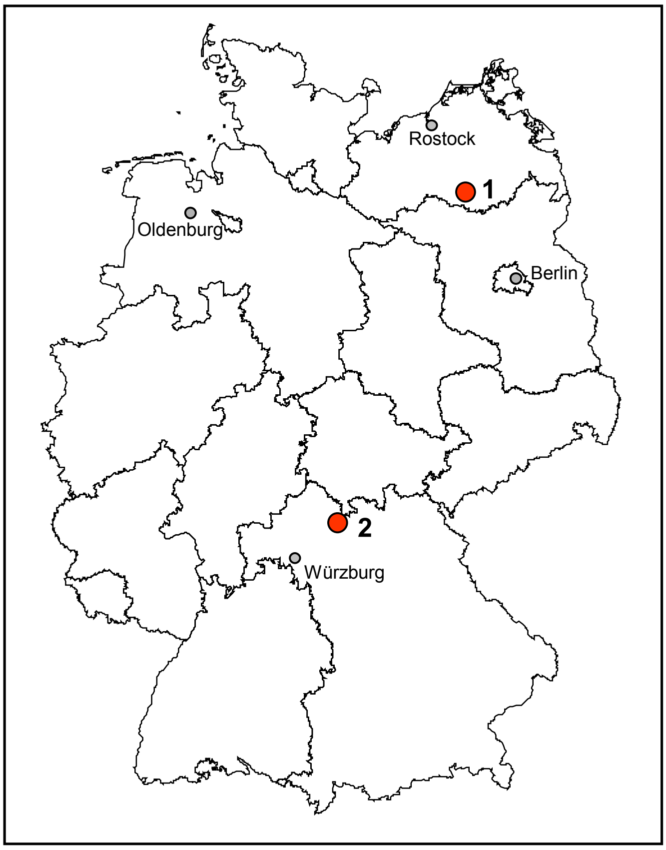

Figure 2.1: The two study sites in Germany: Müritz in Mecklenburg–Western Pomerania (1) and Hassberge in Bavaria (2).

Müritz

Research was carried out in north–eastern Germany (Mecklenburg–Western Pomerania) at the eastern shore of the lake Müritz in the area called Rederang– and Spuklochkoppel (53° 29’ N, 12° 44’ E). The main vegetation consists of extended *Cladium mariscus*–reeds, grazed grasslands and *Juniperus communis*–heathlands. The area totals about 3 km².

Geology and hydrology

The Müritz area emerged after the last ice age (Weichselian glaciation) about 10 000 years ago (Deppe & Prill 1958). Drift sands and, later, melting waters formed the shallow eastern shoreline (Peltz 1906). According to Geinitz (1886) the Müritz can be seen as a ’combination lake’, a lake surface made up of single depressions connected by one water level; Martens (1955) considers the Müritz as a gathering reservoir. With the Müritz–Havel–water way the southern lake part drains into the river Havel, the northern part into the river Elde, both run into the river Elbe and on to the North Sea. The investigation area is part of the Mecklenburg–Brandenburgischer Landrücken. The landscape is characterised by many lakes and glacial kettles. The eastern shoreline comprises of the outwash plain of the Pomeranian Stadium of the Weichselian glaciation, and the geological layers mainly consist of lake sands and Beckenton (south of Müritzhof) and geologically younger fen soils along Lake Rederang (see Figure 2.2).

Due to drier climate and the absence of melting waters from the glaciers it is certain that the Müritz water level was about 4 m lower during the Praeboreal and Boreal than it is at present (Deppe & Prill 1958). In the course of the Atlanticum higher precipitation led to rising water levels, dropping and rising again during Subboreal and Subatlanticum (Deppe & Prill 1958). After colonisation and up to the 12th century artificial structures (e.g. water mills, weirs, sluices) caused a swirl up of 2 m (Deppe & Prill 1958). It was only around 1800 with the canalisation of the river Elde (1798–1803) and the construction of the Bolter Kanal (1831–1837) that the water level dropped by about 1,50 m (Deppe & Prill 1958) and the investigation area emerged. Before regulation of the water level, the elevated area near Müritzhof was a fossil cliff (Hurtig 1962b; Jeschke *et al.* 1980) and the Spukloch was non–existent (Schmidt 1962a; Hurtig 1962b; Schmidt 1962b).

The eastern shore line of the Müritz was and still is a highly dynamic area, where ice movements and grazing kept parts of the banks open giving wind and water time to erode the northern part of the Spuklochkoppel (up to 2 m per year, Martin 1997). In the southern area this is compensated in islands, bays and hooks (Martin 1997). 'Shore banks' were created by depositing sand along the shore. It is likely that this way the Spukloch was separated from the Müritz (Martin 1997). The whole western part of the Spukloch area is made up of these 'shore banks' (Jeschke 1974).

Nowadays the eastern Müritz shoreline is shallow and increasingly determined by overgrowing wetlands with small lagoons and extensive reeds forming the immediate lake shore (Hurtig 1962b).

Soils

The soils in the Müritz investigation area can be subdivided into lowland soils (62–66 m a. m. s. l.), soils of the crossover from lowland to higher elevated areas (66–70 m a. m. s. l.) and soils of high elevated areas (over 70 m a. m. s. l.) (Hurtig 1957). Several soil types can be distinguished in the study area:

1. *Subhydric soils:* These soils can be found on the bottom of the lakes and their shallow shore waters; they are permanently flooded or exposed to air for only a very short time. They are followed by fen soils changing into gleys where mineral components increase. Ground water is important in both soil types. Decreasing influence of ground water occurs as soon as gley soils are superseded by terrestrial soil types which are determined by their source material (Hurtig 1962a).
2. *Fens:* Hurtig (1962a) classified fen soils into 2 categories: wet and dry. From late fall to early summer ground water stays close to the soil surface in the former. Only in late summer it drops down to approximately 30 cm. The latter are only flooded in spring after thaw. Ground water occurs as deep as 60 cm in autumn (September).
3. *Gleys:* Gleys mostly consist of fine and medium sands with low stone and gravel content (Hurtig 1962a). They all show a high amount of humus in the upper layers and there is a strong tendency to podsolation. Ground water table does not seem to follow the lake table but rather the relief form.

4. *Terrestrial soils*: Dominant factor in terrestrial areas are mineral soils of mostly consistent, partly monotonous particle size (Hurtig 1962a), and loamy material is rarely found. The low–nutrient ground water in depths between 130 and 250 cm supports a humid and cool ground climate and herewith enhances humus accumulation and podsolation (Hurtig 1962a).
5. *Clay* occurs especially in the eastern (Müritzhof) and western part of the Müritz area down to 40 m (Deppe & Prill 1958). It was deposited with the glacier retreat and can be found mostly under the outwash plain. The Müritz seems to be lying in a clay basin (Deppe & Prill 1958). During the 2nd half of the 19th century a clay brick facturer established at Müritzhof fetching the glacial clay for 50 years on 30 ha at about 1 m depth of the top layer (Schmidt 1962a; Deppe 1981).
6. In more elevated areas *Cambisols* (Brown earth) occur as Cambisol podsols and can be found close to Müritzhof. They contains only little loam and little organic matter in the topsoil.

Climate

The Müritz area is situated in the 'Mecklenburg–Brandenburgischen Übergangsklima' (Pingel 2003) where oceanic influences from western Europe and the continental east European climate concur. The large proportion of forests and watercourses as well as the changing altitudes and slopes create a certain macroclimate with noticeable precipitation and temperature values. To the west and to the north of the lake precipitation is considerably higher compared to the east side of the lake, especially thunderstorms move south– or northwards around the lake. The mean annual precipitation from 1930–2002 was 583 mm (Wetterdienst des Nationalparkamt Müritz 2003) (Waren/Müritz 1891–1930: 594 mm, Anonymous 1939). The maximum rainfall occurs in summer (July), the minimum in winter (February) (Pingel 2003).

Mean annual temperature 1930–2002 was 8,2°C (Wetterdienst des Nationalparkamt Müritz 2003). The coldest month is January, the warmest July (Pingel 2003). From June onwards into winter, the air temperature is positively influenced by the warmed waters of the Lake Müritz (Schmidt 1962c). Once its waters have cooled down, it causes the spring temperatures in the surroundings of the lake to be colder (Schmidt 1962c). The lake freezes over almost every winter. At the eastern shore strong western winds pile up the melting ice over 6 m high.

Utilisation

After the regulation of water level the area adjacent to Lake Müritz was continuously grazed extensively since 1880 using cattle and horses (Table 2.1). Highly endangered plant species, together with a characteristic fauna, established and survived up to date, for instance the very important Molinion–stands with *Dactylorhiza incarnata* and *D. majalis* as well as *Gentianella baltica* and *G. uliginosa* or *Pinguicula vulgaris* (Jeschke 1993). From 1952 on the area around the Spukloch (see Figure 2.2) was excluded stepwise from grazing to protect ground–breeding birds. Due to this management vegetation succession enhanced, resulting in a decreasing species–richness of birds, for which the management was installed in the first place (e.g. cranes gave up the area as their autumn resting place, Deppe 1980). To re–establish the importance of the area to birds, grazing by cattle was re–installed in 1961 (see Table 2.1), but succession continued. In the 1980s additional mechanical management such as mowing and shrub clearing became necessary (Martin 1985).

The Lange Koppel and the Rederangkoppel were harrowed, rolled and fertilised in spring; the first growth was mowed (May/June), afterwards the area was grazed by cattle (D. Martin, pers. comm.). From 1972 onwards young cattle were allowed to graze from May to October (Ritter in Köber 2001). The animals were left on small sections of the area for a maximum of 3–4 days, after which they were moved to the next section. Fertilisation amounted to a maximum of 60 kg N/ha (Ritter in Köber 2001).

Nowadays, the mechanical treatment is maintained as well as the traditional management (i.e. extensive grazing) which is continued with 0.3 livestock units per ha (I. Heinzel, pers. comm.). Additionally, the sheep are herded irregularly from May to October in the north–western parts of the investigation area, i.e. Spuklochkoppel and semi–open *Juniperus communis*–stands (in the following simply called *Juniperus*–stands) (see Figure 2.2). The remaining time sheep graze on the Rederangkoppel. During the whole year cattle and ponies are allowed to range free across the area, only part of the Lange Koppel is excluded from grazing from May to July for hay making. The hay is used as supplementary nutrition during the winter months (in Figure 2.2 referred to as mowed grassland).

Table 2.1: Utilisation of the investigation area (Martin, pers. comm.)

year	**Rederang–koppel (adjacent Müritzhof)**	**Rederang–koppel (southern part)**	**Lange Koppel (adjacent Müritzhof)**	**Lange Koppel (northern part)**	**Spukloch–koppel/ Ameisen–wiese**	**semi–open *Juniperus communis*–stands**	**Müritzwiese**
~1850 – ~1900	**hill top:** farmland, **rest:** cattle	young cattle, horses					
1901 – 1951	cattle, fertiliser, mowing (?)	cattle, fertiliser			cattle, fertiliser (?)		cattle, fertiliser
1952 – 1959					fallow		
1960		cattle, fertilizer (30 kg N/ha; 150 kg K,P/ha)					cattle, fertilizer (30 kg N/ha; 150 kg K,P/ha)
1961 – 1968					horses, young cattle		
1969 – 1976		cattle **spring:** harrowing, rolling; fertiliser; mowing	cattle **spring:** harrowing, rolling; fertiliser; mowing	cattle **spring:** harrowing, rolling; fertiliser; mowing	Fjell cattle		cattle **spring:** harrowing, rolling; fertiliser, mowing
1977 – 1981					Fjell cattle		
1982 – 1986			Fjell cattle				
1987 – 1988	Fjell cattle, Gotland sheep, Shetland ponies	Gotland sheep, Shetland ponies					
1989				Fjell cattle, Gotland sheep, Shetland ponies			
1990 – 1992			Fjell cattle, Gotland sheep, Shetland ponies		Fjell cattle, Gotland sheep, Shetland ponies		
from 1993	Fjell cattle, Gotland sheep, Shetland ponies						

The semi–open *Juniperus*–stands are situated in–between Spukloch and Lake Müritz. They have a size of 15 ha in total (Martin 1997), and were formed in the 1940s/50s after grazing intensity was reduced (Deppe 1980; Martin 1984). In winter there is a large red deer population (Martin 1984). Ever since the first Fjell cattle came to Müritzhof in 1969, the whole area around the Spukloch was exposed to extensive grazing. The intensive grazing on the Müritzwiese, north of the *Juniperus*–stands, was abandoned in 1973 (Martin 1984) and taken into extensive management in 1977 (Martin, pers. comm.). Rederangkoppel and Lange Koppel were more comfortable to use and therefore intensified in the 1970s/80s by large amounts of fertiliser (Martin 1984). They were taken into extensification from 1982–1988 (Martin, pers. comm.).

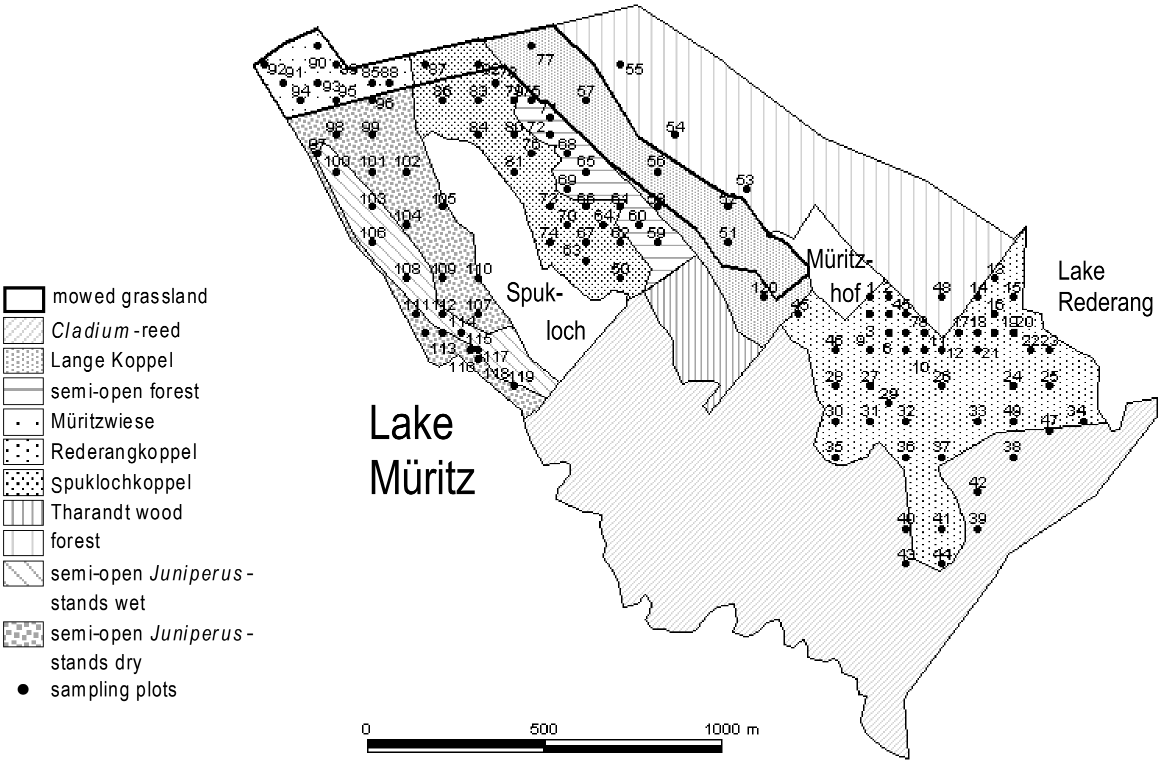

Figure 2.2: Investigation area Müritz with sampling plots, and the different sections the area was divided in.

Fjell cattle

The relatively small and light weighted Fjell cattle are a very old Scandinavian breed (Sambraus 2001) which are undemanding, non–aggressive and naturally hornless animals (Figure 2.3). Besides, the animals are highly resistant towards diseases and weather conditions and can be kept outside year–round. Up to the 1940s they were of economical and breeding importance, but nowadays the breed belongs to the endangered domestic animals due to a dramatic stock decrease. It is likely that the herd of Fjell cattle in the Müritz Nationalpark is the largest herd world wide (Martin 1997).

According to Klafs (1974) and Martin (1985, 1997) Fjell cattle are an effective way to preserve low–growing swampy to dry grasslands. However, only the cattle grazing on Spukloch- and Rederangkoppel cannot avoid succession into shrub land, therefore other herbivore species were introduced and additionally mechanical management was installed.

Figure 2.3: Fjell cattle.

Gotland sheep

Gotland sheep (Figure 2.4, left) are the oldest Swedish sheep breed (Krumme 2003). They are medium–sized, very frugal and robust as well as undemanding concerning feeding and keeping (Sambraus 2001). It is not necessary to shear them as the old wool is lifted by the new wool and simply falls off or can easily be peeled off (Ewert 2001). Gotland sheep are able to walk long distances and prefer trees, shrubs and herbs. They even eat thistles and stinging–nettles. These attributes make them a useful breed for landscape management and migrating sheep–farming (Hentzschel 1999).

Figure 2.4: Gotland sheep (left) and Shetland ponies (right).

Shetland ponies

Shetland ponies (Figure 2.4, right) are one of the oldest English pony breeds. Concerning food they are very robust and undemanding (Ewert 2001) as they are used to an environment of poor soils covered with sparse vegetation, heathlands and moors on the Shetland and Orkney Islands.

Biotopes

The investigation area consists of 14 biotope types which were grouped into 6 main types (Table 2.2) and then characterised according to their utilisation and water household (Table 2.3). The abstracted types will be described within the following paragraph. All explanations were taken from LAUN (1995).

The Spukloch belongs to the biotope type 'permanent small waterbody' continuously containing water and featuring typical plant communities[1]. No plots were established within this biotope type.

'Swamps' (abstracted as reeds) consist of water–dependent treeless vegetation. They are usually situated along shallow lake shores with fluctuating water levels or secondary water–logged soils. Within the investigation area they are predominantly composed of *Cladium mariscus*– or *Phragmitis australis*–reeds, and can be found south of the Rederangkoppel ('*Cladium*–reed') and next to the *Juniperus*–stands.

The grasslands consist of 3 different biotope types. 'Moist–soil meadows' are characterised by reliable sufficient water and nutrient supply, and may be flooded. With the beginning of the vegetation period these areas are partially water–logged or impeded. Within the investigation area these meadows reach from relatively nutrient–poor areas to those characterised by tall sedges or tall–growing perennials even with shrubs and/or trees. They are found along the banks of the Spukloch, partly within the *Juniperus*–stands and on the Müritzwiese, on the Lange Koppel and the southern part of the Rederangkoppel.

Table 2.2: Abstracted biotope types.

abstraction	biotope types
lakes	lake
reeds	swamp
forests and dense tree stands	deciduous forest mixed deciduous forest mixed forest mixed coniferous forest group of trees
grasslands	moist-soil meadow dry meadow calcareous dry grasslands
Juniperus–stands	heath
beaches	beach shore bank

In contrast to the former biotope type, 'dry meadows' are not sufficiently supplied with water. The vegetation cover is closed, and compared to dry grasslands the soil is more humous and not as dry. The northern part of the Rederangkoppel belongs to this biotope type.

'Calcareous dry grasslands' are found on nutrient–poor alkaline soils and harbour species such as e.g. *Danthonia decumbens*. This is the case in parts of the Müritzwiese.

The classical biotope type 'heath' consists of dominant dwarf–shrubs and secondary shrubs and trees. Within the investigation area a special type of heaths exists on dry and acid podsolic sandy soils, i.e. *Juniperus communis*–heath (or stand). It is preserved by extensive grazing and occasional shrub encroachment.

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[1] Note: The biotope mapping for Mecklenburg–Western Pomerania (LAUN 1995) considers the Spukloch as a 'lake' with an average depth of more than 5 m. According to own observations this is not the case.

Beaches are the abstraction of ‘beaches’ in the closer sense and ‘shore banks’. ‘Beaches’ are part of the shore line (in this case of the Lake Müritz), whereas ‘shore banks’ are created by the surf of the lake or built up by ice movements during the winter months. They can reach heights of up to 1 m and are found along the banks of Lake Müritz. These areas are inhabited by e.g. *Carex arenaria* or *Armeria maritima* ssp. *elongata*.

The last biotope type to be described are the abstracted forests. The ‘deciduous forest’ consists of broad–leafed trees only (e.g. *Fagus sylvaticus*), whereas the ‘mixed deciduous forest’ (e.g. *Pinus sylvestris*, *Betula pendula*) includes up to 30% of coniferous tree species. In contrast, the ‘mixed coniferous forests’ contains 30% of deciduous tree species. These forests are found in the north–eastern part of the investigation area.

‘Groups of trees’ are found on the Rederangkoppel. They are no larger than 0.5 ha.

The ‘mixed forest’ is called ‘semi–open forest’ in Figure 2.2. A balanced mixture of deciduous (e.g. *Betula pendula*) and coniferous (e.g. *Pinus sylvestris*) tree species forms this biotope type.

Except for the forest north–east of the investigation area all biotope types within the investigation area are extensively grazed.

Table 2.3: Main biotope types for the Müritz investigation area. For area names see Figure 2.2.

biotope	characteristics	utilisation	area	no. of plots
lakes	wet	-	Spukloch	-
reeds	wet	grazed	*Cladium*-reeds	8
grasslands	wet	extremely grazed	Rederangkoppel southern part, Lange Koppel	19
		grazed	Spuklochkoppel, wet grassland and reeds	23
	+/-dry	mowed + grazed	Lange Koppel, Müritzwiese	16
	dry	extremely grazed	Rederangkoppel northern part	16
beaches	dry	grazed	Müritz banks	6
Juniperus-heath	dry	grazed	*Juniperus*-stands, Rederangkoppel southernmost part	14
forests or dense tree stands	+/-dry	grazed	semi-open forest, dense tree stands Rederangkoppel	14
	dry	not grazed	Forest	4

Conservation history

The nature reserve ’Ostufer der Müritz’ was created in 1949. It covers 4832 ha of lakes, wetlands, fens, mixed beech/oak forests and artificial pine forests. The central area Müritzhof (280 ha) was declared a nature reserve in 1931, but seems to have been considered one since 1911 (Deppe 1981). In 1969/70 the ’Ostufer der Müritz’ became part of the stately owned hunting ground ’Müritz’ (Jessel 2001). Nature conservation had to step back and hunting got priority. However, in 1990 the Müritz National Park was created covering 322 km². It nowadays consists of two parts: Müritz and Serrahn.

Primary objective of the national park is a free and anthropogenically unaffected nature development, i.e. natural biotic and abiotic conditions of the ecosystem are to be protected (§3 Abs. 1, NP–Verordnung). To preserve an ecosystem created by humans and their domestic animals, the historical ’treatment’ needs to be continued. The attended zone (Zone 2) maintains such special biotopes and characteristic landscapes. Part of this zone is the Müritzhof area including the *Juniperus*–heath, the Spukloch– and the Rederangkoppel.

Hassberge

The second study site is situated in southern Germany (see Figure 2.1) in the administrative region Hassberge (Lower Frankonia, northern Bavaria) and is part of the nature park Hassberge. The area is located at the western edge of the Hassberge (50° 03' N, 10° 35' E), its size totals approximately 25 km². It reaches from Zeil am Main in the south to Königsberg i. Bay. in the north, and from Hassfurt in the south–west to Altershausen in the north–east (see Figure 2.5). Eastwards the forested eaves of the main level of the Hassberge border the area.

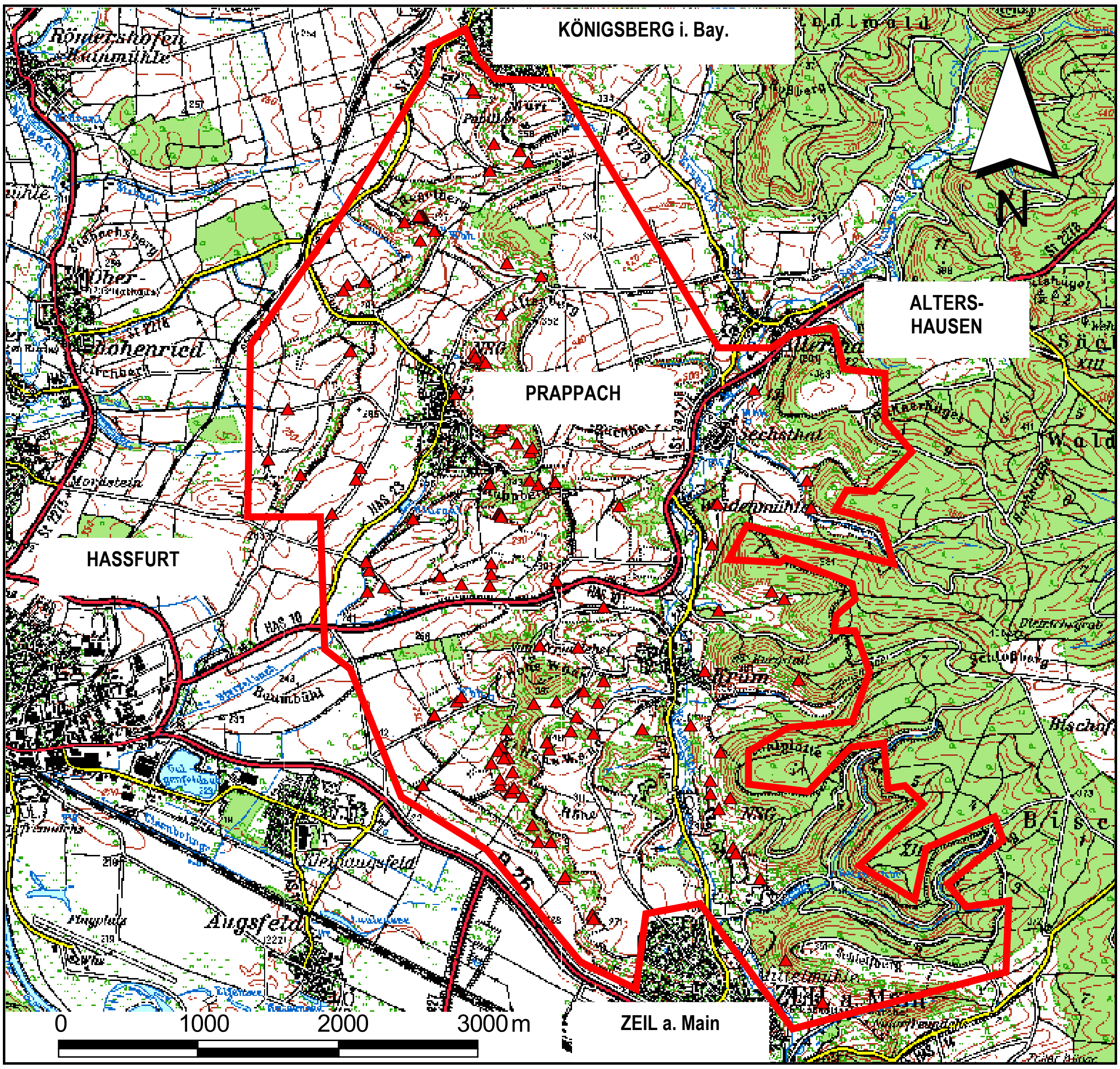

Fig. 2.5: Location of the investigation area 'Hassberge'. The red triangles indicate the sampling sites. (Source: TK 50, Haßfurt, Bayrisches Landesvermessungsamt München)

Geology

The Hassberge are the northernmost part of the southern German Keuperbergland. They are situated between the break–through valley of the river Main in the south and the so–called Grabfeld in Königshofen in the north (Müller-Hohenstein 1971).

The region belongs to the ‘Fränkisches Schichtstufenland’. The forested eaves of the Hassberge main level form the eastward border of the investigation area. The preliminary pre–stage to the west of the main level, including the investigation area, is a typical Gypskeuper bed layer (see Figure 2.6) which was formed about 200 million years ago. Different sandstone formations alternate with clayey substrates. The oldest layer of this sequence is the Myoporien layer (Emmert 1964) which is located westward of Königsberg i. Bay. and Prappach; to the east the Estherien layers follow. Both layers contain high carbonate concentrations (Elsner 1994). Shelf Sandstone as the following layer is rather poor or even free of carbonate, as well as the Lehrberg Layer (Wittmann 1966) forming Rauchberg, Kleine Hohe Wann, and the foot of the Hohe Wann. The roof of the Hohe Wann consists of Blasensandstone containing thin sandstone layers.

Clay stone, clays and clay marl stone as well as marl and clay slate with their interspersed sands and carbonates determine the area (Rutte 1981), but also sandstones are important (Emmert 1964). Especially within the summer months it is possible to observe cracks in the clayey soil caused by the drought.

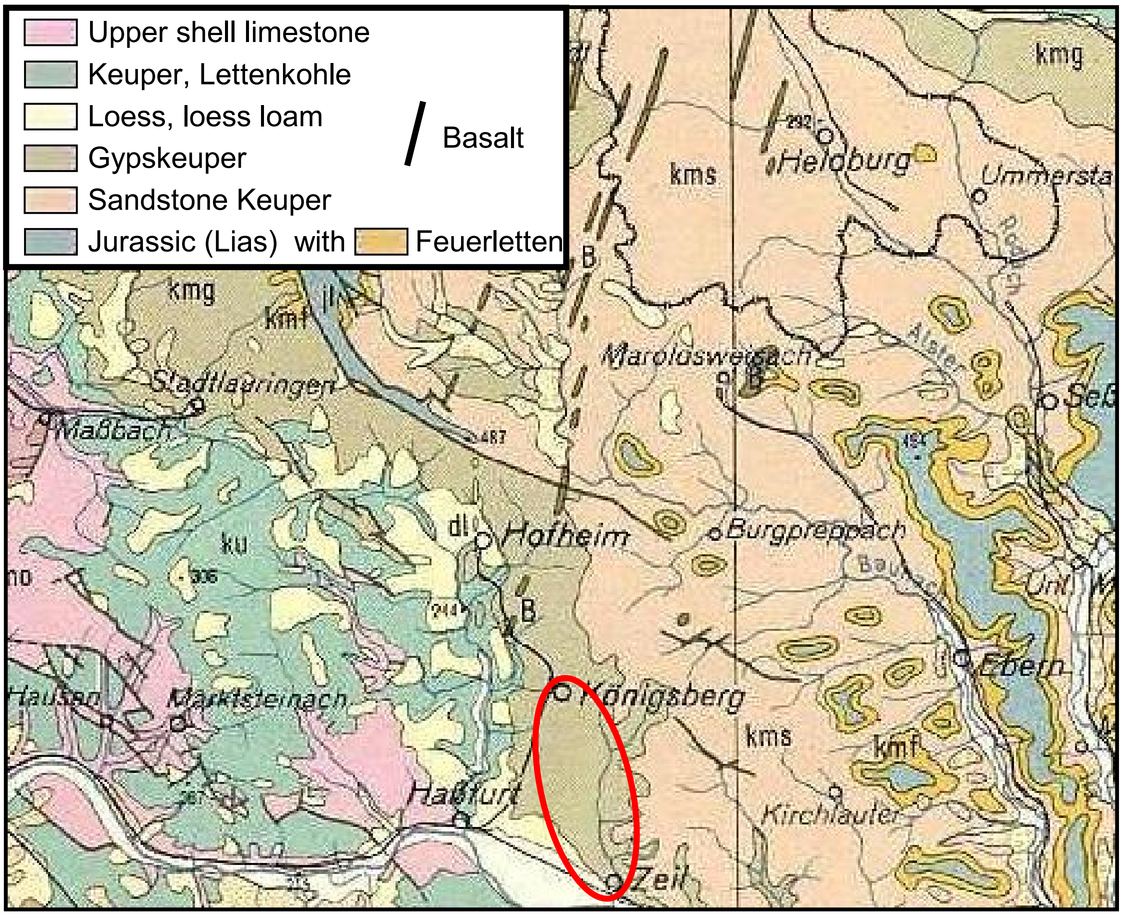

Figure 2.6: Geology of the Hassberge. Geological Map of Bavaria of the Bavarian Geological State Office, Munich 1954. The red outline marks the investigation area.

The pre–stage traverses the investigation area from north to south and contains the Krumbachtal. Westward of Prappach another of these pre–stage levels can be found. The Krumbachtal and the Sterzelbach in Prappach are dominated by Holocene material. Westward of the valley and south–west of Prappach loess–containing Pleistocene sands and loams occur. In the south–western part of the investigation area even drift sands can be found (Elsner 1994). Geomorphologically a clayey base layer and a sandy main layer can be distinguished (cf. Boldt 2001).

The relief as can be seen today was created to a large extend during the tertiary, except for the Pleisto- and Holocene sedimentations along the valleys. The pre–stage to date is highly eroded down to the Shelf Sandstone layer; prominent landmarks are e.g. the Hohe Wann (388 m a.s.l.), Kleine Hohe Wann (348 m a.s.l.), Rappberg (343 m a.s.l.), Rauchberg (344 m a.s.l.) and Hohe Wart (356 m a.s.l.). Solifluction, eolic shifts of material as well as anthropogenic influences during the last millennium (e.g. planation of farmland) have influenced the slope and valley areas and counteract the high relief energy within the investigation area (Eibich 2002).

Soils

Depending on their bedrock different soil types originated. Clay stone and Letten formed heavy soils characterised by intensive swelling and shrinking processes causing a specific water balance. Dry conditions lead to an easily water permeable soil status whereas wet conditions make the soils largely impermeable for water (Elsner 1994). Depending on the clay and carbonate content neutral to slightly acid Cambisols (Brown Earths), Pelosol–Cambisols or Pelosols developed. Especially Pelosols are often superficially decalcified. In places where viticulture was pursued Rigosols are found (Elsner 1994).

Slightly to moderately acid Cambisols or Gray brown podsolic soils originated from Sandstone bedrock (Bushart 1992). On loess loam alkaline Cambisols developed (Elsner 1994).

soil type	% area
Pelosols	34,1
Cambisols (Brown earths)	20,1
Kolluvisols	15,6
Gleys	8,3
Rankers	4,3
Man-made soils	3,8
Pararendzinas	3,2
Vegas	2,0
Pseudogleys	1,2
Gray brown podsolic soil	0,7
Regosols	< 0,1

Table 2.4: Soil types in the Hassberge.

In the course of the MOSAIK–project a detailed survey and mapping on soil types of the Hassberge investigation area took place (see Eibich 2002). It turned out that most of the soils are Pelosols (34,1 %) followed by Cambisols (20,1 %) and Kolluvisols (15,6 %) (Table 2.4).

Pelosol subtype	% area	pH
Norm-Pelosol	8,7	very acid - alkaline
Pelosol	3	very acid - alkaline
Pararendzina-Pelosol	0,4	neutral - alkaline
Lime-Pelosol on marl stone	4,4	neutral - alkaline
Lime-Pelosol on clay stone	*8,9*	*neutral - alkaline*
Cambisol-Pelosol on Shelf Sandstone	3,2	very acid - slightly acid
Cambisol-Pelosol on clay stone	1,7	very acid - slightly acid
Cambisol-Pelosol on marl stone	3,8	very acid - slightly acid
Pseudogley-Pelosol	< 0,1	neutral - alkaline
Gley-Pelosol	< 0,1	neutral - alkaline

Table 2.5: Pelosol subtypes according to Eibich (2002). Italic letters mark the most abundant subtype.

Pelosols are soils originating from primary clayey bed rock (e.g. clay stone or clay marl stone) (Arbeitsgruppe-Boden 1996). Eibich (2002) subdivides them into 10 subtypes (Table 2.5) that can be distinguished by their horizon sequence, their underlying bedrock and pH–values.

Cambisol (Brown earth) subtype	% area	pH
Norm-Cambisol	*11,2*	*very acid - slightly acid*
Cambisol with top layer of drifting sand	1,5	very acid - slightly acid
Cambisol (silty, loamy material)	4,9	very acid - slightly acid
Cambisol (often with colluvial cover)	0,9	very acid - slightly acid
Ranker-Cambisol	< 0,1	very acid - slightly acid
Pararendzina-Cambisol	0,3	neutral - alkaline
Pelosol-Cambisol	0,3	acid - slightly alkaline
Gray brown podsolic soil-Cambisol	1,0	acid - alkaline
Pseudogley- Cambisol	< 0,1	very acid - slightly acid

Table 2.6: Cambisol (Brown earth) subtypes according to Eibich (2002). Italic letters mark the most abundant subtype.

Cambisols (Brown earths) develop on different bed rocks (Arbeitsgruppe-Boden 1996). Eibich (2002) subdivided them into 9 subtypes (Table 2.6). They are also distinguished by their sequence of horizons and their underlying bedrock. Most subtypes found in the investigation area show an acidic pH.

Kolluvisol subtypes	% area	pH
Norm-Kolluvisol	*4,3*	*very acid - slightly alkaline*
Kolluvisol on Keuper clay	1,5	neutral - slightly alkaline
Kolluvisol on marl	3,3	alkaline
Pseudogley-Kolluvisol consisting of sandy-silty material on clay or marl	1,2	very acid - neutral
Thick Pseudogley-Kolluvisol consisting of sandy- silty material	2,3	very acid - neutral
Pseudogley-Kolluvisol consisting of clayey material on clay stone or marl	0,5	acid - alkaline
Relict Gley-Kolluvisol	2,5	very acid - neutral

Table 2.7: Kolluvisol subtypes according to Eibich (2002). Italic letters mark the most abundant subtype.

Kolluvisols as the 3rd most abundant soil type in the area originate from shifted humous soil material (Arbeitsgruppe-Boden 1996). It was either washed away by water and accumulated on slope bases, in depressions or small valleys, or was eroded by wind and subsequently accumulated. Also anthropogenic influences (e.g. farming) caused soil shifts. Eibich (2002) found 7 different Kolluvisol subtypes in the investigation area (Table 2.7). They are distinguished by the way of how material was shifted (i.e. fluviatile, eolic, anthropogenic) and their underlying bed rock. The pH ranges from very acid to alkaline with emphasis on acidic values.

Worth mentioning are also the man–made soils (Rigosols) including vineyards and farmland. Their original sequence of horizons was largely lost due to human activity. They include the deep–ploughed soils which are found under vineyards and make up about 3–4% of the investigation area (see Eibich 2002).

Climate

The macroclimate of the investigation area is stamped by oceanic and continental influences. According to Elsner (1997) it is considered a typical summer rain area. The Hassberge are situated in the climatic region of 'Obermain am Rande des Maintals' (Elsner 1994). Mean annual precipitation amounts to 650–700 mm (Hassfurt 643 mm), the mean annual temperature is 7,5–8,5°C (Elsner 1994). Relatively high winter temperatures are especially important for viticulture. In January they average –1°C (Elsner 1994). The vegetation period lasts between 150 and 160 days (Elsner 1994).

Utilisation

Within the geographical classification of natural landscapes the Hassberge belong to the Keuper–Lias–Land and to the main unit of the Keuperbergland. They mostly consist of forested areas; agriculturally used land is predominantly confined to more or less extended clearings (Kühne 1971). Utilisation in the Hassberge area can be traced back more than a thousand years. Human influence included clearings, straw meadows, forest pasture, afforestation, and crop cultivation (including the consequent spread of weed communities). Beside farmland and pastures viticulture along the southward facing slopes of the main and pre–stage was an important source of income. In 1913/14 the vineyards were infested with the vine pest causing the region's viticulture to collapse almost completely, it has not yet recovered to date even though there has been an increase within the last few decades (Eibich 2002). Also Shelf Sandstone was mined in the area.

The vegetation is dominated by central European–subatlantic and temperate–continental floral elements, but there are also characteristic species of neighbouring floral regions (Müller-Hohenstein 1971). Steep slopes as well as the Franconian way of bequest (Realteilung) resulting in small land parcels, and furthermore poorly workable soils have prevented agriculture in the investigation area from becoming as intense as in other German regions (Schlumprecht 2004). Instead, traditional rural cultivation created habitats featuring a rich flora and fauna, of which most are used as pastures or farmland, and dry slopes are grown with grapes. However, the floral composition of pastures and farmland still in use changed to a great extend by fertilisation and application of chemicals (herbicides and/or insecticides) as well as the cleaning of seeds before sowing. Land consolidation contributed to the impoverishment of habitat structures such as hedges. Besides, private vineyards and the traditional management (e.g. migrating sheep and goat herds; mowing for hay and animal bedding) are a declining form of utilisation, especially for marginal pieces of land. In the past they used to contribute to the income of the owners but nowadays they become more and more unprofitable, and are left to themselves and therewith to natural succession, including a number of rare plant and animal species that adapted to a habitat created under these conditions. Species like *Prunus spinosa* take advantage of ceasing utilisation and invade fallow areas causing vulnerable light–demanding species to disappear. Many parcels of fallow farmland or pastures are found in the area, but most of these areas are still being mowed or mulched due to the fact that farmers receive financial benefits for not leaving the land to natural succession.

Today's utilisation depends much on the slope gradient (Strauß 2002). Flat areas are predominantly used as farmland even though the arable land grade is generally rather low: 30–36 on clayey substrate and 25–35 on sandstone (Elsner 1994). Only gray brown podsolic soils originating from loess loam are given values from 61–74. Agriculturally used land takes up 35% of the investigation area (Strauß 2002) (Table 2.8). In addition, there are 10% of fallow farmland. Most of the sloped land is used as grassland or open orchard meadows; steep slopes are sporadically grown with grapes (Strauß 2002). Many of the pastures still in use are mowed once or twice a year, others are mowed once and then grazed, others again are solely grazed. Fallow farmland or pastures can be found in different successional stages, ranging from recently abandoned, i.e. 1–5 years ago, to long–term abandonment dating back more than 20 years.

Biotopes

Within the MOSAIK–project a biotope mapping took place (Eibich 2001) (see Table 2.8). In the following a short characterisation of the biotope types based on Eibich (2001) will be given.

As mentioned above the quality of the 'arable land' is rather poor, nitrogen supply is limited. Predominant crops are raps, different grains, root crops and flax, and a number of arable weeds are found (e.g. *Apera spica–venti*, *Matricaria maritima*).

Table 2.8: Size of biotope types within the investigation area (modified according to Strauß (2002) and Eibich (2001)).

biotope type	**ha**	**%**
arable land	**736**	**35**
fallow farmland	**219**	**10**
- fallow farmland 1-3 years	71	3
- fallow farmland >3 year with mesotraphent species	53	3
- fallow farmland >3 year with thermophilic species	95	5
grassland	**386**	**18**
- fertilised meadows	107	5
- fertilised meadows with species indicating nutrient–poor conditions	99	5
- extensively used dry meadows	126	6
- Mesobromion	54	3
fringe, thermophilic	**17**	**1**
hedges, copses, shrubs (thermophilic or mesotrophic)	**115**	**5**
forests	**462**	**22**
sealed surface	**110**	**5**
miscellaneous	**64**	**3**
total	**2109**	**100**

'Fallow farmland 1–3 years' includes former arable land which was abandoned 1–3 years ago. Vegetation is sparse and mostly consists of annuals or biennials mingled with former crop species and arable weeds.

'Fallow farmlands >3 years with mesotraphent/thermophilic species' were abandoned more than 3 years ago. Nutrient–rich and shady conditions support mesotraphent perennial herbs (e.g. *Aegopodium podagraria*) and grasses forming a closed vegetation cover. In contrast dry sunny locations provide suitable conditions for thermophilic perennial ruderals (e.g. *Melilotus officinalis*) and species of extensively used grasslands (e.g. *Melampyrum arvense*). Arable weeds in both biotope types indicate the former utilisation.

Grasslands make up 18% of the investigation area, four different types can be distinguished (see Table 2.8). Species–poor tall–growing stands dominated by productive grasses (e.g. *Lolium perenne*, *Phleum pratense*) form the biotope type of 'fertilised meadows'. Generally they are cut at least twice a year and/or are grazed.

'Fertilised meadows with species indicating nutrient–poor conditions' are the manured version of the Arrhenatheretum elatioris and show sporadic species indicating their former floral composition (e.g. *Anthoxanthum odoratum*, *Salvia pratensis*). *Alopecurus pratensis* or *Lolium perenne* as exemplar species dominate the stands showing intensive utilisation. The biotope type underlies the same treatments as 'fertilised meadows'.

'Extensively used dry meadows' generally belong to the Arrhenatheretum elatioris and are regularly used (cutting once or twice a year or rotation pasture). Indicators of intensively treated meadows are missing as they receive no fertilisers. *Salvia pratensis*, *Ranunculus bulbosus* or *Leucanthemum ircutianum* give a colourful impression. These meadows are generally confined to sites hard to manage.

'Mesobromion' is found only on dry sunny sites. Species combination depends on the type of utilisation. On mowed sites *Bromus erectus* is the characteristic grass species; *Primula veris* and *Onobrychis viciifolia* are abundant herbs. Phytosociologically they belong to the Mesobrometum. If the sites are used as rotation pastures *B. erectus* disappears in favour of a Gentiano–Koelerietum pyramidatae.

'Thermophilic fringes' are found on the same sites as dry grasslands. They often lead over from copses to the Mesobromion and can be several meters wide. Thermophilic fringes are not utilised, they are characterised by tall–growing perennials like *Astragalus glycyphyllos*. Without mowing or the occasional shrub encroachment they would turn into thermophilic copses.

The biotope type 'hedges, copses, shrubs' includes linear hedges as well as extensive copses. The latter forms a nearly closed shrub layer, up to 2–3 m height. Hedges and copses may consist of meso– and thermophilic species, and are often connected to fringes and dry grasslands. Frequently old fruit trees are embedded.

Tree stands larger than 1 ha are considered as 'forests'.

The investigated utilisation types included utilised and fallow farmland, utilised and fallow grasslands, hedges and copses.

Conservation history

The investigation area Hassberge is located in the nature reserve 'Hohe Wann'. It belongs to the nature park 'Hassberge' (Anonymus 1983) and was given the status of a nature reserve in 1996. The main intention amongst others is to preserve the characteristic and small parcelled structures originating from the traditional viticulture for endangered animal and plant species. Another objective is to conserve the characteristic landscape predetermined by the natural relief as the rural land use created a diverse mosaic of utilisation, e.g. in nutrient poor dry grasslands or extensively used farmland.

Experimental design

All the studies made for this project are data–defined *sensu* Gitay & Noble (1997).

Sampling design

Müritz

In the Müritz study area 120 sampling plots were set up within a regular 50 m x 50 m – grid. The plots were arranged with emphasis on the biotope types of which there are 6 main types in the investigation area. Where possible they were divided into a dry and a wet variant (see Table 2.3). Attention was also paid to the percentage of area covered by the biotope, and to the terrain's contour lines to record the differences even for small altitudinal gradients. Density of sample plots was higher where habitat combinations changed rapidly on a small scale (e.g. ground level elevation)

Fig. 2.7: Sampling plots Müritz area. Left: 2 m x 2 m – version, right: 1,5 m x 1,5 m – version.

The plots consisted of a 1,50 m x 1,50 m (in heavily grazed areas) or 2 m x 2 m (in less grazed areas) exclosure (Figure 2.7) and an equally sized adjacent comparable plot outside the exclosure.

Hassberge

In the Hassberge area I used random stratified sampling to set up 120 sampling plots with a size of 2 m x 2 m along a gradient of soil humidity and management regime, including mowing, grazing, mowing and grazing, roto–tilling, vineyards, farmland, and fallow lands in different successional stages. 16 plots were established in co–operation with Fritzsch (2004) on the roto–tilled slopes, 59 plots with Binzenhöfer (2004) and Hein (2004) on farmland, utilised grassland, and fallow land older than 10 years. The remaining 45 plots were set up on vineyards and fallow land younger then 10 years.

Variables

For each of the 120 plots several variables were recorded. They are distinguished into explanatory and response variables.

Explanatory variables

Explanatory variables include soil factors, disturbance parameters and geomorphological characters.

Soil factors

Soil samples were taken from each layer of a 60 cm deep hole (where possible). Layer thickness and stone content were recorded on site, the following parameters were determined in the laboratory: texture, soil density, pH, $CaCO_3$, K, P, C, N. For methodology see Table 2.9.

Variable	abbreviation	method	literature
texture	-	finger test	Arbeitsgruppe-Boden (1966)
stone content	-	tables	
water permeability in saturated soil	kf	tables	
plant available water	PAW	tables	
air capacity	AC	tables	
effective cation exchange capacity	CEC_{eff}	tables	
total carbon	C	Carlo–Erba C/N–Analyser	-
total nitrogen	N	Carlo–Erba C/N–Analyser	
soil density	-	drying and weighing of a 100 cm³ soil sample	Schlichting *et al.* (1955)
calcium carbonate	$CaCO_3$	gasvolumetrical determination according to SCHEIBLER	
pH	pH	potential in $CaCl_2$	Schachtschnabel *et al.* (1984)
plant available potassium	K	ammonia–lactate solution according to EGNER & RIEHM	
plant available phosphorus	P		

Table 2.9: Methodology for soil sampling and literature.

For the Müritz area additionally soil water logging in winter (SWL_{wint}) and in summer (SWL_{summ}) was recorded.

Disturbance parameters

For the Müritz area

- winter grazing intensity (GI_{wint}) and
- summer grazing intensity (GI_{summ})

were recorded. To do so, in each exclosure and its adjacent comparable plot a 1 m² area was mowed. Summer mowing took place from July – August 2001 and winter mowing in March 2002. The samples were dried for 40 hours at 60°C to achieve a constant weight. Grazing intensity is defined as the percentage of eaten biomass on the comparable plot in relation to the exclosure biomass (potential biomass production).

For the Hassberge area the following disturbance parameters were recorded:

- disturbance frequency

- disturbance magnitude
- below–ground disturbance 1997
- above–ground disturbance 1997
- disturbance week.

Table 2.10 gives an overview on the used categories.

Table 2.10: Disturbance categories for the Hassberge area.

disturbance parameter	category	explanation
frequency	0.01	longer than every 10 years
	0.13	every 6 - 10 years
	0.27	every 2 - 5 years
	0.33	every 3rd year (roto-tilling)
	0.5	every 2nd year (roto-tilling)
	1	1x (roto-tilling 1x per year or mowing 1x per year)
	2	2x (mowing 2x per year or extensive grazing)
	3	3x (mowing+grazing)
	4	4x (intensive grazing)
	5	5x (arable fields or vineyards)
magnitude	50	ca. 50% destroyed (above ground disturbance) (mowing or grazing or mowing+grazing)
	100	ca. 100% destroyed (below ground disturbance) (arable fields or vineyards or roto-tilling)
below-ground disturbance 1997	0	no below-ground disturbance 5 years ago
	1	below-ground disturbance 5 years ago (arable fields, vineyards, roto-tilling)
above-ground disturbance 1997	0	no above-ground disturbance 5 years ago
	1	above-ground disturbance 5 years ago (mowing, grazing, mowing+grazing)
week	1 - 53	number of week; week 53 stands for fallow

Geomorphological parameters

The Hassberge area features a high relief energy. Therefore

- slope and
- exposition

needed to be recorded. Exposition was coded in a binary variable with all slopes exposed in south–eastern to west north–western direction being called sunny slopes while those ranging from north–west to east south–east denoted as shady slopes (Arbeitsgruppe-Boden 1996).

Response variables

The response variables included species composition as well as the biological traits, the latter was recorded on selected plots depending on individual plant quality. Only vascular plants were taken into account.

Species composition

The occurrence of plant species on the plots was recorded as presence/absence data. Recording took place twice: the first time in May to define the spring flowering species, the second time in July for the complete summer species set.

Biological traits

After recording species composition certain species were chosen to analyse their biological traits. The following species–selection–criteria were applied:

1. Prevalence: A species had to occur in at least 10% (i.e. 12) of the sampling plots.
2. Dominance: Dominant species were measured. This also includes those in less than 10% of the sampling plots (e.g. *Calamagrostis epigejos*, *Cladium mariscus*).
3. Selection: A few species were selected, that were
    a) important for a certain habitat type (e.g. *Erodium cicutarium* for intensely grazed and dry habitats) or
    b) existent in both investigation areas (e.g. *Galium verum*, *Daucus carota*) or
    c) named in the Red Data Book for endangered plant species of the concerned federal states (e.g. *Pinguicula vulgaris*, *Ranunculus flammula*). Orchids were not included.
    This category also concerns species occurring in less than 5% (i.e. 6) but at least 3,33% (i.e. 4) of the sampling plots.

For a) and b) applies that no species occurs in less than 5% (i.e. 6) of the plots.

This resulted in 88 species for the Müritz and 75 for the Hassberge (Table 2.11).

Biological traits in the field were recorded according to Cornelissen *et al.* (2003), and included specific leaf area (SLA), canopy height, seed mass (only for Müritz) and seed number (for Müritz complete, for Hassberge only partly). Further data were gathered by means of literature (see Table 2.12).

The determination of seed number was carried out as follows: Six inflorescences were collected from six different individuals/ramets at different sites, and the total number of inflorescences was counted. The seeds per inflorescence were counted and multiplied by the number of inflorescences per individual/ramet. This resulted in the total seed number per individual/ramet.

Measuring seed weight was difficult to conduct, as in many cases it was impossible to obtain sufficient seed numbers due to seed predation or unripeness. However, for most species at least ten seeds were available for weighing, for detailed values see Appendix Table 1.

For measurements of SLA the ADC Area Meter AM 100 was used. Ten individuals were sampled at ten different sites, area and weight of two leaves per individual were measured. The mean of all 20 leaves was taken as the overall SLA–value per species.

Canopy heigt was measured at ten sites as described in Cornelissen *et al.* (2003).

Table 2.11: Selected species for which biological traits were recorded.

species	**Müritz**	**Hassberge**
Achillea millefolium	x	x
Agrimonia eupatoria		x
Agropyron repens	x	x
Agrostis capillaris	x	
Agrostis stolonifera	x	
Alopecurus pratensis		x
Anthoxanthum odoratum	x	x
Armeria maritima ssp. *elongata*	x	
Arrhenatherum elatius		x
Avenula pubescens	x	x
Brachypodium pinnatum		x
Briza media	x	
Bromus erectus		x
Bromus hordeaceus	x	x
Bromus sterilis		x
Bupleurum falcatum		x
Calamagrostis epigejos	x	
Calamagrostis stricta	x	
Capsella bursa-pastoris	x	
Carex arenaria	x	
Carex disticha	x	
Carex flacca	x	
Carex hirta	x	
Carex nigra	x	
Carex panicea	x	
Centaurea jacea	x	x
Centaurea scabiosa		x
Cerastium arvense	x	
Cerastium brachypetalum		x
Cerastium glomeratum	x	
Cirsium arvense	x	x
Cirsium palustre	x	
Cladium mariscus	x	
Convolvulus arvensis	x	x
Cornus sanguinea		x
Crataegus monogyna		x
Cynosurus cristatus	x	
Dactylis glomerata	x	x
Danthonia decumbens	x	
Daucus carota	x	x
Deschampsia cespitosa	x	
Dianthus carthusianorum		x
Eleocharis uniglumis	x	
Erodium cicutarium	x	
Euphorbia cyparissias		x
Falcaria vulgaris		x
Festuca ovina agg.	x	x
Festuca pratensis	x	x
Festuca rubra	x	x
Fragaria viridis		x
Galium aparine		x
Galium mollugo	x	x
Galium palustre	x	
Galium uliginosum	x	
Galium verum	x	x
Genista tinctoria	x	
Gentianella uliginosa	x	
Geum urbanum		x
Holcus lanatus	x	x
Hydrocotyle vulgaris	x	
Hypericum perforatum		x
Inula conyza		x
Juncus articulatus	x	
Juniperus communis	x	
Knautia arvensis		x
Lathyrus pratensis	x	x
Leontodon autumnalis	x	
Leontodon hispidus	x	x

species	**Müritz**	**Hassberge**
Leucanthemum vulgare		x
Linum carthaticum	x	
Lolium perenne	x	x
Lotus corniculatus	x	x
Lotus uliginosus	x	
Luzula campestris	x	
Luzula campestris		x
Medicago lupulina	x	x
Mentha aquatica	x	
Molinia caerulea	x	
Myosotis ramosissima		x
Odontites vulgaris	x	
Ononis repens		x
Origanum vulgare		x
Parnassia palustris	x	
Phragmitis australis	x	
Pimpinella saxifraga		x
Pinguicula vulgaris	x	
Plantago lanceolata	x	x
Plantago media		x
Poa annua	x	
Poa pratensis agg.	x	x
Poa trivialis	x	x
Polygala vulgaris	x	
Potentilla anserina	x	
Potentilla erecta	x	
Potentilla reptans	x	x
Potentilla neumanniana		x
Primula veris		x
Prunella vulgaris	x	
Prunus spinosa		x
Ranunculus acris	x	x
Ranunculus bulbosus		x
Ranunculus flammula	x	
Ranunculus repens	x	
Rhinanthus minor		x
Rhinanthus serotinus	x	
Rosa canina agg.		x
Rumex acetosa	x	x
Rumex acetosella	x	
Salix repens	x	
Salvia pratensis		x
Sanguisorba minor		x
Saxifraga granulata		x
Stellaria graminea	x	
Succisa pratensis	x	
Taraxacum officinale agg.	x	x
Taraxacum palustre	x	
Thlaspi perfoliatum		x
Tragopopgon pratensis		x
Trifolium fragiferum	x	
Trifolium pratense	x	x
Trifolium repens	x	x
Trisetum flavenscens		x
Valeriana dioica	x	
Valerianella locusta		x
Veronica arvensis	x	x
Veronica chamaedrys	x	x
Vicia angustifolia		x
Vicia cracca	x	
Vicia tetrasperma		x
Viola canina	x	
Viola hirta		x

Table 2.12: Traits gathered from literature.

trait	source
woodiness	Poschlod *et al.* 2003
clonality (length of tillers)	Klimeš *et al.* 1997
spacers (above or below ground)	Klimeš *et al.* 1997; Poschlod *et al.* 2003
plant life span	Rothmaler 1994; Kleyer 1995
aerenchyma	only Müritz, Eber, pers. comm.
thorny and other physical defence	only Müritz, Klapp 1971; Rothmaler 1995; Kossegg 2001; Poschlod *et al.* 2003
start seasonal seed shedding	only Hassberge, Poschlod *et al.* 2003
seed number	field measurements (Müritz and partly Hassberge) and Stakevitch 1988; Eriksson & Jakobsson 1998; Kästner *et al.* 2001; Poschlod *et al.* 2003
seed mass	field measurements (Müritz and partly Hassberge) and Eriksson & Jakobsson 1998; Klotz *et al.* 2002; Cerabolini *et al.* 2003
seed longevity in soils	Lefèbvre & Chandler-Mortimer 1984; Aarssen *et al.* 1986; Grunicke 1996; Kühner 1998; Oberdorfer 2001; Römermann 2002; Cerabolini *et al.* 2003; Poschlod *et al.* 2003; Fritzsch 2004

However, considering the single investigation areas, one will notice that the recorded traits were different (see Table 2.12). This applies to aerenchyma, thorny and other physical defence and the start of seed shedding. The reason for these differences are environmental conditions. Soil water logging, for example, occurred only in the Müritz area. There, presence of aerenchymas was included in the selected traits as they ensure the internal gas transport and therewith the survival of species on frequently or permanently waterlogged soils (e.g. Colmer 2003). The start of seed shedding was not considered for the Müritz area as for most plots there was no uniform utilisation such as mowing. Thorny and other physical defence were left out for the Hassberge as grazing was only a minor disturbance factor and mostly combined with mowing. However, 8 traits were consistently recorded in both investigation areas, namely SLA, canopy height, woodiness, spacers, clonality, seed mass, seed number, seed longevity in soil (SLI) and plant life span.

Statistics

Indices

Indices were calculated for traits of which information was compiled from the literature, i.e. seed longevity, plant life span, spacers, woodiness and clonality. This became necessary since different authors gave different statements on the considered traits. The above mentioned traits consist of three trait attributes (e.g. *trait*: 'plant life span'; *trait attributes*: 'annual', 'biennial', 'perennial') (see Table 2.13). Generally, for the index ranking the underlying conditions were considered undisturbed. Therefore, the 'strongest' (i.e. most competitive) trait attribute was ranked '1' (t_n), the 'weakest' (i.e. least competitive) was ranked '0' (t_1). All attributes lying inbetween t_1 and t_n are ranked according to the following formula:

$$r_i = \frac{i-1}{n-1} \qquad \text{(formula 1)}$$

r_i = rank of trait attribute
i = trait attribute number
n = total number of trait attributes of the considered trait

The indices of plant life span, spacers, woodiness, and clonality were calculated similar to the seed longevity index (SLI) (see Thompson *et al.* 1998). The following slightly changed general formula applied:

$$I = \frac{\sum_{i=1}^{n} x_i * (\frac{i-1}{n-1})}{\sum_{i=1}^{n} x_i} \qquad \text{(formula 2)}$$

I = Index
i = trait attribute number
n = total number of trait attributes of the considered trait
x_i = number of literature records for trait attribute

Indices always adopt values within the continuum of '0' to '1', and are then assigned to the attribute ranks. However, an exception is SLI. Its values are not continuous but were classified according to R. Bekker (pers. comm.) (see Table 2.13). There are no indices for numerical traits such as SLA, canopy height, seed number and seed mass.

Table 2.13: Traits and trait features. (*according to Bekker, R., pers. comm.)

trait	data type	trait features
specific leaf area (SLA)	numerical	$mm^2 * mg^{-1}$
canopy height	numerical	mm
seed mass	numerical	mg per seed
start seed shedding	numerical	month
seed number	numerical	number
aerenchyma	categorical	0 – not present 1 – present
physical defence	categorical	0 – not present 1 – present
clonality (length of tillers)	categorical	0 – not clonal 0.5 – < 10mm 1 – >10mm
plant life span	categorical	0 – annual 0.5 – biennial 1 – perennial
spacers (above or below ground)	categorical	0 – no spacers 0.5 – above ground 1 – below ground
woodiness	categorical	0 – not woody 0.5 – woody at base 1 – woody
seed longevity in soil (SLI)	index	< 0.3* – transient 0.3–0.55* – short-term persistent > 0.55* – long-term persistent

Given the case that there are records for only one attribute of the traits we considered, 'distinct values' can be defined for each trait attribute, i.e. '1' for strongest competitive trait, '0.5' for medium strong competitive trait and '0' for weakest competitive trait.

Even though there were data available for most of the traits there are no index values for some species. The reason for this phenomenon are contrary records for trait attributes. To give an example: As mentioned above the trait 'plant life span' consists of the 3 trait attributes 'annual', 'biennial', and 'perennial'. 'Perennial' is considered the strongest attribute (=‘1’), as once established the species can hold its ground. The weakest attribute is ‘annual’ (=‘0’) as the species will have to re–establish in a suitable place. According to literature study *Medicago lupulina* had two records for ‘perennial’, and one record for ‘annual’. The result after using the formula is a value of ‘0.6667’. This index, though, locates the species in the vicinity of ‘biennial’ (see below) which is not consistent with the literature records. Therefore, for *M. lupulina* the trait ‘plant life span’ was left out from the index table.

So before going into further analyses, checking on every index is absolutely necessary.

Statistical analysis

Three different matrices were set up: (1) ‘site x species matrix’, (2) ‘site x environmental factors matrix’, and (3) ‘species x trait matrix’ (see Appendix Tables 2 – 5 for the Hassberge, and Appendix Tables 6 – 9 for the Müritz).

Logistic regression: Habitat models in this study were generated by means of stepwise logistic regression. To include a variable into the model a significance level of $p_{in}=0.1$ had to be met, equally $p_{out}=0.1$ applied to exclude a variable from the model. The models were evaluated using the goodness of fit measures of AUC– and R^2_N–value. The AUC is the **A**rea **U**nder a ROC (Receiver Operating Characteristic) – **C**urve. It evaluates the prediction of presences and absences by the regression model, and visualises the proportion of false positive predictions against the proportion of true positive predictions for a given number of different classification thresholds. According to Hosmer & Lemeshow (2000) an AUC exceeding 0.7 can be regarded as acceptable, an AUC beyond 0.8 is considered as excellent and > 0.9 is outstanding. For optimisation an AUC–threshold of 0.7 was introduced which a model had to meet to be processed further.

The second criterion on model quality is the R^2–value according to Nagelkerke (1991) (R^2_N) actually generalising the coefficient of determination for linear regression models. A high R^2_N–value indicates a well–calibrated model, i.e. a good fit between model and data (Reineking & Schröder 2004a). An R^2_N–threshold of 0.3 was used.

I checked for multicollinearity as too many variables cause an overfitting of the models, making them unreliable at least for independent test data sets (Harrell 2001). Also, interpretation of many variables is difficult (Reineking & Schröder 2004b). Therefore one of two highly correlated variables was omitted, and additionally those influencing only few species. For the latter step I decided iteratively by trial and error which variables could be omitted depending on the number of species being lost for clustering.

Clustering: To arrange the responsive species according to similar biological traits we used Ward’s clustering method (or minimum variance clustering) as it produces clusters of about the same size. Trait variables were standardised before clustering. In the procedure, the number of resulting clusters needed to be predefined. To receive an optimal number of clusters the SAS procedure was run for a number of 6, 7, 8, 9 and 10 clusters (for Chapter 3 and 4) and for 10, 11, 12, 13, 14, 15, 16 and 17 clusters (for Chapter 5). If the number of clusters is small, probability rises to receive very large clusters with 20 or more species. If the number of clusters is high many single species clusters can be expected.

Figure 2.8 shows an overview on the procedure of statistical analysis.

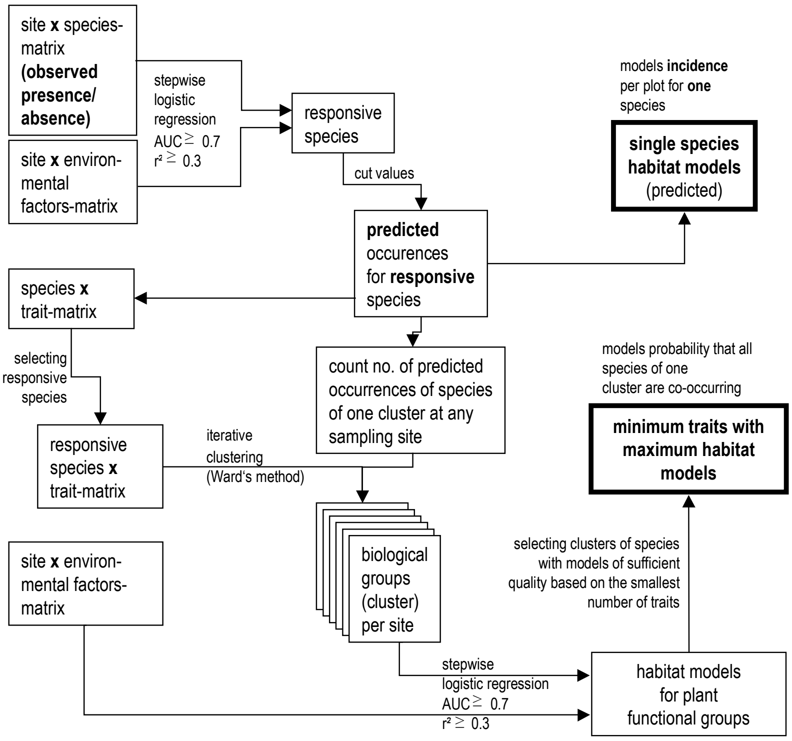

Figure 2.8: General statistical procedure.

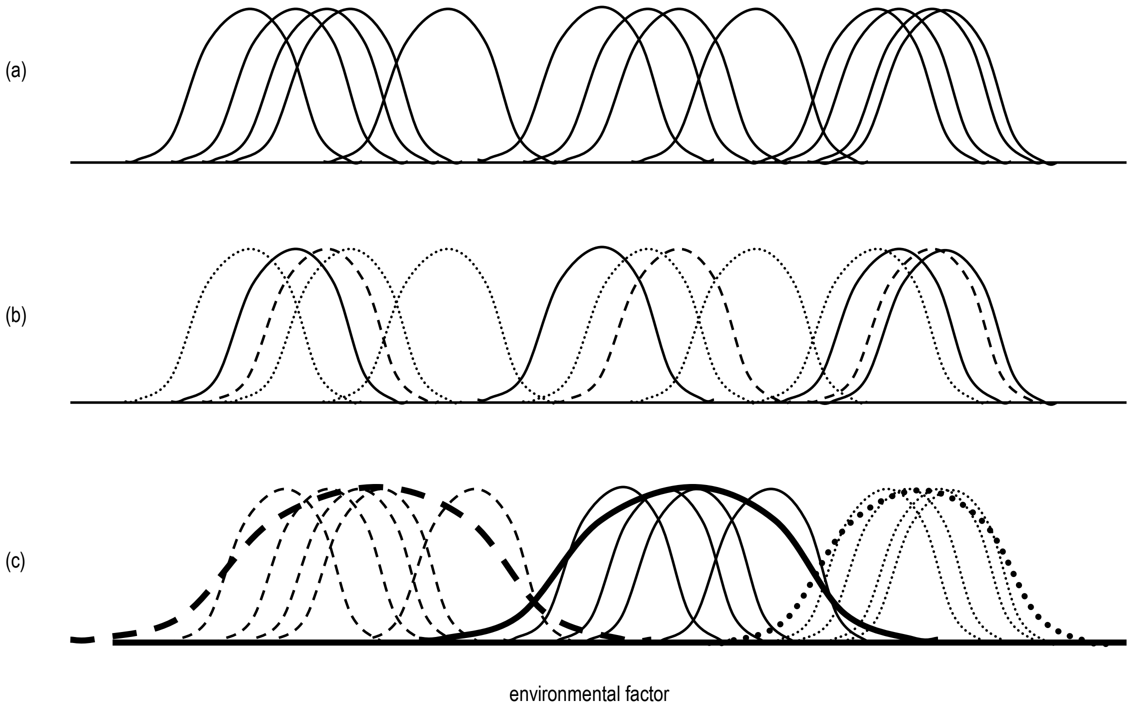

Figure 2.9: Clustering procedure for species with similar trait attributes (e.g. three clusters: dotted, dashed and continuous lines); (a) response curves of responsive species (results from step 1); iterative clustering and logistic regression (step 2) resulting in (b) clusters of low quality yielding no plant functional group models – species DO NOT co–occur, and (c) clusters of high quality yielding significant, well calibrated plant functional group models – species DO co–occur.

Step 1: Habitat models for single species:

Setting the ‘site x species matrix’ and the ‘site x environmental variables matrix’ we determined the ecological optimum of single species based on resource availability and disturbance intensity applying stepwise logistic regression as outlined above. Most of this step was done in SAS. However, in cases where the estimation procedure for the maximum likelihood was not conducted, we calculated the models with SPSS.

At the end of step 1 we received cross–validated predicted occurrences for responsive species (significant models meeting the introduced goodness of fit thresholds) and therewith habitat models for single species modelling the incidence per plot for one species (Figure 2.9 a).

In using only species with significant, cross–validated models and sufficient model quality (i.e. responsive species) we expect habitat models for plant functional groups of better quality by reducing ‘noise’ caused by low quality models.

Step 2: Habitat models for plant functional groups:

Setting the ‘species x trait matrix’ the responsive species from step 1 were selected and iteratively clustered into biological groups according to their biological traits. For each cluster the number of the cross–validated predicted occurrences of its species was counted at any sampling site. These cluster data and the ‘site x environmental factors matrix’ were then again put into another stepwise logistic regression procedure (events–trial option, SAS-Institute 1989) with the above mentioned goodness of fit measures. The regression estimates, for a given species group with similar biological traits, the probability of co–occurrence of all species in this group along gradients of soil and disturbance factors. An optimum occurs where most species of the group are present (Figure 2.9 c) An alternative approach would be to simply model all occurrences of species of a group under the label of this group (see Nygard & Ejrnæs 2004). However, this would lead to multiple occurrences per site if two or more species belonging to one cluster co–occur and violate the assumption of statistical independence (Legendre *et al.* 1997). Note that both methods are biased towards species with many occurrences if a cluster consists of species which exhibit large variation in prevalence.

The result are habitat models for plant functional groups. This step was iterated for each possible combination of trait attributes. We started by clustering the responsive species set on the basis of only one trait and running the logistic regressions for these clusters, then doing all combinations of two traits, followed by three traits etc.

Step 3: Selection of the most parsimonious set of functional traits:

As the goodness of fit thresholds eliminate models of low quality resulting in the loss of clusters and their species, and hence there is not only one habitat model per cluster resulting from step 2 but numerous models of different trait and species combinations, we needed to select functional groups with models of sufficient quality based on the smallest number of traits containing as many of the modelled species as possible. Therewith, the highest number of species in models with sufficient goodness of fit measures was selected and taken as the ultimate trait combination. Eventually these are the minimum traits with maximum habitat models.

The whole procedure involving several thousand regressions was implemented in a SAS–macro using PROC LOGISTIC and PROC CLUSTER (SAS-Institute 1989). Additional computations were done in SPSS.

CHAPTER 3

PLANT FUNCTIONAL GROUPS ALONG GRADIENTS OF SOIL RESOURCES AND MANAGEMENT

Plant functional groups along gradients of soil resources and management

with Michael Kleyer

Abstract

A new method was used to statistically model the occurrence of plant functional groups along single environmental gradients. We simultaneously analysed a species composition data set, an environmental gradient data set and a functional attribute data set. Responsive species were selected to create plant functional groups (PFG) with the most parsimonious set of attributes, which consists of plant life span, specific leaf area (SLA), canopy height and seed number. Plant life span is the most important trait extracted from the analysis to determine competitive success in the investigated grasslands. SLA and canopy height are dependent on soil nutrient and water status. There is a high variability of seed number among the single species of each PFG.

Stepwise logistic regression revealed the most important environmental factors for the PFGs. Mainly it is disturbance history accounting for the different attributes within PFGs. Plant available water (PAW) as well as pH and disturbance week are also important environmental variables. The presented habitat models for PFGs are strongly influenced by model quality of the contained species especially at low species numbers and species differing much in their single habitat requirements. Trying to suit every included species leads to lower quality PFG–models.

Nomenclature: Rothmaler (1994)

Introduction

Expert knowledge on the occurrence of plants is no longer sufficient to protect endangered species or communities. Effective conservation actions often require specific and accurate models of relations between organisms and their environment (O'Neil & Carey 1986; Stauffer 2002), and area–wide data bases and predictions about the distribution of plant species have become important planning instruments (Siemon 2003). One possibility to predict the impact of certain management strategies and changing environmental conditions are habitat models. By their means presence/absence or spatial distribution of focal species or groups are predictable (Peeters & Gardeniers 1998). Habitat models are an important part within modern conservation biology and environmental management (Morrison *et al.* 1998) as they are transparent, comprehensible and objective (Schröder 2002). They formalise habitat–environment–relationships by analysing readily recordable biotic and abiotic key factors, and furthermore quantify habitat quality of biotope types for selected species (Kleyer *et al.* 1999/2000; Schröder & Richter 1999/2000).

Single–species habitat models will result in an innumerable number of models world–wide. One way to reduce this diversity is the fact that every organism features certain morphological and reproductive attributes and therefore can be classified according to these traits. An established example is the life–form approach of Raunkiær (1934). Groups of species displaying similar biological traits and showing similar reactions to various environmental factors are called plant functional groups (Gitay & Noble 1997; Lavorel *et al.* 1997). Functionality has been discussed within several contexts including global climate response (Raunkiær 1934; Box 1981a) and climate change (Box 1996), exploitation of environmental resources (e.g. Simberloff & Dayan 1991; Wilson & Watkins 1995) or ecosystem function (Körner 1993).

There are two recent theories on plant functional groups; the CSR (Competitors, Stress–tolerators, Ruderals) concept first introduced in 1974 by Grime (Grime 1974; Grime 1979; Grime *et al.* 1988) and the Leaf–Height–Seed (LHS) strategy scheme published in 1998 by Westoby. According to Westoby (1998) the CSR concept focuses on coexisting species within a landscape, i.e. how they occupy and use a site; it is not orientated towards geographical–scale variation and implies a complex of plant traits (Grime *et al.* 1997c). In contrast Westoby's LHS scheme uses three readily measurable plant traits which are correlated with a number of other features not as conveniently recordable (Westoby 1998). Investigated species can easily be positioned within the scheme without reliance on observed species distributions relative to each other. It opens up the 'path to world–wide comparisons and meta–analyses' (Westoby 1998).

The concept of using biological traits to classify numerous species into fewer non–taxonomic groups has provided a useful alternative approach for ecological studies of a wide range of vegetation types (e.g. Grime *et al.* 1988; Leishmann & Westoby 1992; Boutin & Keddy 1993; Skarpe 1996; Sala *et al.* 1997; Scholes *et al.* 1997; Smith *et al.* 1997; Kleyer 1999; Gondard *et al.* 2003). Predicting the impact of perturbations with great sensitivity becomes possible by establishing functional group–environment relationships (Shipley & Parent 1991; Smith *et al.* 1993). In times of accelerated habitat fragmentation and loss, and growing impacts of global climate change these predictions of future vegetation composition are of increasing relevance (Grime 1993; Woodward & Cramer 1996; Días & Cabido 1997; Steffen & Cramer 1997).

Within the last centuries human activities opened up the central European landscape and kept it open over long periods of time, increasing habitat diversity. Continuous long–term man–made disturbances like traditional grassland utilisation systems (e.g. three–field rotations, migrating herds of domestic animals, mowing for animal food and bedding) have created habitats with nutrient–poor soils and high radiation (Hobohm 2000). Due to these favourable conditions species from other regions naturally expanded their range or were deliberately or incidentally introduced (Hobohm 2000). Those that now persist changed the floral composition, and diverse plant communities developed (Hobohm 2000). However, traditional ways of utilisation are abandoned (e.g. extensively used grassland ecosystems – Poschlod & Schumacher 1998) as value and profitability are decreasing, and in the way that cultural landscapes undergo transformations also plant communities and species compositions change. Protecting the habitats for rare plant and animal species has become an important and expensive task for conservation authorities and NGOs as ceasing anthropogenic disturbance or utilisation trigger secondary succession generally ending with the potential natural vegetation (Tasser & Tappeiner 2002). Today landscapes are kept open by regular mowing or migrating sheep herds, both of which are financially at least supported. High costs for personnell, machinery and disposal ask for alternative methods, e.g. permanent grazing systems with low–stock–densities or profound disturbances into the soil root zone within longer intervals.

The presented study is part of the MOSAIK–project. For 3 years the project investigated supposedly cheaper alternative methods for the expensive mowing procedure to preserve species–rich open landscapes. Here, we consider an agriculturally used area in southern Germany with a number of different utilisation types ranging from long–term abandonment over grasslands to intensive crop cultivation. Generally, changing environmental conditions lead to a patchy distribution of vegetation (e.g. Kleyer *et al.* 1999; Tasser & Tappeiner 2002). Amongst other factors the occurrence of plant species and communities greatly depends on the availability of resources as well as the disturbance regime (Peppler-Lisbach 2003); according to Grime (1979) these two parameters belong to the most important environmental factors for plant communities. Resources are to a great extend controlled by physical factors whereas human activities decidedly affect disturbance in cultural landscapes. Land–use imposes a large impact, in which type (e.g. grazing, mowing, roto–tilling, ploughing) and intensity (e.g. frequency, application of chemicals, number of grazing animals) create characteristic vegetation communities (Gómez-Sal *et al.* 1992; Linusson *et al.* 1998; Jutila 1999; Stampfli & Zeiter 1999). As it is a decisive factor in modelling community and species distribution (Zimmermann & Kienast 1999) land–use needs to be integrated into the modelling approach as one of the explanatory variables. For mountain vegetation Tasser & Tappeiner (2002) found land–use changes to be the most important driving force for vegetation change. Furthermore they state that both intensification and abandonment of extensively used areas are accompanied with decreasing species numbers.

For our analysis plant functional attributes, i.e. biological traits, were chosen considering their relevance for survival and regeneration in an agricultural landscape. Using multivariate statistics we classified the species pool into groups of similar biological traits. Based on the availability of data for the individual species traits are subjectively selected. In this study we considered two main gradients; i.e. resource supply and disturbance parameters. We suggest life history features such as plant persistence and expansion to exhibit large functional variations along with fertility, in contrast to regeneration.

Methods

Study area

The investigation area covers approximately 25 km² of dry grasslands, fields, fallow vineyards and shrubland at the western edge of the 'Hassberge' mountains in Lower Frankonia, southern Germany (50° 03' N, 10° 35' E). Clay stone, sandstones clays and clay marl stone as well as clay and marl slate with their interspersed sands and carbonates determine the area (Rutte 1981).

The macroclimate is stamped by oceanic and continental influences. Mean annual precipitation amounts to 650–700mm, the mean annual temperature is 7.5–8.5°C with relatively high winter temperature (Elsner 1994). Land use can be traced back more than a thousand years. Beside farmland and pastures viticulture along the southward facing slopes was an important sources of income. The steep slopes as well as the Franconian way of bequest resulting in small land parcels, and moreover poorly workable land have prevented agriculture in the investigation area from becoming as intense as in other German regions (Schlumprecht 2004). Instead the traditional rural cultivation created diverse habitats featuring a rich flora and fauna.

Today's utilisation depends much on the slope gradient (Strauß 2002). Flat areas are predominantly used as farmland. Most of the sloped land is used as grassland or open orchard meadows, steep slopes are sporadically grown with grapes (Strauß 2002). Many of the pastures are still in use (i.e. mowing, grazing, both); fallow farmland or pastures can be found in different successional stages.

For a more detailed overview see Chapter 2.

Sampling design

We used random stratified sampling to set up 120 plots with a size of 2 m x 2 m along a gradient of soil humidity and management regime, including mowing, grazing, mowing and grazing, roto–tilling, vineyards, farmland, and fallow lands in different successional stages. 16 plots were established in co–operation with Fritzsch (2004) on the roto–tilled slopes, 59 plots with Binzenhöfer (2004) and Hein (2004) on farmland, utilised grassland, and fallow land older than 10 years. The remaining 45 plots were set up on vineyards and fallow land younger then 10 years.

Methodology

Explanatory and response variables were recorded for all 120 sampling plots.

Explanatory variables: Soil samples were taken from each layer of a 60 cm (where possible) deep hole. Layer thickness and stone content were determined on site, the following parameters in the laboratory: texture (following Arbeitsgruppe-Boden 1996), soil density (Schlichting *et al.* 1995), pH, calcium carbonate ($CaCO_3$) (according to Scheibler in Schlichting *et al.* 1995), plant available potassium (K) and phosphorus (P) (ammonia–lactate solution according to Egner & Riehm in Schachtschnabel *et al.* 1984), total carbon (C) and total nitrogen (N) content (GCM Carlo–Erba C/N–Analyser). Soil physical parameters, namely plant available water (PAW), water permeability in saturated soil (kf), air capacity (AC), and effective cation exchange capacity (CEC_{eff}) were calculated from texture and soil density according to Arbeitsgruppe-Boden (1996).

Table 3.1: Disturbance categories.

disturbance parameter	category	explanation
disturbance frequency	0.01	longer than every 10 years
	0.13	every 6 - 10 years
	0.27	every 2 - 5 years
	0.33	every 3rd year (roto-tilling)
	0.5	every 2nd year (roto-tilling)
	1	1x (roto-tilling 1x per year or mowing 1x per year)
	2	2x (mowing 2x per year or extensive grazing)
	3	3x (mowing+grazing)
	4	4x (intensive grazing)
	5	5x (arable fields or vineyards)
magnitude	50	ca. 50 % of biomass destroyed (above ground disturbance) (mowing or grazing or mowing+grazing)
	100	ca. 100% of biomass destroyed (below ground disturbance) (arable fields or vineyards or roto-tilling)
below-ground disturbance 1997	0	no below-ground disturbance 5 years ago
	1	below-ground disturbance 5 years ago (arable fields, vineyards, roto-tilling)
above-ground disturbance 1997	0	no above-ground disturbance 5 years ago
	1	above-ground disturbance 5 years ago (mowing, grazing, mowing+grazing)
disturbance week	1 - 53	number of week; week 53 stands for fallow

Exposition was coded in a binary variable with all slopes exposed in south–eastern to west north–western direction being called sunny slopes while those ranging from north–west to east south–east denoted as shady slopes (Arbeitsgruppe-Boden 1996). Also, slope angle was recorded along with disturbance parameters, i.e. frequency, magnitude, and week for the first disturbance impact. Using stereo aerial photos from 1997 below– and above–ground disturbance were recorded to characterise a change in management within the last 5 years.

Table 3.2: Traits and trait features. (*according to Bekker, R., pers. comm.)

trait	data type	trait features	literature source
SLA	numerical	mm^2*mg^{-1}	field measurements
canopy height	numerical	mm	field measurements
seed mass	numerical	mg per seed	partly field measurements and Eriksson & Jakobsson 1998; Kästner *et al.* 2001; Klotz *et al.* 2002; Cerabolini *et al.* 2003; Poschlod *et al.* 2003
start seed shedding	numerical	month	Poschlod *et al.* 2003
seed number	numerical	number	partly field measurements and Stakevitch 1988; Eriksson & Jakobsson 1998; Kästner *et al.* 2001; Poschlod *et al.* 2003
clonality (length of tillers)	categorical	0 – not clonal	Klimeš *et al.* 1997
		0.5 – < 10mm	
		1 – >10mm	
plant life span	categorical	0 – annual	Rothmaler 1994; Kleyer 1995
		0.5 – biennial	
		1 – perennial	
spacers (above or below ground)	categorical	0 – no spacers	Klimeš *et al.* 1997; Poschlod *et al.* 2003
		0.5 – above ground	
		1 – below ground	
woodiness	categorical	0 – not woody	Poschlod *et al.* 2003
		0.5 – woody at base	
		1 – woody	
seed longevity in soil	index	< 0.3* – transient	Lefèbvre & Chandler-Mortimer 1984; Aarssen *et al.* 1986; Grunicke 1996; Kühner 1998; Oberdorfer 2001; Römermann 2002; Cerabolini *et al.* 2003; Poschlod *et al.* 2003; Fritzsch 2004
		0.3–0.55* – short-term persistent	
		> 0.55* – long-term persistent	

Magnitude was recorded as the destruction of biomass. For above–ground disturbances we assumed a biomass destruction of about 50%, whereas below–ground disturbances caused a biomass loss of 100%.
For detailed disturbance variables see Table 3.1.
Part of the study area is randomly grazed by shifting flock of sheep. The impact on the vegetation is low and will not be considered any further.

Response variables: For all vascular plant species presence/absence data were collected. Biological traits in the field were recorded according to Cornelissen *et al.* (2003), i.e. specific leaf area (SLA) (measured with ADC Area Meter AM 100), canopy height, and partly seed mass. Seed number was calculated as follows: Six inflorescences were collected from six different ramets at different sites, and the total number of inflorescences was counted. The seeds per inflorescence were counted and multiplied by the number of inflorescences per individual/ramet. This resulted in the total seed number per individual/ramet. Other relevant traits were gathered by means of literature (Table 3.2).

Indices

For calculation of indices see Chapter 2.

Statistical analysis

Three different matrices were set up: (1) 'site x species matrix' (Appendix Table 2), (2) 'site x environmental factors matrix' (Appendix Table 3), and (3) 'species x trait matrix' (Appendix Tables 4). For species codes see Appendix Table 5.
For the general clustering and logistic regression features see Chapter 2.

After checking for multicollinearity the 'site x environmental parameters matrix' finally consisted of the following explanatory variables and their squares, all of which were entering the eventual model calculation (for abbreviations see above):

- soil parameters: K, N, pH, PAW, CEC_{eff}
- disturbance parameters: magnitude, disturbance above ground 1997, disturbance below ground 1997, frequency, week
- geomorphological parameters: exposition, slope

Clustering: To receive an optimal number of clusters the SAS–procedure was run for a number of 6, 7, 8, 9 and 10 clusters. If the number of clusters is small probability rises to receive very large clusters with 20 or more species. If the number of clusters is high many single species clusters can be expected.

Step 1 – 3 of the statistical procedure were conducted as can be seen in Chapter 2. Species included into the procedure met the following criteria:

Prevalence: A species had to occur in at least 10% (i.e. 12) of the sampling plots.

Dominance: Dominant species were measured. This also includes those in less than 10% of the sampling plots (e.g. *Cornus sanguinea*).

Selection: A few species were selected, that were existent also in the Müritz investigation area (e.g. *Galium verum*, *Daucus carota*).

This resulted in 75 species (see Appendix Table 4) entering the statistical analysis.

Results

Resource supply

The sample sites form a resource gradient within the investigated landscape (see Table 3.3). 36 sites contain no measurable inorganic carbonate, this is especially true for grazed and/or mowed fresh grasslands (47%), another 25% are found on dry grazed and/or mowed grasslands. The other 84 sites range between $4.3*10^4$ and $2.8*10^6$ kg $CaCO_3*ha^{-1}$. The nutrient–poorest soils contain no P, the richest sites show values of more than 4.400 kg $P*ha^{-1}$. The N–supply ranges from about 210 kg $N*ha^{-1}$ to $2.3*10^4$ kg $N*ha^{-1}$, and the relation between C and N shows values from 0 – 52. The highest resource supplies were found on fallow arable fields and on vineyards still in use. Correlation between P and K is 0.62, between K and N 0.37, and between C and N 0.57. Because of these associations P and C were excluded from the analysis. Furthermore $CaCO_3$ (correlation with pH = 0.67), C/N (correlation with C = 0.75), kf (correlation with AC = 0.62) and AC (correlation with PAW = 0.78) were left out from the analysis.

	min.	max.	mean	std.dev.
P [$kg*ha^{-1}$]	0	4424	503	613
CaCO3 [$kg*ha^{-1}$]	0	$2.8*10^6$	$5.7*10^5$	$6.4*10^5$
C [$kg*ha^{-1}$]	0	$2*10^5$	$6,3*10^5$	$4.4*10^4$
C/N	0	52	8	6
kf [$cm*d^{-1}$]	1	41	10	9
AC [mm]	2	82	22	13
K [$kg*ha^{-1}$]	352	$13.7*10^3$	2360	1876
N [$kg*ha^{-1}$]	210	$2.3*10^4$	8150	4322
pH	4.4	7.5	6.8	0.7
PAW [mm]	11	165	75	30
CEC_{eff} [$cmol_C*kg^{-1}$]	5	39	30	10
slope [°]	0	30	12	8
dist_ag5	0 (no)	1 (yes)	-	-
dist_bg5	0 (no)	1 (yes)	-	-
frequency [a^{-1}]	0.01	5	-	-
exposition	0 (shade)	1 (sun)	-	-
magnitude [%]	50	100	-	-
week	19	53	40	-

Table 3.3: Resource gradients and statistical values. Variables above the double line are not taken into regression analysis. (std.dev. = standard deviation, max. = maximum, min. = minimum, K = potassium, $CaCO_3$ = calcium carbonate, C = carbon, C/N = carbon-nitrogen-ratio, kf = water permeability in saturated soil, AC = air capacity, P = phosphorus, N = nitrogen, PAW = plant available water, CEC_{eff} = effective cation exchange capacity, magnitude = biomass destruction, dist_ag5 = disturbance above ground 1997, dist_bg5 = disturbance below ground 1997, frequency = disturbance frequency, week = disturbance week)

Disturbance intensity and species

For the investigation area we found 237 species within the established plots.

Arable fields and vineyards represent the land use with the highest disturbance frequency and magnitude. Also roto–tilled sites are severely disturbed below ground but disturbance occurs only once per year or even every 2 or 3 years. Fallow arable fields are the least disturbed plots with disturbance return intervals of 2–5 years, 6–10 years, and more than 10 years.

Grazed and mowed plots (i.e. ca. 50% biomass loss) range from a disturbance frequency of four times per year by intensive grazing to mowing once per year. The overall least used areas are fallow grasslands with disturbance intervals of more than 10 years. There are negative associations between disturbance week and frequency (-0.53) as well as between week and above–ground disturbance history (-0.72). Another negative correlation was found between below–ground disturbance history and slope (-0.49), which vice versa was positive for slope and above–ground disturbance history (0.33). Magnitude is negatively related to above–ground disturbance history (-0.36) and positively to below–ground disturbance history (0.37), meaning that some but not all sites were managed in the same way for a time period of more than 5 years.

Statistical analysis

Responsive species

75 species (see species in bold letters Appendix Table 4) entered step 1 of the statistical analysis. After applying stepwise logistic regression 51 responsive species with sufficient quality models remained (Appendix Table 10). During regression analysis those variables significantly improving the single species models are selected. Most of the species show sensitivities to above–ground disturbance history (1997) and pH (see Figure 3.1).

Similar to vegetation tables the single species can be divided into groups according to the variables that they are sensitive to (Appendix Table 10). The first group of species reacts sensitive to pH, the second is characterised by their sensitivity to PAW–values and pH. The third group shows dependencies only from PAW. Group 4 species are sensitive to disturbance frequency, whereas those of the fifth group are influenced by week of disturbance. Slope angle appears to be the most important environmental variable for species of group 6, and group 7 species show high affinities to the history of above–ground disturbances.

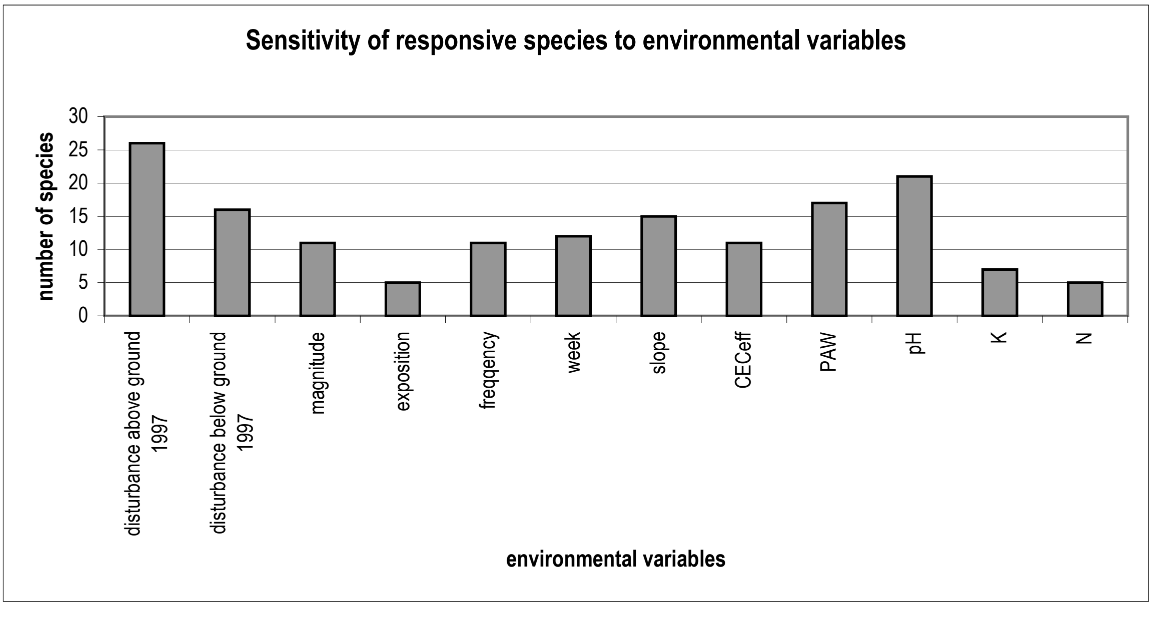

Figure 3.1: Species sensitivity to environmental variables (magnitude = disturbance magnitude, frequency = disturbance frequency, week = disturbance week, CECeff = effective cation exchange capacity, PAW = plant available water, K = plant available potassium, N = nitrogen).

Plant functional groups

Screening different numbers of clusters per cluster analysis resulted in applying an 8 cluster solution (data not shown). This solution avoided clusters comprising large species numbers as well as those with only one species. From our iterative analysis the most parsimonious trait combination covering a maximum of responsive species consisted of specific leaf area (SLA), canopy height, plant life span and seed number. 48 out of 51 responsive species were clustered, 3 species were omitted as there was no seed number available. 6 PFGs with a total number of 40 species met the goodness of fit thresholds (Table 3.4). All other trait combinations yielded PFGs comprising less species that met the goodness of fit thresholds.

Table 3.4: Plant functional groups (=PFG). The grey marked clusters do not meet the goodness of fit criteria.

PFG	AUC	R^2_N	species (prevalence)	no. of species
1	0.773	0.3124	*Bromus erectus* (26), *Centaurea scabiosa* (10), *Festuca ovina* agg. (49), *Knautia arvensis* (23), *Plantago lanceolata* (48), *Plantago media* (33), *Poa pratensis* agg. (82), *Potentilla neumanniana* (17), *Primula veris* (22), *Ranunculus acris* (18), *Ranunculus bulbosus* (28), *Salvia pratensis* (34), *Sanguisorba minor* (52), *Trifolium pratense* (38), *Trifolium repens* (19)	15
2	0.810	0.3057	*Convolvulus arvensis* (41), *Leontodon hispidus* (16), *Lolium perenne* (9), *Luzula campestris* (26), *Rumex acetosa* (31), *Saxifraga granulata* (13), *Taraxacum officinale* agg. (50), *Veronica chamaedrys* (27)	8
3	0.811	0.3391	*Achillea millefolium* (66), *Alopecurus pratensis* (26), *Avenula pubescens* (23), *Brachypodium pinnatum* (17), *Centaurea jacea* (29), *Dactylis glomerata* (66), *Euphorbia cyparissias* (23), *Lathyrus pratensis* (17), *Lotus corniculatus* (39), *Origanum vulgare* (10), *Trisetum flavenscens* (44)	11
4	0.789	0.1794	*Bromus hordeaceus* (9), *Bromus sterilis* (11), *Cerastium brachypetalum* (30), *Galium aparine* (15), *Rhinanthus minor* (18), *Thlaspi perfoliatum* (24)	6
5	0.893	0.4681	*Anthoxanthum odoratum* (22), *Holcus lanatus* (21), *Poa trivialis* (14)	3
6	0.863	0.3745	*Cirsium arvense* (18), *Galium verum* (22)	2
7	0.765	0.2821	*Cornus sanguinea* (10), *Prunus spinosa* (38)	2
8	0.910	0.4843	*Rosa canina* agg. (22)	1
unclustered species			*Fragaria viridis* (46), *Inula conyza* (10), *Viola hirta* (28)	3

Figure 3.2 traces back the clustering procedure, whereas Table 3.5 shows medians and coefficients of variation for the traits. Especially plant life span shows clearly defined values (coefficient of variation = 0). Also SLA is a distinctive feature for most PFGs. High coefficients of variation indicate that not all species in one cluster display exactly the same traits. However, to be able to abstract, all further implementations work with the medians.

The PFGs can be mainly distinguished (a) by their plant life span, and (b) by their plant height (see Appendix Table 11). PFG 4 is the only group featuring annuals, whereas PFG 7 and 8 by far grow highest. The latter can be separated mainly by their seed number, whereby PFG 8 shows the highest seed number per ramet among all groups, which is almost four times as high as that of PFG 7. They also differ in SLA; PFG 8 shows the lowest SLA among all PFGs. Both groups consist only of woody species.

PFG 1, 2, 3, 5 and 6 solely comprise off perennials. PFG 5 is clearly distinct due to high SLA–values, being the highest among all groups. PFG 6 can be separated by its tall growth and high seed number. Of the remaining PFGs group 1 shows the lowest SLA, whereby group 3 exhibits the tallest canopy height. Group 2 displays the lowest seed number among all PFGs.

Generally, the probability that all species of a group with similar biological traits co–occur is high, for most of the clusters probability exceeds 0.4. Only for PFG 1 and 4 it is < 0.4.

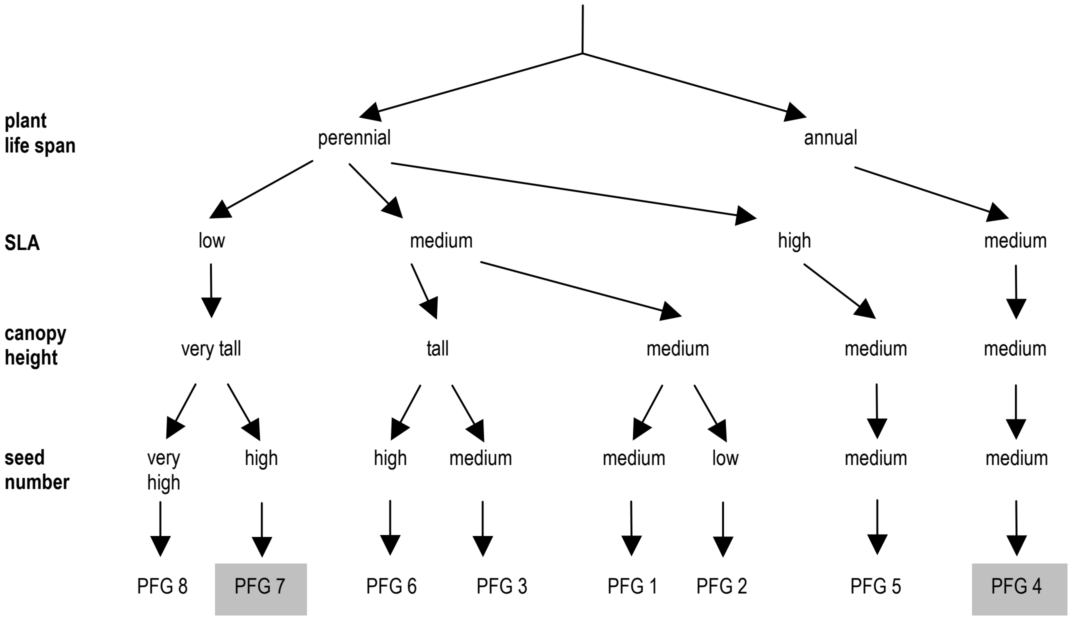

Figure 3.2: Derivation of PFGs during clustering. (SLA $[mm^2*mg^{-1}]$: very low: < 10, low: 10–20, medium: 20–30, high: 30–50, very high: > 50; canopy height [mm]: very small: < 100, small: 100–200, medium: 200–400, tall: 400–800, very tall: > 800)

Table 3.5: Coefficients of variation (first line per trait) and characteristics (second line per trait) of PFGs. Grey marked PFGs are not meeting the quality requirements. Bold numbers indicate low variance within the characters for the single species in each cluster. (*even though the coefficient of variation is poor, still a precise interpretation is possible; cf. Appendix Table 11)

PFG	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
plant life span	**0.00**	**0.00**	**0.00**	**2.45***	**0.00**	**0.00**	**0.00**	-
	per	per	per	ann	per	per	per	per
SLA $[mm^2*mg^{-1}]$	**0.13**	**0.10**	**0.11**	**0.18**	**0.13**	0.35	**0.04**	-
	20.2	28.6	28.1	28.5	40.3	20.6	18.2	13.0
canopy height [mm]	0.37	0.49	**0.20**	0.57	0.40	**0.28**	**0.08**	-
	244	207	463	262	393	619	1294	928
seed number per ramet	0.54	1.05	0.70	1.49	**0.24**	0.36	1.27	-
	271	119	316	163	169	1290	923	3623

During stepwise logistic regression those variables are selected that significantly improve the models. Table 3.6 shows the regression coefficients for these environmental parameters for each PFG. PFG 1 depends on low K (as well as P, being correlated with K and therefore excluded from the analysis) and on long–term mowing regimes. PFG 3 also responds negatively to fertility (K, CEC_{eff}) and positively to long–term mowing regimes with reduced frequency. PFG 2 responds positively to available soil water and negatively to nitrogen as well as late mowing or abandonment. PFG 5 decreases with pH and increases if formerly disturbed below–ground (Figure 3.3). PFG 6 decreases with disturbance frequency and responds positively if formerly disturbed below–ground. PFG 8 only depends on low soil water availability.

Table 3.6: Regression coefficients for environmental parameters after stepwise logistic regression. For parameter abbreviations see methodology. The appendix '2' labels the square of the variable. Grey columns indicate the low–quality clusters. (K = plant available potassium, N = total nitrogen, CECeff = effective cation exchange capacity, PAW = plant available water)

PFG	1	2	3	4	5	6	7	8
K2	-2.53E-07	-	-	-	-	-	-	-
K	7.01E-04	-	-1.87E-04	-	-	-	-	-
N2	-	-2.98E-09	-	3.60E-09	-	-	-	-
N	-	-	-	-	-	-	-	-
pH2	-	-	-	-	-0.16	-	0.27	-
pH	-	-0.52	-	-	-	-	-	-
CEC$_{eff}$2	-	-	-3.36E-04	-9.10E-04	-	-	-	-
CEC$_{eff}$	-	-	-	-	-	-	-	-
PAW2	-	2.09E-04	3.73E-05	-	-	-	-	-
PAW	-	-0.022	-	-0.016	-	-	-	-0.065
disturbance frequency2	-	-	-	-	-	-0.369	-	-
disturbance frequency	-	-	-	-0.406	-	-	-	-
disturbance week2	-	-6.13E-04	-2.68E-04	-	-	-	-	-
disturbance week	-	-	-	-	-0.060	-	-	-
slope2	-	-6.16E-03	-	-	-	-	-	-
slope	-	-	-	-	-	-	-	-
exposition	-	-	-	-	-	-1.24	-	-
magnitude	-	-	-9.06E-03	-	-	-	-	-
above–ground disturbance 1997	1.54	-	1.73	1.98	-	2.87	-	-
below–ground disturbance 1997	-1.94	-	-	-	1.08	4.06	-	-
Intercept	-2.20	4.28	-0.68	-1.73	6.68	-3.06	-14.91	2.22

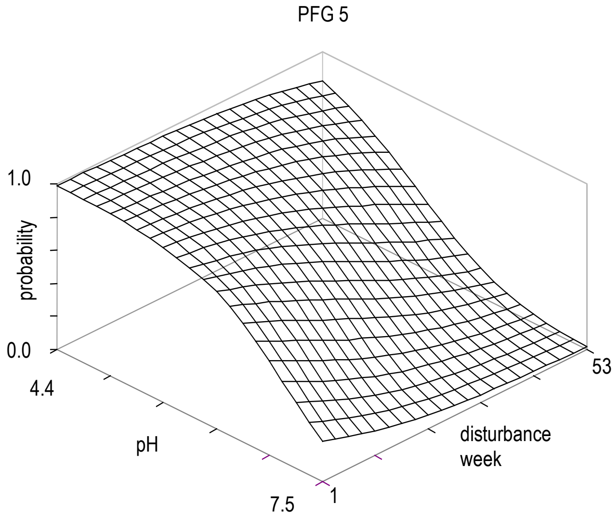

Figure 3.3: PFG 5; pH versus disturbance week for disturbance below–ground = 1.

Discussion

Environmental conditions

Nutrient conditions generally ranged from very low to very high. This was especially the case for P and N where contents differed by the 100– and 1000fold, respectively. Strong differences also showed in $CaCO_3$ and therewith pH originating from the various bedrock in the area.

Wide ranges were also recorded for the disturbance parameters, especially frequency and week. These differences originate from the various forms of utilisation and successional stages. Used farmland can show high nutrient values just as well as fallow grassland. This arises from both places being fertilised, farmland with artificial fertiliser, grasslands by dung or, in hedges, auto–fertilisation by fallen leaves.

With respect to habitat modelling, large gradients are desirable as they allow to capture the realised niches (Austin 1990; Austin *et al.* 1990) of many species as completely as possible. Plant species are mostly found to be arranged independently of one another in 'continua' along environmental gradients (Callaway 1997), expressed as unimodal Gaussian or skewed, or bimodal curves (Mueller-Dombois & Ellenberg 1974; Austin *et al.* 1990; Collins *et al.* 1993). However, plants interact interdependently via direct and indirect interactions (Callaway 1997), and therefore our models do not represent the full range of plant response. Oksanen & Minchin (2002) suggest that general additive models are a good choice for general predictive modelling, whereas Huisman–Olff–Fresco–models provide a better alternative for parametric questions of model shape.

Responsive species models

75 species entered the statistical procedure but only 51 of them showed models of sufficient goodness of fit. There were 3 species not modelled at all in the first place; i.e. Geum urbanum, Myosotis ramosissima and Valerianella locusta. In this case no environmental variable was significant to develop a valid model.

species	**prevalence in 120 plots**
Agrimonia eupatoria	24
Agropyron repens	36
Arrhenatherum elatius	70
Bupleurum falcatum	18
Crataegus monogyna	12
Daucus carota	27
Dianthus carthusianorum	11
Falcaria vulgaris	19
Festuca pratensis	24
Festuca rubra	35
Galium mollugo	36
Geum urbanum	10
Hypericum perforatum	15
Leucanthemum vulgare	17
Medicago lupulina	22
Myosotis ramosissima	24
Ononis repens	14
Pimpinella saxifraga	24
Potentilla reptans	17
Tragopopgon pratensis	10
Valerianella locusta	22
Veronica arvensis	33
Vicia angustifolia	46
Vicia tetrasperma	10

Table 3.7: Species with insufficient quality of fit measures: prevalence within the investigation area.

The reasons for low–quality models for the remaining 21 species are of different natures. The first expected explanation would be low prevalences in the data set whereby simply the low number of records made it impossible to find a consistent distribution pattern. This seems especially to be the case for *Crataegus monogyna*, *Dianthus carthusianorum*, *Hypericum perforatum*, *Ononis repens*, *Tragopogon pratensis* and *Vicia tetrasperma*. They occurred in only 10 to 15 of the 120 plots (for prevalence values see Table 3.7).

A second explanation is scattered presence along the whole recorded disturbance and resource gradient. This is the case for *Agrimonia eupatoria*, *Agropyron repens*, *Arrhenatherum elatius*, *Bupleurum falcatum*, *Daucus carota*, *Festuca pratensis*, *Festuca rubra*, *Galium mollugo*, *Medicago lupulina*, *Pimpinella saxifraga*, *Potentilla reptans*, *Veronica arvensis* and *Vicia angustifolia*. These species occurred in 12–70 of the sampling plots (see Table 3.7) and do not relate to any of the environmental factors we considered. Also, some may exhibit bimodal distributions which cannot be modelled with unimodal logistic regressions (Kleyer 1999).

species	prevalence per 120 plots	no. of variables	presences/ variable
Achillea millefolium	66	2	**33**
Alopecurus pratensis	26	5	5
Anthoxanthum odoratum	22	3	7
Avenula pubescens	23	3	8
Brachypodium pinnatum	17	4	4
Bromus erectus	26	2	**13**
Bromus hordeaceus	9	4	2
Bromus sterilis	11	2	6
Centaurea jacea	29	3	**10**
Centaurea scabiosa	10	3	3
Cerastium brachypetalum	30	3	**10**
Cirsium arvense	18	3	6
Convolvulus arvensis	41	3	**14**
Cornus sanguinea	10	2	5
Dactylis glomerata	66	2	**33**
Euphorbia cyparissias	23	8	3
Festuca ovina	49	5	**10**
Fragaria viridis	46	4	**12**
Galium aparine	15	2	8
Galium verum	22	6	4
Holcus lanatus	21	5	4
Inula conyza	10	3	3
Knautia arvensis	23	2	**12**
Lathyrus pratensis	17	3	6
Leontodon hispidus	16	4	4
Lolium perenne	9	2	5
Lotus corniculatus	39	2	**20**
Luzula campestris	26	6	4
Origanum vulgare	10	2	5
Plantago lanceolata	48	2	**24**
Plantago media	33	2	**17**
Poa pratensis	82	2	**41**
Poa trivialis	14	3	5
Potentilla neumanniana	17	3	6
Primula veris	22	3	7
Prunus spinosa	38	2	**19**
Ranunculus acris	18	3	6
Ranunculus bulbosus	28	1	**28**
Rhinanthus minor	18	4	5
Rosa canina	22	3	7
Rumex acetosa	31	6	5
Salvia pratensis	34	4	**9**
Sanguisorba minor	52	6	**9**
Saxifraga granulata	13	2	7
Taraxacum officinale	50	3	**17**
Thlaspi perfoliatum	24	4	6
Trifolium pratense	38	3	**13**
Trifolium repens	19	2	**10**
Trisetum flavenscens	44	3	**15**
Veronica chamaedrys	27	4	7
Viola hirta	28	4	7

Table 3.8: Prevalences and EPV–values for the responsive species. Bold marked species fulfil the criterion of 10 events per variable.

For the responsive species an opposite problem occurs namely habitat models of unrealistically good quality. Using categorical variables causes higher complexity of the model and increases the possibility of overfitting (Schröder & Reineking 2004b), leading to unstable, unreliable models (Harrell 2001). Overfitting has been seen as the most frequent reason for poor predictions (Reineking & Schröder 2004b). If overfitting occurs, an insufficient number of observations of the dependent variables faces too many explanatory variables. Steyerberg *et al.* (2001) give a benchmark of 10 events (presences) per variable (EPV) (see also Peduzzi et al. 1996).

According to the above mentioned criteria more than half of our models are overfitted (see Table 3.8). This could negatively influence the habitat models for the responsive species themselves but also those for the PFGs. However, the PFG habitat models are based on the predicted probabilities, and given the benchmark of Steyerberg et al. (2001) they fulfil the criterion of 10 events per variable (Table 3.9).

Clustering and traits

In our study, ten traits entered the clustering procedure. The most parsimonious trait combination explaining a maximum number of species consisted of only 4 traits: plant life span, seed number, SLA and canopy height. Incorporating seed mass, starting month of seed shedding, clonality (length of tillers), spacers above– or below–ground, woodiness and seed bank longevity into the clustering process, either alone or in all possible combinations, led to models with less predictive value. The selection of functional traits versus non–functional traits represents the major indication of functional hierarchies, i.e. functional traits are superior to non–functional traits. Within functional traits, the coefficient of variation (C_V) is an indicator of consistency, i.e. similar trait values across all species of a PFG can be interpreted as high pressure towards uniform trait response. Apart from plant life span, SLA was the trait showing the lowest C_V across all PFGs, followed by canopy height and seed number.

However, those traits incorporated into the most parsimonious trait combination do not necessarily only stand for themselves but also represent the other traits which are not part of the trait combination. Here, we will take a closer look at those traits. It is understood that spacers and clonality are highly associated with plant life span as only perennials are capable of developing vegetatively reproductive organs. Perennials are predominantly *K*–selected *sensu* MacArthur & Wilson (1967), and inhabit sites with stable environmental conditions (e.g. above–ground disturbed grasslands or fallow land). *R*–selected populations (MacArthur & Wilson 1967), mainly annuals, inhabit sites highly variable in space and time, e.g. regular below–ground disturbances, requiring a response in dispersal and regenerative traits. Plant life span as a persistence trait therefore includes vegetative regeneration.

Another part of the trait combination is seed number as a regenerative trait. It represents seed mass and SLI as there are trade–offs between these features for all 75 species (seed number and seed mass: -0.26; seed mass and SLI: -0.34). This confirms findings of e.g. Westoby *et al.* (1992), Thompson *et al.* (1993), Dupré & Ehrlén (2002) and Cerabolini *et al.* (2003). The start of seed shedding is also included in seed number as it is associated with seed mass (seed mass and start of seed shedding: 0.23). The start of seed shedding is important for plants on utilised grasslands as utilisation previous to seed ripeness will destroy most seeds (Kahmen & Poschlod 2004). In this way, seed mass, seed bank longevity and start of seed shedding are also functional traits, but seed number suffices to provide the best models. However, vegetative spread is the more dominant regeneration strategy within grasslands (Eriksson & Jakobsson 1998; Kahmen & Poschlod 2004) and therefore also more promising unless there are gap–creating disturbances (e.g. roto–tilling) as found within the investigation area.

Being woody within the considered landscape becomes important as soon as utilisation seizes. Woodiness is represented in canopy height as the tallest species grow woody stems and branches.

Westoby (1998) suggested a three–dimensional scheme for vegetation description based on the trade–offs between seed mass, SLA and canopy height. The latter two contribute to a plant's vertical expansion and its capacity to acquire carbon. Canopy height always determines competitive success and comes with increasing construction costs for supportive tissue, maximised in woody species. SLA is positively correlated with relative growth (Westoby 1998) and photosynthetic capacity of leaves (Reich *et al.* 1999). Large values indicate rapid growth and extension of the leaf canopy ('aquisitive type', Díaz *et al.* 2004). SLA is negatively correlated to leaf life span (Westoby *et al.* 2002), whereby longer life span permits conservation of acquired resources (Aerts & Chapin 2000; Westoby *et al.* 2002).

SLA and canopy height are directly represented in our functional classification. Instead of seed mass it features seed number, but as mentioned above there is an association between the two, and one substitutes the other. Our classification brings forward a fourth feature, i.e. plant life span. Obviously, Westoby's (1998) three traits are not sufficient to capture enough plant variability to functionally represent the floristic diversity along the recorded environmental gradients.

Plant functional groups

Hitherto, there are only few investigations dealing with statistical habitat models for PFGs (Kleyer 1997, 1999; Kleyer 2002). Compared to Kleyer (1999) PFGs in this study are not displayed along a general resource gradient but rather along gradients of single environmental factors. Given the benchmark of Steyerberg *et al.* (2001) the PFGs fulfil the criterion of 10 events per variable (Table 3.9); overfitting can be eliminated.

For our investigation seed number generally is a trait of secondary interest, as it always shows high coefficients of variation. The following considerations will mainly refer to plant life span, SLA and canopy height.

Plant life span as a persistence trait splits plant species into two branches: annuals and perennials. PFG 4 is the only group containing annuals, and is mainly characterised by their consistent SLA representing medium values. SLA stands for relative growth rate of a species and is positively correlated to resource richness (e.g. Garnier & Aronson 1998; Westoby 1998; Wilson *et al.* 1999; Aerts & Chapin 2000; Kahmen & Poschlod 2004). Medium SLA therefore corresponds with medium nutrient levels at which indeed the majority of the species occurs (except *Bromus hordeaceus* and *Galium aparine*). In contrast canopy height and seed number display high coefficients of variation (see Table 3.5). On highly disturbed sites Kleyer (1999) found two groups of annuals differing in their seed biology (SLI, seed mass and number) depending on the resource supply. Annuals representing PFG 4 in parts seem to combine these two subgroups and consequently the probability for the species to co–occur is very low resulting in a badly calibrated habitat model. Hence, PFG 4 is not a plant functional group.

PFG	prevalence sum for all species	variables/ PFG	EPV
1	499	3	166
2	213	5	43
3	360	6	60
4	107	5	21
5	57	3	19
6	40	4	10
7	48	1	48
8	22	1	22

Table 3.9: EPV–values for PFGs.

If disturbance is confined to above–ground impacts or is not present at all, a perennial life cycle replaces the annual. This is represented in the opposite branch of plant life span. Vegetative spread (included in plant life span) is the dominant regeneration strategy within grasslands (Eriksson & Jakobsson 1998; Kahmen & Poschlod 2004). Also after abandonment colonisation and propagation happen by vegetative means (Van der Valk 1992; Jensen & Schrautzer 1999). The latter is confirmed in PFG 7 and 8, as they form extensive populations of tall–growing woody individuals by pronounced spread of tillers (especially *Prunus spinosa*). Thompson *et al.* (2001) found invasibility to be related to fertility, and low pH to clearly reduce the overall level of invasion. Our investigation did not show fertility to be a major cause for the occurrence of woody species. However, for PFG 7 it is pH (see Table 3.6) confirming the observations of Thompson *et al.* (2001), as high pH–values obviously support the invasion by *P. spinosa* and *C. sanguinea*. Another indication for the insignificance of nutrients in this case could be low SLA–values for both PFGs, as SLA is related to fertility only in unshaded habitats (Kahmen & Poschlod 2004). SLA steps back in favour of canopy height, as the latter is the most space and light taking and therewith competitively more successful trait (cf. Givnish 1982; Gaudet & Keddy 1988 and Lehsten & Kleyer subm.). Generally, this becomes obvious considering all responsive species in a Spearman correlation analysis. There is a trade–off between SLA and canopy height (cf. Box 1).

PFG 1, 2 and 3 contain species of typical grassland communities. Whereas long–term, i.e. continuous, above–ground disturbance history as disturbance factor determines the occurrence of PFG 1 and 3, it is an early disturbance week that is most important for PFG 2 (and also slightly influences PFG 3 in the same way). In combining trait functions with environmental factors, we find perennials with low SLA, low canopy height and intermediate seed number (PFG 1, 15 species) on sites with low fertility (potassium) and continuous biomass loss by mowing, representing a 'conservative/retentive type' with respect to resources (Díaz *et al.* 2004). Several studies found species with low SLA occurring more on sites with low fertility or rainfalls and those with high SLA more on sites with high fertility or rainfall (Díaz & Cabido 1997; Cunningham *et al.* 1999; Poorter & De Jong 1999; Fonseca *et al.* 2000). PFG 1 co–occurs with PFG 3 which is a slightly more 'aquisitive' and competitive type extending to sites with more available soil water. Phytosociological evidence confirms co–occurrence of these species in mesic grasslands that are occasionally mown (Oberdorfer 1978). Co–existence of both PFGs despite a supposedly higher competitive effect of PFG 3 might be attributed to inter–annual resource variation at dry sites alternately favouring more 'conservative' and more 'aquisitive' types.

In contrast, PFG 2 is less competitive with respect to canopy height but more aquisitive with respect to SLA and grows in early mown meadows with ample water supply and a tendency towards lower nutrient supply. It has been shown that species combining low canopy with high SLA can be as effective in light harvesting as taller species (Werger *et al.* 2002). This may be especially relevant if the growth interval between start of the growing season and first mowing is small.

Considering PFG 5 and 6 both are biased towards high prevalence of one or two species in the cluster, i.e. the habitat model is influenced mainly by the more prevalent species. This problem arises if clusters are composed of a small number of species. Combined with medium plant height and medium seed numbers PFG 5 shows the overall highest SLA–values. Especially *Holcus lanatus* and *Anthoxanthum odoratum*, though, occur on sites with low pH–values (Figure 3.4). Low pH results in low nutrient availability and therefore low canopy height (cf. Diekmann & Falkengren-Grerup 2002) and SLA. This contradicts the findings of e.g. Garnier & Aronson (1998), Westoby (1998), Wilson *et al.* (1999), Aerts & Chapin (2000) or Kahmen & Poschlod (2004), whereby SLA is positively correlated to resource availability. However, the presented results are only valid for the investigated area and possibly represent only a part of the ecological amplitude of the two species. According to Buckland *et al.* (2001) *H. lanatus* occurs on fertile physically disturbed sites, whereas *A. odoratum* shows indifferent behaviour towards nitrogen (Ellenberg *et al.* 1992).

PFG 5 is the only group determined by below–ground disturbance history. This is mainly influenced by *P. trivialis* which in the investigation area predominantly occurred on fallow farmlands with high pH–values

(Figure 3.4). *H. lanatus* and *A. odoratum* occur nearly simultaneously in above–ground disturbed grasslands, there is no interference with *Poa trivialis* (see Figure 3.4). The exemplary PFG–model shows the occurrence of *A. odoratum* and *H. lanatus* combined with the isolated model of *P. trivialis*, assigning all three species to occur at low pH–levels largely independent from below–ground disturbance history.

However, like all others also this habitat model reflects only circumstances in the investigated area, and there are grasslands with favourable nutrient conditions on fresh to wet habitats where *H. lanatus* and *P. trivialis* do co–occur (Knapp 1971). In fact all three species can co–occur within the Arrhenatheretum (Ellenberg 1996).

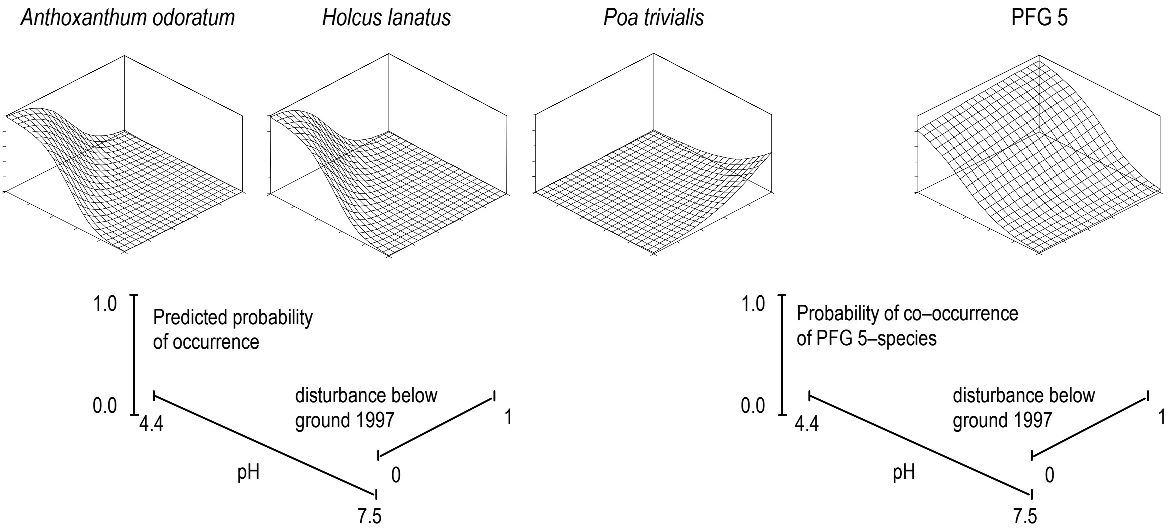

Figure 3.4: PFG 5. Single species habitat models and habitat model of the PFG. Disturbance below ground 1997 can adopt only two concrete values, i.e. '0' and '1'. Therefore the axis can interpreted only for these two values. The models are valid for disturbance week 36 (median).

Amongst the groups of herbaceous perennials PFG 6 shows least consistence in traits. The trouble is, that it contains two completely different species, i.e. *Cirsium arvense* and *Galium verum*. This becomes obvious considering the single habitat models, and is also expressed in the coefficients of variation, which are rather poor. Only canopy height can constrictedly be considered less variable. Both species behave differently concerning nitrogen levels (Ellenberg *et al.* 1992). Similar as in PFG 5 here it is *C. arvense* dominating the PFG–models. Therefore disturbance history below–ground is more important than that above–ground. However, disturbance frequency needs to be low for both species and can therefore be generalised over the whole PFG. Still, the magnitude of its effect largely depends on whether the site was used as farmland or as grassland.

Finally, we shall give a short comment on woody and herbaceous plants. Considering their seed number this trait cannot be compared between woody and herbaceous species. The reason for this phenomenon is that seed numbers were counted per shoot. This can be a complete tree or one ramet of a clonal grass. Because of such size differences, comparison between seed numbers of the woody PFGs 7 and 8 and the herbaceous

PFGs 1 to 6 is not reliable. Counting the seed number per square meter could have been a better measure to compare herbaceous and woody species/PFGs.

Conclusions and perspectives

Presence/absence of individual species might only reflect coincidental dispersal and recolonisation events (Willby *et al.* 2000). To get away from the single species approach, clustering according to biological traits is an appropriate method to generate groups of plants with similar biology. These groups are non–static as adding or omitting one or more species would lead to a different similarity structure within the species list, and clusters would differ in their species composition (own results and Kleyer 1997; Nygard & Ejrnæs 2004). The same effect occurs with changing the number of clusters. Yet the results change only slightly as still the most similar species would be grouped together.

Applying stepwise logistic regression expectedly revealed a disturbance gradient within the identified high quality PFGs reaching from groups preferring sites with below– over above–ground disturbance history to agriculturally abandoned habitats (Figure 3.5). Plant life span is the most important attribute dividing groups into annuals, and herbaceous and woody perennials. Decreasing intensity of utilisation and abandonment promotes the growth of competitive woody, light–taking species. SLA and canopy height could be shown to be related to resource richness, which confirms findings of e.g. Garnier & Aronson (1998), Westoby (1998), Wilson *et al.* (1999), Aerts & Chapin (2000) or Kahmen & Poschlod (2004) as well as disturbance parameter (Figure 3.5). Seed number was not considered further as variability within the PFGs was very high.

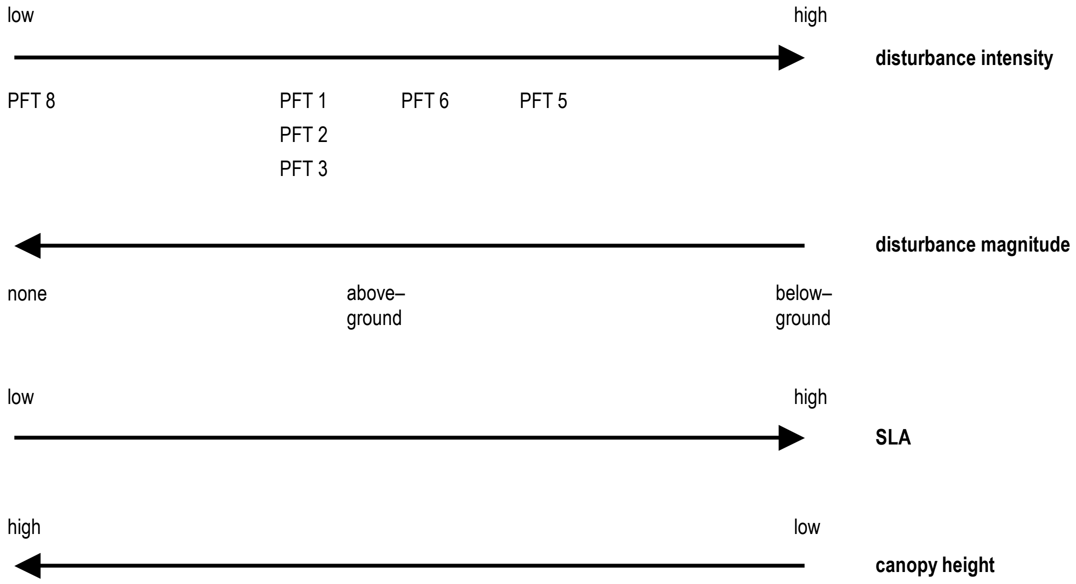

Figure 3.5: Plant functional groups and disturbances. Only PFGs with well–calibrated models are shown.

Recent land use change suggests that disturbance exhibits large and increasing variation in the study area. However, generally the functional groups are determined by factors associated to both fertility and disturbance. Factors associated to fertility vary across functional groups, with potassium as explaining factor for PFG 1 and available water, nitrogen or pH for other PFGs. In contrast, history of disturbance regime is a factor that determines most PFGs. For grassland species of well–drained grasslands (PFG 1 and 3) this is continuity, i.e. 2002´s regime equals that of 1997. For PFG 5, this is discontinuity, i.e. the disturbance regime was above–ground in 2002 and below–ground in 1997.

The presented habitat models for PFGs are strongly influenced by model quality of the contained species especially at low species numbers and species differing much in their single habitat requirements. Hence, trying to suit every included species leads to lower quality PFG–models.

One of our hypotheses was that the disturbance gradient that had become extended through land use change would promote regenerative traits to exhibit higher ranks in the functional hierarchy. This is not the case. SLA and canopy height, which have been associated mainly to fertility (Garnier & Aronson 1998; Westoby 1998; Wilson *et al.* 1999; Aerts & Chapin 2000) exhibit higher ranks than seed number, apart from plant life span. Vegetative regenerative traits as spacer length and position as well as generative traits as seed mass and seed bank longevity are not necessarily functional in this landscape and therefore low in the hierarchy.

Westoby (1998) suggested a three–dimensional plant strategy scheme based on seed mass, SLA and canopy height. In Westoby´s scheme, these traits are deductively defined as being sufficient for representing plant strategies across scales and regions. Our four traits resulted inductively from an optimisation procedure and, as a matter of fact, are quite similar to those Westoby (1998) proposed. SLA and canopy height are directly represented in our functional trait set. Seed number was selected instead of seed mass, but both traits are correlated. Plant life span is an indispensable trait to achieve models of high predictive quality in this kind of landscape. A study using the same methods in a landscape characterised by light grazing and large differences in water availability resulted in a parsimonious set of five traits of which the most important was the capacity to build aerenchyma (Kühner & Kleyer unpubl.). This suggests that although a limited set of functional traits may suffice to predict plant responses in a given landscape there is no generally applicable trait set across all scales and regions.

CHAPTER 4

WINTER GRAZING AND GROUND WATER DETERMINE THE ASSEMBLY OF PLANT FUNCTIONAL GROUPS IN A PERMANENTLY GRAZED SEMI–NATURAL GRASSLAND

Winter grazing and ground water determine the assembly of plant functional groups in a permanently grazed semi–natural grassland

with Michael Kleyer

Abstract

Freely ranging herds of cattle, sheep and horses are alternative management options to preserve semi–natural grasslands. To generalise plant community responses to the resulting shifting mosaics of habitat quality, a functional view on species–environment relations is necessary. Investigations were carried out in a long–term extensive multi–species grazing system near the lake Müritz in north–eastern Germany. On 120 sampling plots we recorded soil characteristics and grazing intensity as well as 11 selected biological traits for the 88 most frequent plant species. With the aid of stepwise logistic regression we created habitat models for every single species, of which 53 met the introduced goodness of fit thresholds. Using Ward's clustering method these 53 species were grouped into 9 biological types. Again we applied stepwise logistic regression to eventually build statistical habitat models for plant functional groups (PFGs). 8 of the 9 PFGs met the goodness of fit thresholds. We found especially winter grazing and soil water supply to be the most important environmental factors influencing the occurrence of PFGs. Out of 11 traits, 5 were functional for a maximum number of responsive species. They are namely aerenchyma, thorny physical defence, canopy height, location of spacers and seed longevity. Depending on grazing intensity we found canopy height to reach from very small to very tall. Grazing intensity itself was recognised to be dependent on soil water supply which in turn is responsible for the occurrence of aerenchymas as a stress tolerance trait. Furthermore we provide evidence that grazing intensity increases species diversity. We suggest that the community is rather stable and appears to be adapted to grazing due to its long history of human association. Finally, we conclude that in permanently grazed areas stocking density of large herbivores is the wheel to turn to change vegetation patterns.

Nomenclature: Rothmaler (1994)

Introduction

The impact of grazing is a key issue for range management (Sternberg *et al.* 2000) and for nature conservation (Collins *et al.* 1998). In temperate grasslands moderate grazing is the major form of management (Bullock *et al.* 2001), and it is recommended as an alternative to traditional mowing regimes on semi–natural grasslands (Bakker 1998; Pykälä 2000). Herbivores profoundly alter the spatial structure of the affected ecosystem implying changes in habitat diversity and in the diversity of other consumers (e.g. insects, Dennis *et al.* 1998). As an important stress factor grazing reduces the dominance of competitive species and by trampling creates germination niches in the bare soil (Grubb 1977). It therefore has a direct effect on the structure and organisation of plant communities (Noy-Meir *et al.* 1989; Sternberg *et al.* 2000) and furthermore, on a variety of ecosystem functions (Adler *et al.* 2001).

Various studies have provided evidence that grazing entails higher plant species diversity (e.g. Sala 1988; Bakker 1989; Milchunas & Lauenroth 1993; Sternberg *et al.* 2000). However, this is strongly dependent on productivity (Bakker 1998; Braschler *et al.* 2004) as well as on type and abundance of herbivore species (Olff & Ritchie 1998). Generally, in environments with very low as well as very high nutrient resources diversity of plants is low (Proulx & Mazumder 1998). Species richness in mesotrophic environments can be promoted even more by frequently removing the above–ground biomass, whereas in more oligotrophic environments only occasional removal is necessary (Bakker 1998). Compared to general agents such as clearcutting (Floret *et al.* 1992) and mowing which treat every part of an area the same, grazing is a selective agent (Hadar *et al.* 1999). Its distribution in terrestrial habitats is controlled by food (biomass), but also by water and minerals (Adler *et al.* 2001). Grazers often select the landscape unit richest in resources and then the most productive communities (Senft *et al.* 1987). Large herbivores, therefore, typically create frequent, small–scale disturbances across the landscape (Shankar & Singh 1996) resulting in a small–scale mosaik or micro–pattern (Bakker 1998). This implies increasing soil heterogeneity by spatially heterogeneous urine and dung deposition (Steinauer & Collins 1995) but has little direct impact on soil compaction and nutrient cycling (Bakker 1998). The main effects of grazing, however, are rather indirect, such as influencing light availability and the opportunities for germination and seedling establishment by affecting the structure of the vegetation canopy (Bakker 1998).

As aforementioned the type of herbivores is important to plant species diversity in grazed systems. Herbivores differ in terrain use, food habits and therewith in their potential to influence vegetation development (Bakker 1998). They differ in body size or digestive system or use different parts of the vegetation (Gordon 1989a). Putman (1986) found cattle to show a relatively constant pattern of habitat use throughout the year in the New Forest in Hampshire, England. In contrast, ponies showed marked seasonality in their use of plant communities. On the Isle of Rhum, Scotland, Gordon (1989b) found goats to prefer heathland, while cattle and ponies preferentially selected grassland communities. There are also differences in feeding behaviour. While cattle use their tongue to rupture plant parts (Klapp 1971), sheep are more selective as they have much smaller muzzles (Lutz 1990), and may select even single flowers or leaves. Horses are more selective than ruminants and can bite off plants directly at the soil surface (Klapp 1971). Trampling is much more distinctive.

Considering these differences multi–species grazing may be of value to the management of plant communities (Bakker 1998).

The abundance of herbivores shows different effects on plant species diversity and habitat quality. Intensive livestock farming may result in unselective grazing and can create erosive, detrimental soil disturbances (Milchunas *et al.* 1988). Plant diversity is reduced as only few tolerant species will survive. Increasing numbers of rosette plants indicate high grazing intensities (Van den Bos & Bakker 1990). Moderate grazing is advantageous for short–lived plants and grasses, and also promotes flat rosettes as well as species with high seed dispersal ability (Stammel *et al.* 2003). Generally, relatively low stocking densities result in 'random' and extensive grazing, i.e. not the entire annual production is utilised, and micro–patterns develop (Bakker 1998). Extensive grazing leads to variation in, amongst others, dung deposition, soil compaction and heterogeneous removal of plant material due to herbivore selectivity (Bakker 1998). Compared to mowing it creates a higher structural diversity (Bakker 1998). Therefore, grazing at different intensities is advantageous for reaching a greater vegetational differentiation (Harper 1977).

Abiotic and biotic conditions as well as disturbance act as filters and result in a species composition featuring sets of attributes associated with these environmental factors (Diaz *et al.* 1998). According to their traits and a similar response to environmental conditions single species can be abstracted into plant functional groups (PFGs) (Gitay & Noble 1997; Lavorel *et al.* 1997). PFGs represent ecosystem structure (Smith *et al.* 1997) and at regional to global scales they are much easier to handle than numerous single species. PFGs based on morphology may link ecophysiological traits with ecosystem processes relevant at large scales (Chapin 1993).

For systems with a long grazing history changes in plant attributes rather than in plant composition have previously been observed (Díaz *et al.* 1999; Sternberg *et al.* 2000). Various investigations were conducted to evaluate the effects of grazing on plant traits. The most consistent response was found to be plant stature, i.e. tall plants are eliminated in favour of small and prostrate species (e.g. Sala *et al.* 1986; Noy-Meir *et al.* 1989; Díaz *et al.* 1992; Milchunas & Lauenroth 1993; Hadar *et al.* 1999; Lavorel *et al.* 1999; Stammel *et al.* 2003). Other important traits considering disturbance by grazing include the location of regeneration buds (e.g. Hadar *et al.* 1999), dispersal strategy (e.g. McIntyre *et al.* 1995), flowering phenology (especially in seasonally grazed systems) (e.g. Hadar *et al.* 1999), life cycle (e.g. McIntyre *et al.* 1995), or chemical and pyhsical defence mechanisms (e.g. Augustine & McNaughton 1998; Jauffret & Lavorel 2003; Papachristou *et al.* 2003; Stammel *et al.* 2003).

Trying to develop a generally applicable system to position plant species along gradients of abiotic conditions and disturbances using easily measurable plant traits Westoby (1998) introduced the leaf–height–seed plant ecology strategy scheme. He claims that any vascular land plant species can be positioned within it, solely by recording specific leaf area, plant height and seed mass. For grazing this implies that palatability is not directly dependent on physical defence mechanisms. However, there are various studies providing evidence of anti–herbivore defence mechanisms such as chemical and physical structures to avoid grazing pressure (e.g. Augustine & McNaughton 1998; Jauffret & Lavorel 2003; Papachristou *et al.* 2003; Stammel *et al.* 2003). In contrast, however, Noy-Meir *et al.* (1989) found palatability not to be a major factor of grazing response.

Furthermore, Westoby's scheme gives no possibility to place any plants of even only temporarily waterlogged soils within. We suggest that especially in water–influenced environments (e.g. lakes, rivers, swamps or temporarily flooded areas) certain traits are needed by plants to survive. In this case, plants can outlast only with the aid of aerenchymas, providing for oxygen transport to organs under water (e.g. roots). Aerenchymas as a stress–tolerance feature are functional in respect to soil water content.

We expect aerenchymas and physical defence mechanisms to play a major role within the differentiation of PFGs. Furthermore we assume that

(a) grazing intensity depends on soil resource availability, and
(b) natural succession is predominantly suppressed or even inverted by grazing in the winter months.

These assumptions will be reflected in the PFGs we will create by means of Ward's clustering and stepwise logistic regression.

The investigation area is situated within the temperate zone with natural succession leading to the loss of open landscapes terminating in forest communities due to its climatic conditions. There are only few naturally treeless habitats such as lakes, swamps, dunes or rocky and alpine areas (Briemle *et al.* 1991). The establishment of shrubs and trees on grasslands or farmland is a consequence of abandoning their utilisation. However, traditionally and extensively used semi–natural grasslands are home to a diverse flora and fauna (e.g. Poschlod & WallisDeVries 2002) and therefore worth preserving. As grazers typically prefer open grasslands (Bakker 1998), permanent grazing at low stocking densities is suggested to be a solution to today's money– and time consuming management of such habitats (Bakker 1998; Pykälä 2000; Kleyer *et al.* 2002). This concept is realised at the lake Müritz in north–eastern Germany since 35 years with approximately 0.5 livestock units per ha. Free ranging cattle and horses as well as daily herded sheep graze an area of 3 km². The area consists of extensive reeds, grasslands of various water availability and more or less open forests, providing a variety of different habitats.

Methods

Study area

Investigations were carried out in north–eastern Germany in Mecklenburg–Western Pomerania at the eastern shore of the lake Müritz on the Rederang– and Spuklochkoppel (53° 29' N, 12° 44' E). The size of the area totals about 3 km².

The Müritz region emerged after the Weichsel ice age about 10.000 years ago. Drift sands and later melting waters formed the shallow eastern shoreline (Peltz 1906). The investigation area emerged from the Müritz waters only some 165 years ago after a major drop of water level by about 1,50 m (Deppe & Prill 1958). Different soil types can be distinguished within the study area: subhydric soils, fens, gleys, terrestrial soils, clay and Cambisols (brown earths).

The Müritz area is situated in the ‚Mecklenburg–Brandenburgischen Übergangsklima'. Here oceanic influences from western Europe and the continental east–European climate concur. The mean annual precipitation from 1930–2002 was 583 mm (Wetterdienst des Nationalparkamt Müritz 2003). The maximum rain fall occurs in summer (July), the minimum in winter (Februar), the mean annual temperature is 8,2°C.

Ever since the 1880s there has been a continuous extensive grazing history with horses and cattle (Deppe 1980; Jeschke 1993). In 1969 Fjell cattle were brought in after a 15 year–period of animal exclusion on the Spuklochkoppel (see Figure 4.1) in order to protect ground–breeding birds and consequently enhanced succession (Deppe 1980). The cattle alone were not sufficient to stop succession, so Gotland sheep and Shetland ponies were introduced some 20 years ago (Martin 1997). Extensive grazing as traditional management is continued nowadays with 0.3–1.5 lifestock units per ha. Additionally, mechanical management like mowing and shrub encroachment became necessary and continue to date. From May to October the sheep are herded morning to midday in the north–western parts of the investigation area, i.e. Spuklochkoppel and semi–open *Juniperus communis*–stands (in the following called *Juniperus*–stands) (Figure 4.1). Afternoons and nights they spend on the Rederangkoppel. Fjell cattle and Shetland ponies range free across the area. Part of the area is excluded from grazing from May to July for hay making (in Figure 4.1 referred to as mowed grassland). In winter this hay is fed as supplementary nutrition to the animals.

For a more detailed overview see Chapter 2.

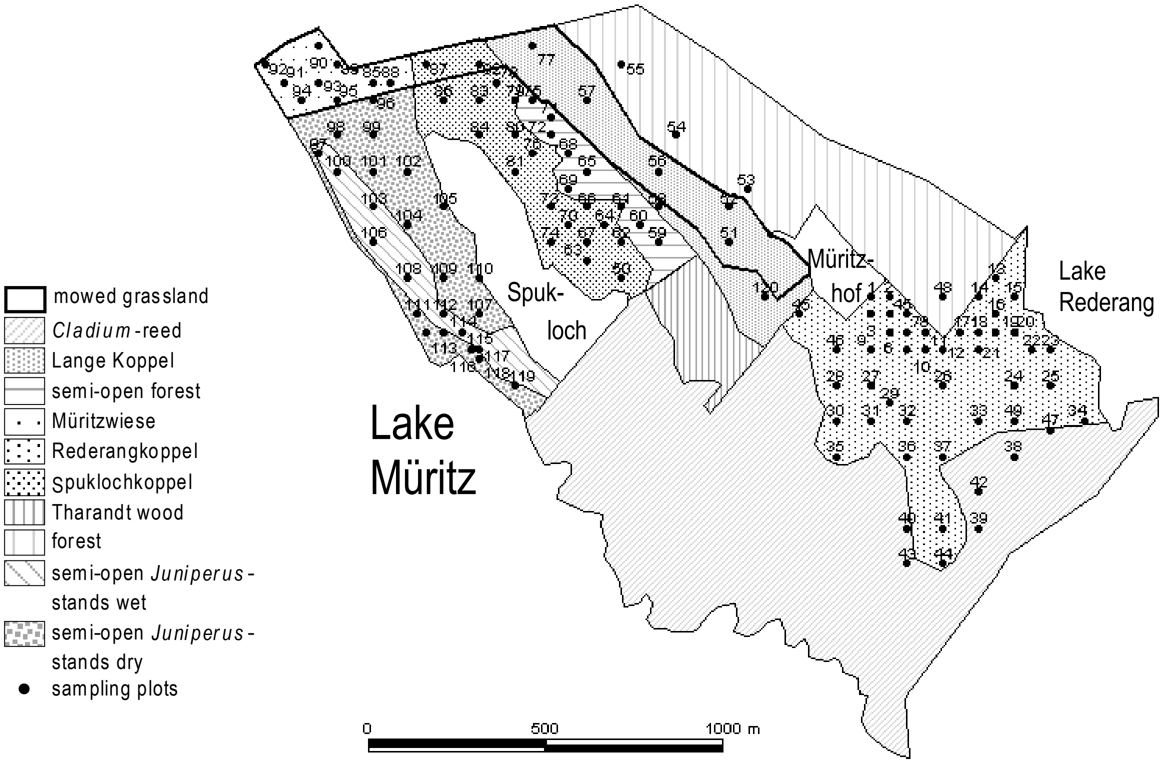

Figure 4.1: Investigation area Müritz with sampling plots.

Sampling design

120 sampling plots were set up along a 50 m x 50 m – grid. They were arranged in similar numbers for each biotope type (see Chapter 2). The plots consist of an exclosure (1.50 m x 1.50 m in heavily grazed areas; 2 m x 2 m in less grazed areas) and an equally sized comparable plot beside the exclosure. Density of plots grew where habitat combinations changed rapidly on a small scale (e.g. ground level elevation).

Methodology

Explanatory and response variables were recorded for all 120 sampling plots.

Explanatory variables: For soil parameters see Chapter 3.

Additionally, soil water logging in winter (SWL_{wint}) and in summer (SWL_{summ}) were recorded as measures for the ground water table, as well as winter (GI_{wint}) and summer (GI_{summ}) grazing intensity as disturbance variables. For GI 1 m² was mowed within the exclosure as well as in the adjacent comparable plot. Summer mowing took place in July/August 2001, winter mowing in March 2002. Biomass was dried for 40 hours at 60°C and weighed. GI is defined as the percentage of eaten biomass on the comparable plot in relation to the exclosure biomass (i.e. potential biomass production). Mean annual precipitation and temperature within the investigation period (2001) were consistent with long–term data. Therefore, SWL_{wint} and SWL_{summ} were assumed to be 'normal' as in average years.

Table 4.1: Traits and trait features. (*according to Bekker, R., pers. comm.)

trait	data type	trait features	literature source
SLA	numerical	mm^2*mg^{-1}	field measurements
canopy height	numerical	mm	field measurements
seed number	numerical	number	field measurements and Stakevitch 1988; Eriksson & Jakobsson 1998; Kästner *et al.* 2001; Poschlod *et al.* 2003
seed mass	numerical	mg per seed	field measurements
seed longevity index (SLI)	numerical	< 0.3* – transient 0.3–0.55* – short-term persistent > 0.55* – long-term persistent	Lefèbvre & Chandler-Mortimer 1984; Aarssen *et al.* 1986; Grunicke 1996; Kühner 1998; Oberdorfer 2001; Römermann 2002; Cerabolini *et al.* 2003; Poschlod *et al.* 2003; Fritzsch 2004
clonality (length of tillers)	categorical	0 – not clonal 0.5 – < 10mm 1 – > 10mm	Klimeš & Klimešová 1999
plant life span	categorical	0 – annual 0.5 – biennial 1 – perennial	Rothmaler 1994; Kleyer 1995
spacers (above or below ground)	categorical	0 – no spacers 0.5 – above ground 1 – below ground	Klimeš & Klimešová 1999; Poschlod *et al.* 2003
aerenchyma	categorical	0 – not present 1 – present	Eber, pers. comm.
thorny and other physical defence	categorical	0 – not present 1 – present	Klapp 1971; Rothmaler 1995; Kossegg 2001; Poschlod *et al.* 2003

Response variables: For all vascular plant species presence/absence data were collected. For the recording of biological traits see Chapter 3. An overview of all considered traits is given in Table 4.1.

Indices

For calculation of indices see Chapter 2.

Statistical analysis

Three different matrices were set up: (1) 'site x species matrix' (Appendix Table 6), (2) 'site x environmental factors matrix' (Appendix Table 7), and (3) 'species x trait matrix' (Appendix Tables 8). For species codes see Appendix Table 9.
For the general clustering and logistic regression features see Chapter 2.

Also for the Müritz investigation area we checked for multicollinearity. Finally, the 'site–environmental factors–matrix' consisted of the following explanatory variables and their squares, all of which were entering the eventual model calculation (for abbreviations see above):

- soil parameters: P, K, pH, PAW, SWL_{wint}
- disturbance parameters: GI_{summ} and GI_{wint}

Clustering: As for the Hassberge (Chapter 3) the SAS–procedure was run for a number of 6, 7, 8, 9 and 10 clusters to avoid too small and too large groups.

For step 1 – 3 of the statistical procedure see Chapter 2. As for the Hassberge the following criteria applied for species to be included into the procedure:

a) Prevalence: A species had to occur in at least 10% (i.e. 12) of the sampling plots.
b) Dominance: Dominant species were measured. This also includes those in less than 10% of the sampling plots (e.g. *Cladium mariscus*).
c) Selection: A few species were selected, that were existent also in the Hassberge area (e.g. *Galium verum*, *Daucus carota*).

This resulted in 88 species (see Appendix Table 8) entering the statistical analysis.

Results

Resource supply

As for the Hassberge area (Chapter 3) the sites form a large resource gradient ranging over several orders of magnitude (Table 4.2). The nutrient–poorest soils contain no measurable P, the richest sites show values of almost 3 000 kg*ha^{-1}. The N–supply ranges from 804 kg*ha^{-1} to 9.6*10^{4} kg*ha^{-1}. The relation between C and N shows values from 2.5 – 65. The highest resource supplies (P and N) are found on plots near the Müritzhof within the elevated areas. We could not detect any measurable inorganic carbonate at 53 sites, this is especially true for the higher elevated area east of the Müritzhof and the forest (51 %). Also the dry shore banks (4 plots) and the swampy parts in the north–west of the investigation area (9 plots) show no carbonate. The $CaCO_3$–content for the other 67 sites ranges between 2 546 kg*ha^{-1} and 2.2*10^{6} kg*ha^{-1}. There are slight correlations between CEC_{eff} and pH (0.35), C/N and C (0.32) as well as SWL_{summ} and SWL_{wint} (0.27).

Furthermore, we found strong associations between C and N (0.84), CEC_{eff} and C (0.55), pH and $CaCO_3$ (0.8), and PAW and AC (0.75). Because of these correlations CEC_{eff}, C, N, C/N, $CaCO_3$, AC and SWL_{summ} were omitted from the analysis.

	min.	max.	mean	std. dev.
$CaCO_3$ [$kg*ha^{-1}$]	0	$2.2*10^6$	$2.7*10^5$	$4.6*10^5$
C [$kg*ha^{-1}$]	7920	$1.5*10^6$	$1.4*10^5$	$2.4*10^5$
N [$kg*ha^{-1}$]	804	$9.6*10^4$	9762	$1.4*10^4$
C/N	2.5	65	15	10
CEC_{eff} [$cmol_c*kg^{-1}$]	2	52	5	7
AC [mm]	0	168	107	36
SWL_{summ} [0=no; 1=yes]	0	1	0	0
P [$kg*ha^{-1}$]	0	2952	232	363
K [$kg*ha^{-1}$]	33	1309	237	221
pH	3.3	7.7	6.1	1.2
kf [$cm*d^{-1}$]	10	653	249	159
PAW [mm]	45	216	118	40
SWL_{wint} [0=no; 1=yes]	0	1	0	0
GI_{summ} [%]	0	100	45	30
GI_{wint} [%]	0	100	68	32

Table 4.2: Resource gradients and statistical values. Variables above the double line are not taken into regression analysis. (std.dev. = standard deviation, max. = maximum, min. = minimum, $CaCO_3$ = calcium carbonate, C = total carbon, N = total nitrogen, C/N = carbon-nitrogen-ratio, CEC_{eff} = effective cation exchange capacity, AC = air capacity, P = plant available phosphorus, K = plant available potassium, kf = water permeability in saturated soil, PAW = plant available water)

Disturbance intensity and species

Most of the investigation area is grazed year–round. The most intensively grazed plots (GI > 75%) both in summer and in winter are found on the Rederangkoppel, especially within the higher elevated area east of the Müritzhof (Figure 4.2). In summer GI is rather low in the western part with values ranging between 20% and 60% whereas in winter they even reach up to 80%. Especially on the Lange Koppel GI increases from summer to winter by 20–40%.

Even though GI_{wint} and GI_{summ} are highly correlated (0.57), they both were left in the analysis as otherwise there would have been a high loss in the number of species due to low goodness of fit. There also is an important association for GI_{wint} and GI_{summ} with K (both 0.43) as well as between GI_{wint} and SWL_{wint} (-0.35).

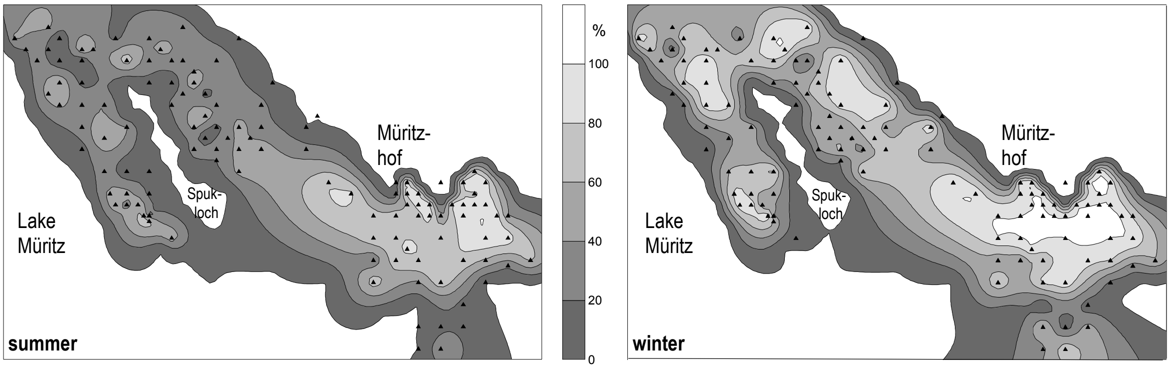

Figure 4.2: Grazing intensity in summer (left) and winter (right). The black triangles indicate the investigation plots.

On the sampling plots within the investigation area 223 species were found. We found a weak correlation between GI_{wint} and species number (0.19).

Statistical analysis

Responsive species

After considering the presence–absence data 88 species (see Appendix Table 8) entered step 1 of the statistical analysis. 53 responsive species with sufficient quality models resulted from stepwise logistic regression (see species in bold letters Appendix Table 8). Most of the species show sensitivities to pH and GI_{wint} (see Figure 4.3).

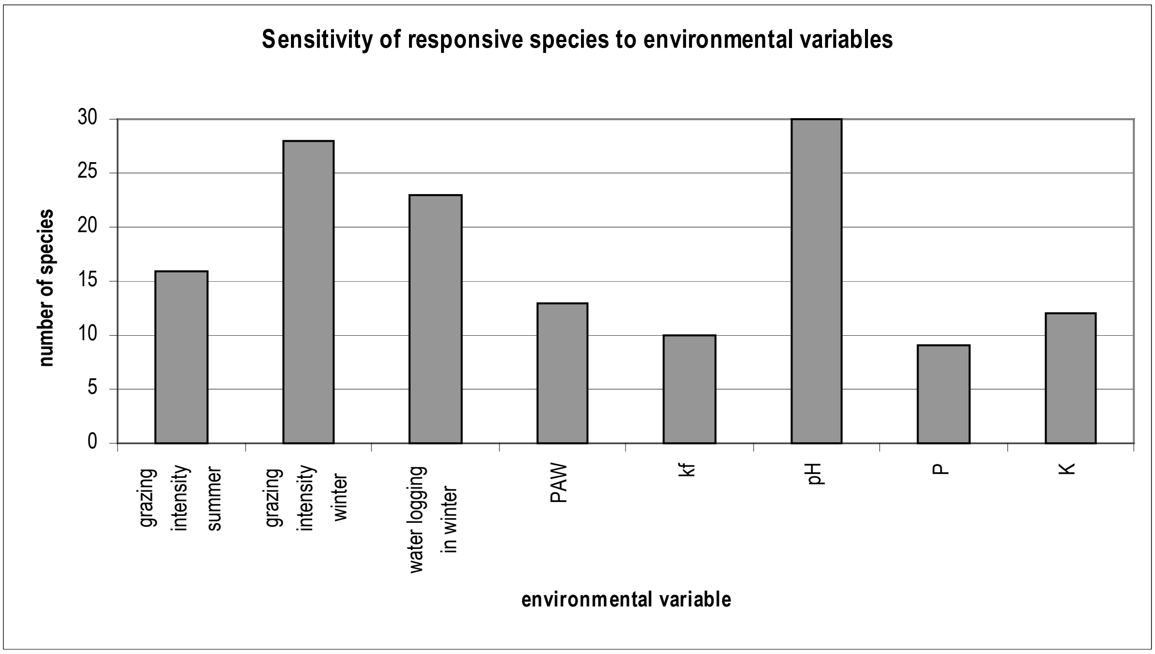

Figure 4.3: Sensitivity of responsive species to environmental variables. (PAW = plant available water, kf = water permeability in soil, P = plant available phosphorus, K = plant available potassium)

The single species can be divided into groups similar to vegetation tables according to the variables that they are sensitive to (Appendix Table 12). The first species group is characterised by their sensitivity to kf; except for *Taraxacum palustre* all species require soils without impeded water. The second group is sensitive to PAW–values. Most of the species occur on rather dry soils, whereby *Calamagrostis stricta*, *Cladium mariscus* and *Mentha aquatica* are promoted by wet soils. The third group shows dependencies from P, in which *Anthoxanthum odoratum*, *Centaurea jacea*, *Luzula campestris* and *Carex arenaria* tend to be found in locations with rather little P. Contrary *Capsella bursa–pastoris*, *Bromus hordeaceus*, *Erodium cicutarium* and *Veronica arvensis* prefer high P–values. Group 4 and 5 species are both sensitive to K, moreover those of group 5 are promoted by SWL_{wint}. Additionally to K and SWL_{wint} GI_{summ} has a positive influence on species of group 6. Group 7 shows high affinities to SWL_{wint} and GI_{summ}, whereas group 8 is mainly influenced by SWL_{wint}. GI_{summ} and pH are the only important factors for *Potentilla erecta* and *Convolvulus arvensis* (group 9), and species of group 10 solely depend on GI_{wint} and pH.

Plant functional groups

Screening different numbers of clusters per cluster analysis resulted in applying a 9 cluster solution (data not shown). As for the Hassberge this solution avoided clusters comprising only one species as well as those with large species numbers. The most parsimonious trait combination covering a maximum of responsive species consisted of aerenchyma, thorny physical defence, spacers, SLI and canopy height. 48 out of 53 responsive species were clustered, 5 species were omitted as there were no SLI–values available. 44 species in 8 PFGs met the goodness of fit thresholds (Table 4.3).

Table 4.3: Plant functional groups (=PFG). The grey marked group is not meeting the goodness of fit criteria.

PFG	AUC	R^2_N	species (prevalence)	no. of species
1	0.947	0.6228	*Bromus hordeaceus* (31), *Cerastium glomeratum* (30), *Erodium cicutarium* (10), *Veronica arvensis* (19)	4
2	0.834	0.3626	*Carex disticha* (12), *Carex flacca* (29), *Carex hirta* (41), *Carex nigra* (18), *Carex panicea* (32), *Galium palustre* (29), *Hydrocotyle vulgaris* (24), *Juncus articulatus* (24), *Mentha aquatica* (38), *Potentilla anserina* (34)	10
3	0.823	0.3758	*Danthonia decumbens* (26), *Deschampsia cespitosa* (38), *Molinia caerulea* (35), *Potentilla erecta* (43), *Potentilla reptans* (47), *Ranunculus acris* (46), *Ranunculus repens* (34)	7
4	0.793	0.3002	*Agrostis capillaris* (54), *Anthoxanthum odoratum* (34), *Cerastium arvense* (25), *Convolvulus arvensis* (9), *Dactylis glomerata* (12), *Leontodon autumnalis* (23), *Lolium perenne* (34), *Luzula campestris* (24), *Plantago lanceolata* (54), *Poa pratensis* agg. (60), *Rumex acetosella* (30), *Trifolium pratense* (29), *Trifolium repens* (46)	13
5	0.898	0.3509	*Eleocharis uniglumis* (24), *Galium uliginosum* (24), *Parnassia palustris* (13), *Trifolium fragiferum* (17), *Valeriana dioica* (15)	5
6	0.646	0.1324	*Achillea millefolium* (41), *Agropyron repens* (16), *Briza media* (35), *Centaurea jacea* (41)	4
7	0.874	0.5062	*Cladium mariscus* (9), *Phragmitis australis* (50)	2
8	0.987	0.8099	*Capsella bursa-pastoris* (10), *Poa annua* (17)	2
9	1.000	0.9912	*Cirsium arvense* (31)	1
unclustered species			*Calamagrostis stricta* (12), *Carex arenaria* (9), *Gentianella uliginosa* (13), *Odontites vulgaris* (8), *Taraxacum palustre* (6)	5

Table 4.4 shows the coefficients of variation and the median for the biological traits, whereas Figure 4.4 traces back the clustering procedure. Coefficients of variation for thorny physical defence and aerenchyma are 0, indicating clearly defined values for these two traits within the PFGs. Also spacers are a distinctive feature for most groups. Not all species in one cluster display exactly the same traits. This is expressed in high coefficients of variation. However, abstraction of the traits is necessary, therefore, all further implementations work with the medians as shown in Table 4.4.

The PFGs can mainly be separated (a) by the existence of thorny physical defence, (b) by the occurrence of aerenchymas, and (c) by the location of spacers (Appendix Table 13). PFG 9 is the only group featuring thorny physical defence, whereas PFG 7 by far grows highest. PFG 1 and 8 are closely related. Both contain mainly small annuals, with PFG 8 being the only group possessing a long–term persistent seed bank. PFG 3 and 5 are also very similar. Both are wetland plants of short canopy heights only distinguishable by SLI: PFG 3 seeds are short–term persistent, whereas seeds of PFG 5 are transient. Even though PFG 2 and 6 both feature below–ground spacers and medium canopy height, they are not related as only PFG 2 possesses aerenchymas. Moreover they differ in SLI, with PFG 2 having short–term persistent seeds, and PFG 6 featuring transient seeds. Besides not possessing aerenchymas and exhibiting below–ground spacers PFG 4 represents small–growing species with short–term persistens seeds.

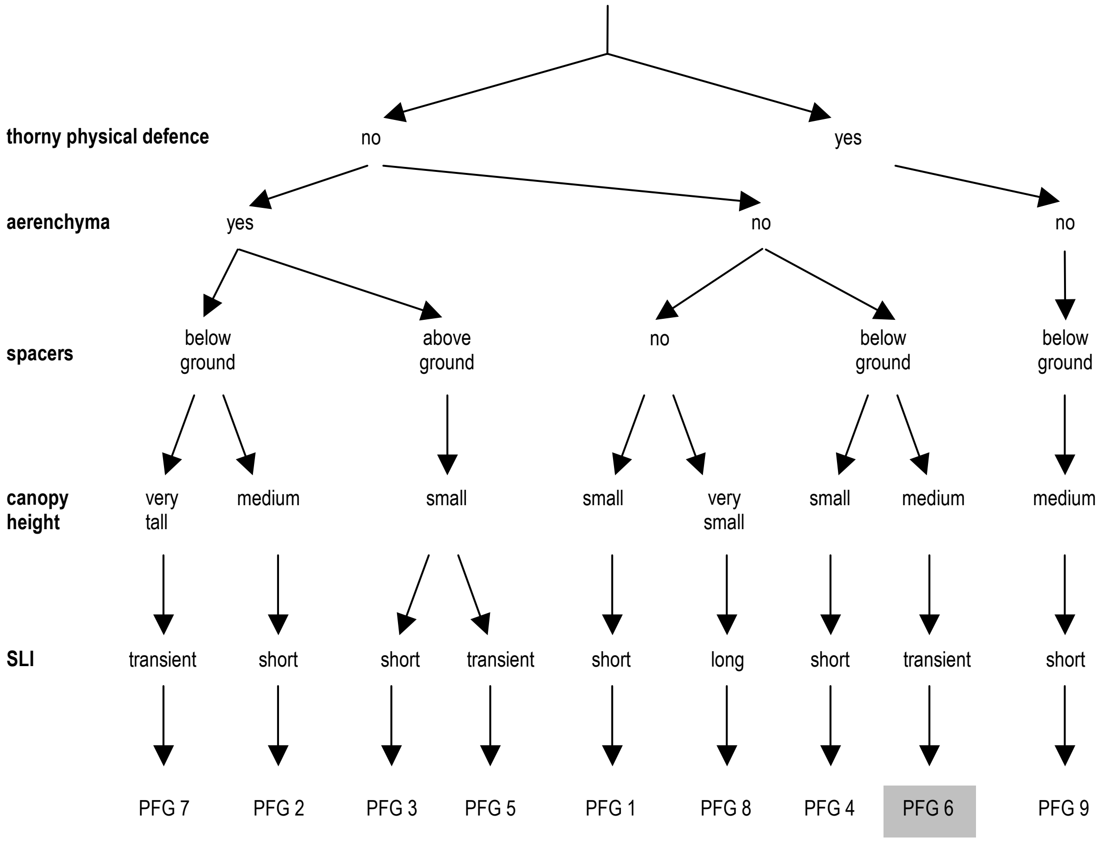

Figure 4.4: Derivation of PFGs during clustering. The grey marked PFG shows poor quality measures. (canopy height [mm]: very small: < 100, small: 100–200, medium: 200–400, tall: 400–800, very tall: > 800)

Table 4.4: Coefficients of variation (first line per trait) and characteristics (second line per trait) of PFGs. Grey marked PFGs are not meeting the quality requirements. Bold numbers indicate low variance within the characters for the single species in each cluster. (*even though the coefficient of variation is poor, still a precise interpretation is possible; cf. Appendix Table 13) (trans – transient; short – short-term persistent; long – long-term persistent)

PFG	1	2	3	4	5	6	7	8	9
aerenchyma	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	-
	no	yes	yes	no	yes	no	yes	no	no
thorny physical defence	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	-
	no	no	no	no	no	no	no	no	yes
spacers	**0.00**	**0.13**	**0.00**	**0.21**	0.34	**0.10**	**0.20**	**0.00**	-
	no	below	above	below	above	below	below	no	below
canopy height [mm]	0.70	**0.24**	0.38	0.76	0.65	**0.25**	**0.08**	**0.02**	-
	103	248	145	149	187	201	1298	90	389
seed longevity index	**0.18**	0.34	0.26	**0.27**	**1.38***	0.74	**1.41***	**0.01**	-
	short	short	short	short	trans	trans	trans	long	short

Generally, all PFGs are somehow influenced by GI (Table 4.5): PFG 1, 3, 4, 6 and 9 positively respond to high GI_{wint}. PFG 7 prefers medium to low GI_{wint}, and PFG 5 occurs at low winter and high summer GI. PFG 2 and 8 depend on high GI_{summ}. Additionally, pH and PAW are important environmental factors. PFG 1, 2, 3, 4 and 9 respond to high pH–values, whereas PFG 5 is capable of enduring at high and low pH–values. Apart from PFG 7 (see example Figure 4.5) all other sensitive groups (1, 3, 6 and 9) prefer little available soil water.

Table 4.5: Environmental parameters after stepwise logistic regression. The appendix ‘2’ labels the square of the variable. The grey column indicates the low–quality cluster. (P = plant available phosphorus, K = plant available potassium, GI_{wint}/GI_{summ} = grazing intensity in winter/summer, kf = water permeability in saturated soil, PAW = plant available water, SWL_{wint} = soil water logging in winter)

PFG	1	2	3	4	5	6	7	8	9
P	6.72E-03	-	-	-	-	-	-	-	-
P2	-1.41E-06	-	-	-	-	-	-	7.68E-07	-
K	-	-	-	-	-	-	-0.012	0.025	-
K2	-	-	-3.25E-06	-	-	-	-	-1.88E-05	-
pH	-	0.69	6.32	1.41	-6.82	-	-	-	-
pH2	0.041	-	-0.39	-0.11	0.67	-	-	-	2.73
GI_{wint}	-	-	0.045	-	-0.033	-	0.082	-	-
GI_{wint}2	9.26E-04	-	-3.06E-04	2.53E-04	-	5.17E-05	-1.05E-03	-	6.74E-03
GI_{summ}	-	0.032	-	-	-	-	-	-	-
GI_{summ}2	-	-2.63E-04	-	-	4.82E-04	-	-	9.35E-04	-
kf	-	2.53E-03	-1.39E-03	-1.11E-03	-	-4.58E-03	-	-	-
kf2	-	-	-	-	-	-	-	-	-
PAW	-0.02	-	-0.015	-	-	-	-	-	-0.35
PAW2	-	-	-	-	-	-1.05E-04	4.85E-05	-	-
SWL_{wint}	0.9	2.15	-	-1.66	1.99	-	-	-	-
Intercept	-10.72	-8.19	-24.4	-6.27	10.62	1.28	-0.48	-13.83	-131.15

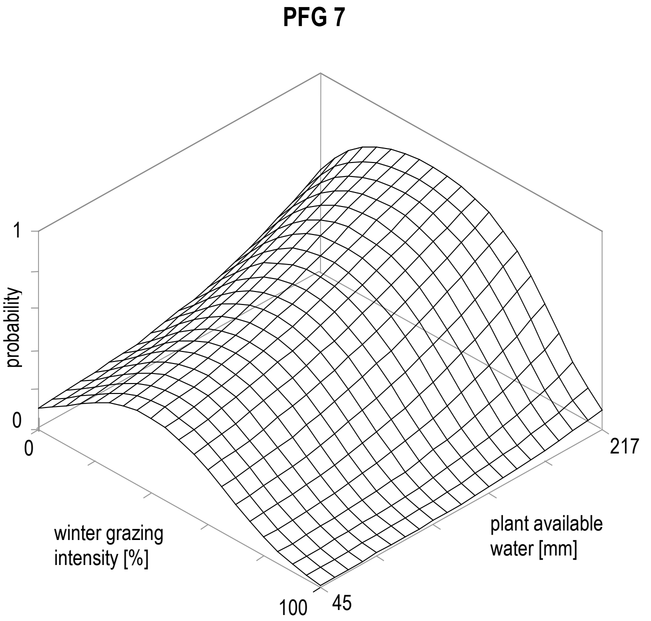

Figure 4.5: PFG 7; winter grazing intensity versus plant available water for K = 148 kg*ha^{-1} (median).

Generally, the probability that all species of a group with similar biological traits co–occur is high, for most of the clusters probability exceeds 0.4. Only for PFG 5 it is predominantly < 0.4.

PFG 1 furthermore depends on high fertility (P). There is a positive regression coefficient for SWL_{wint}. PFG 2 prefers easily water permeable soils and water logging in winter. PFG 3 and 4 both depend on low water permeability of the soil. PFG 3 is additionally promoted by low K–concentrations, whereas PFG 4 is negatively influenced by water logging in winter. PFG 5 prefers winter water logged soils. Low K–concentrations promote the occurrence of PFG 7. PFG 8 responds positively to fertility (K and P).

Discussion

Environmental conditions and species diversity

Considering nutrient conditions they generally ranged from low to very high. Especially P and N contents differed by the 100- and 1000fold, respectively. Originating from the area's history strong differences also showed in $CaCO_3$ and therewith pH. The area mainly used to be part of the lake floor before the Müritz waters fell by about 1,50 m 165 years ago (Deppe & Prill 1958). More than half of the sites containing no measurable inorganic carbonate are found within the elevated area near the Müritzhof which used to be a fossil cliff (Hurtig 1962b; Jeschke *et al.* 1980) and therewith cannot contain lake chalk. Other $CaCO_3$–free plots are found on the highly dynamic decalcified shore banks which are affected every winter by ice movements from the Müritz waters.

Table 4.6: Species with insufficient quality of fit measures: prevalence within the investigation area.

species	prevalence in 120 plots
Agrostis stolonifera	29
Armeria maritima ssp. *elongata*	8
Avenula pubescens	10
Cirsium palustre	10
Cynosurus cristatus	33
Daucus carota	9
Festuca ovina	35
Festuca pratensis	39
Festuca rubra	42
Galium mollugo	19
Genista tinctoria	14
Holcus lanatus	63
Juniperus communis	9
Lathyrus pratensis	11
Linum catharticum	12
Lotus corniculatus	16
Lotus uliginosus	19
Medicago lupulina	14
Poa trivialis	32
Polygala vulgaris	9
Prunella vulgaris	21
Rumex acetosa	13
Salix repens	17
Stellaria graminea	29
Succisa pratensis	10
Taraxacum officinale	18
Veronica chamaedrys	22
Vicia cracca	29

Full ranges were recorded for GI (0–100%). Especially the Rederangkoppel is highly grazed as sheep are fenced here in winter and outside the herding hours. GIs lower than expected were found within the herding area (mainly *Juniperus*–heath), originating from herding hours mainly concurring with low grazing activity of sheep (Ewert 2001). The lowest GIs were recorded in wet and reed areas which are obviously avoided by larges herbivores. This finding is supported by negative correlations between GI_{wint} and SWL_{wint} (–0.35), GI_{wint} and PAW (–0.18), and GI_{summ} and PAW (–0.22) and confirmed by Bakker (1998).

As for the Hassberge area large gradients of the environmental parameters are desirable. They allow to capture the realised niches (Austin 1990; Austin *et al.* 1990) of many species as completely as possible. For further comments see discussion of environmental conditions in Chapter 3.

We found a weak correlation between species number and GI_{wint}, indicating that removal of biomass especially during the winter months gives space and light to a larger number of species. Sternberg *et al.* (2000) found paddocks under continuous grazing to have higher numbers of species than seasonally grazed paddocks. However, species number was independent of grazing intensity. Bakker (1989), however, found species richness in the permanently grazed Westerholt in The Netherlands to show a positive relationship with grazing intensity, supporting our results. In this context Noy-Meir *et al.* (1989) observed cattle grazing to considerably increase the number, size and diversity of gaps in the grassland enabling many species to germinate and establish successfully.

Table 4.7: Prevalences and EPV–values for the responsive species. Bold marked species fulfil the criterion of 10 events per variable.

species	prevalence per 120 plots	no. of variables	presences/ variable
Achillea millefolium	41	2	**21**
Agropyron repens	16	4	4
Agrostis capillaris	54	5	**11**
Anthoxanthum odoratum	34	5	7
Briza media	35	4	9
Bromus hordeaceus	31	2	**16**
Calamagrostis stricta	12	2	6
Capsella bursa-pastoris	10	2	5
Carex arenaria	9	2	5
Carex disticha	12	5	2
Carex flacca	29	2	**15**
Carex hirta	41	4	**10**
Carex nigra	18	2	9
Carex panicea	32	4	8
Centaurea jacea	41	4	**10**
Cerastium arvense	25	4	6
Cerastium glomeratum	30	3	**10**
Cirsium arvense	31	3	**10**
Cladium mariscus	9	3	3
Convolvulus arvensis	9	3	3
Dactylis glomerata	12	2	6
Danthonia decumbens	26	5	5
Deschampsia cespitosa	38	2	**19**
Eleocharis uniglumis	24	1	**24**
Erodium cicutarium	10	2	5
Galium palustre	29	4	7
Galium uliginosum	24	1	**24**
Gentianella uliginosa	13	2	7
Hydrocotyle vulgaris	24	2	**12**
Juncus articulatus	24	4	6
Leontodon autumnalis	23	4	6
Lolium perenne	34	1	**34**
Luzula campestris	24	3	8
Mentha aquatica	38	5	8
Molinia caerulea	35	3	**12**
Odontites vulgaris	8	2	4
Parnassia palustris	13	2	7
Phragmitis australis	50	5	**10**
Plantago lanceolata	54	3	**18**
Poa annua	17	4	4
Poa pratensis agg.	60	3	**20**
Potentilla anserina	34	4	9
Potentilla erecta	43	3	**14**
Potentilla reptans	47	4	**12**
Ranunculus acris	46	4	**12**
Ranunculus repens	34	5	7
Rumex acetosella	30	5	6
Taraxacum palustre	6	2	3
Trifolium fragiferum	17	2	9
Trifolium pratense	29	2	**15**
Trifolium repens	46	3	**15**
Valeriana dioica	15	2	8
Veronica arvensis	19	2	**10**

Responsive species models

Only 53 of 88 species entering the statistical procedure showed models of sufficient goodness of fit. 7 species were not modelled at all; i.e. *Calamagrostis epigejos*, *Galium verum*, *Leontodon hispidus*, *Pinguicula vulgaris*, *Ranunculus flammula*, *Rhinanthus serotinus* and *Viola canina*. Obviously, no environmental variable was significant to develop a valid model.

Another 28 species showed low–quality models. There are various reasons for this phenomenon. As can be seen for the Hassberge, the first expected explanation here would be again low prevalences in the investigation plots. Simply the low number of records made it impossible to find a consistent distribution pattern. This applies to *Armeria maritima*, *Avenula pratensis*, *Cirsium palustre*, *Daucus carota*, *Genista tinctoria*, *Juniperus communis*, *Lathyrus pratensis*, *Linum catharticum*, *Polygala vulgaris* and *Succisa pratensis*. They were present in 8 to 14 of the 120 investigation plots (for detailed prevalence values see Table 4.6).

A second explanation for models not meeting the quality requirements is species presence along the whole recorded disturbance and resource gradient independent of prevalence. This applies to *Agrostis stolonifera*, *Cynosurus cristatus*, *Festuca ovina*, *Festuca pratensis*, *Festuca rubra*, *Galium mollugo*, *Holcus lanatus*, *Lotus corniculatus*, *Lotus uliginosus*, *Medicago lupulina*, *Poa trivialis*, *Prunella vulgaris*, *Rumex acetosa*, *Salix repens*, *Stellaria graminea*, *Taraxacum officinale*, *Vicia cracca* and *Veronica chamaedrys*. These species occurred in 13–63 of the sampling plots (see Table 4.6), and there is no relation to any of the considered environmental factors.

Furthermore, bimodal distributions might be exhibited which cannot be modelled with unimodal logistic regressions (Kleyer 1999).

PFG	prevalence sum for all species	variables/ PFG	EPV
1	90	5	18
2	281	4	70
3	269	5	54
4	434	4	109
5	93	4	23
6	133	3	44
7	59	3	20
8	27	3	9
9	31	3	10

Table 4.8: EPV–values for PFGs.

Again, an opposite problem occurs for the responsive species, i.e. habitat models of unrealistically good quality. For further comments see discussion on responsive species models in Chapter 3.

Considering the above mentioned criteria more than half of our responsive species models are overfitted (Table 4.7). This could result in negative influences on the habitat models for the responsive species but also on those for the PFGs. However, as for the Hassberge the PFG habitat models are based on the predicted probabilities, and except for PFG 8 fulfil the criterion of 10 events per variable given the benchmark of Steyerberg *et al.* (2001) (Table 4.8).

Clustering and traits

In our study there were 11 traits entering the clustering procedure. The most parsimonious trait combination consisted of 5 traits: thorny physical defence, aerenchyma, spacers above– or below–ground, canopy height and SLI. Incorporating the remainder of the considered traits into the clustering process resulted in models with less predictive value.

As mentioned for the Hassberge area those traits not included into the parsimonious combination are not necessarily independent from the included traits. That means that they are indirectly represented through the chosen trait combination. In the following we will consider such associations. Again (cf. Chapter 3) spacers are highly associated with clonality and plant life span as only perennials develop vegetatively reproductive organs representing a perennial life cycle and vegetative regeneration.

Compared to Chapter 3 it is SLI as a generative trait putting emphasis on dispersal in time. It represents seed mass and number as there are trade–offs between these features for all 88 species (seed number and seed mass: -0.38, seed mass and SLI: -0.38). These trade–offs again confirm the findings of e.g. Westoby *et al.* (1992), Thompson *et al.* (1993), Dupré & Ehrlén (2002) or Cerabolini *et al.* (2003). However, again considering grasslands also for the Müritz area vegetative spread is likely to be the more dominant regeneration strategy (Eriksson & Jakobsson 1998; Kahmen & Poschlod 2004) and therefore generally more promising. Only gap–creating disturbances (e.g. trampling), as also found within the investigation area, promote regeneration by seeds. Furthermore, seed mass is hypothesised to decrease under grazing pressure (Vesk *et al.* 2004). Because of the negative correlation between seed mass and SLI (-0.38) this would result in a rising SLI.

Aerenchymas are found in many water and marsh plants enabling them to survive temporary or permanent water logging (stress tolerance). We detected a weak trade–off between the presence of aerenchymas and

SLA (-0.28). This fact contradicts the commonly accepted idea of water and marsh plants having hygrophile leaves resulting in high SLA–values. However, only 12 out of 37 species containing aerenchymas reach SLA–values below 20 mm^2*mg^{-1}, and only 1 of them goes below the exceptionally low SLA of 10 mm^2*mg^{-1}. Therefore, we regard this trade–off as misleading and thus unimportant for further consideration.

Furthermore, we found a strong association (0.49) between the presence of aerenchymas and physical defences other than spikes and thorns (i.e. hard or mucilaginous leaves; leaves with nettles, hooks or bristles). Obviously, in the investigation area there are a lot of plant species living in wet conditions. Many of them exhibit some sort of weak physical defence, especially hard leaves (see Appendix Table 8). Hard leaves can be caused by sclerification of vascular bundles, presence of collenchyma strands or a thick epidermis providing protection against herbivores or other physical hazards (Cunningham *et al.* 1999). This indicates that species need to allocate nutrients to invest into anti–herbivore defence.

Disturbance response within the most parsimonious trait combination is represented by thorny physical defence. We found its presence to be weakly negatively correlated with SLA (-0.23). Again, this suggests that plants investing into physical defence (here: thorns and spikes) need to produce more supporting tissue for their defence mechanism. Generally, however, anti–herbivore defence may in parts be a by–product of defence against the physical environment (Grime *et al.* 1996).

Another trade–off with SLA (-0.33) we found for canopy height. Both traits represent the vertical expansion and are measures of the competitive ability of plants. According to McIntyre *et al.* (1999) and Jauffret & Lavorel (2003) plant height is relevant for grazing palatability. Furthermore, Díaz *et al.* (2001) found reduced height in response to disturbances and abiotic stress to be the single best predictor of grassland response to grazing.

Even though SLA is not represented within the most parsimonious trait combination it is always present through a variety of correlations and therefore cannot be eliminated from the considerations. Sufficient N–supply increases SLA (Duru *et al.* 1995). Low SLA has been shown to be negatively associated to a species' feeding value (Duru 1997), there is a close correlation between SLA and digestability (Duru *et al.* 2004, for *Dactylis glomerata* and *Festuca rubra*). Species with low SLA show a greater leaf life–span and accumulate a greater mass of leaf, and can therefore also capture large amounts of light (Westoby 1998).

Considering Westoby's (1998) three–dimensional scheme for vegetation description based on the trade–offs between seed mass, SLA and canopy height, the former two traits are only represented indirectly. Canopy height contributes to a plant's vertical expansion and its capacity to acquire carbon. It always determines competitive success (Lehsten & Kleyer subm.). Instead of seed mass, we found SLI to be important for the considered grazing system, but as mentioned above there is an association between the two, and SLI substitutes seed mass.

Our classification brings forward additional attributes, which are important for grazing response (strong physical defence) and concern specific environmental stress (aerenchymas). The fifth feature, i.e. spacers, represents a plant's capability of lateral expansion, including its life cycle. Obviously, Westoby's three traits are not sufficient to capture enough plant variability to functionally represent the floristic diversity along the recorded environmental gradients.

Plant functional groups

Generally, the most important factor determining the occurrence of the PFGs is GI. We found especially winter GI to be important. This supports the theory that permanent stocking at low densities is most effective against natural succession in winter (Kleyer *et al.* 1999), as then there is no biomass regrowth. Even though receiving supplementary nutrition in winter sheep, cattle and horses will graze large areas of the remaining biomass within the investigation area down to the soil surface, which is especially visible south–east of the Müritzhof, where 100% of the standing biomass was eaten (see Figure 4.2).

Considering the traits, Noy-Meir *et al.* (1989) found plant growth form to be most strongly associated with grazing response, and tall plants with elevated leaves to increase with no or slightly to intermittently grazing. Also Díaz *et al.* (2001) state, that reduced height in response to disturbances and abiotic stress is the single best predictor of grassland response to grazing, and McIntyre *et al.* (1999) and Jauffret & Lavorel (2003) stress the relevance of plant height and grazing palatability. In our investigations canopy height ranges from very small to medium for most of the created PFGs; it is only PFG 7 representing very tall plants. Its habitat model generalises wet sites with medium to low GI to promote the group (see Figure 4.5), confirming observations of Noy-Meir *et al.* (1989). Furthermore, at a low stocking rate (which is given within the investigation area), herbivores graze selectively and avoid wetter sites (Rozé 1993). However, very importantly PFG 7 shows physical defence mechanisms other than thorns and spikes leading to an avoidance by animals and consequently to tall stature. This point will be discussed later.

Canopy height as a measure of competitive ability decreases with a lack of nutrients (cf. Diekmann & Falkengren-Grerup 2002). P–shortages at high pH–values (> 7.3) are triggered by Ca–ions, whereas at low pH–values (< 5.5) they are caused by aluminium or iron ions, all binding plant available P (Busman *et al.* 1998). Soil pH between 6 and 7 will generally results in the most efficient use of phosphate (Busman *et al.* 1998). Furthermore, as mentioned above, high GI is responsible for the occurrence of small species. Most of the created PFGs indeed show small or medium statures. Looking at PFG 2, 3 and 4 their occurrence is highest at high GIs and high pH–values, causing low P–supplies. However, PFG 2 features medium canopy height, which can be attributed to its dependency on SWL_{wint}. Considering its species they are all indicators for humid to wet soils (Ellenberg *et al.* 1992), which are as mentioned afore avoided by herbivores (Rozé 1993) especially in winter, as most of the waterlogged places superficially dry up during summer. Furthermore, most species of the group show physical defence mechanisms other than spikes and thorns, which also indicates an avoidance by herbivores and explains the medium canopy height.

Avoidance by herbivores due to the water level has afore been named one reason for the tall stature of PFG 7, which prefers habitats with medium to low grazing intensities (see Figure 4.2). Especially *Cladium mariscus* is predominantly found in permanently flooded reeds. A second reason are its tough and sharply toothed leaves, which were hardly ever observed being eaten by horses and cattle occasionally passing through the reeds. However, Lerrack (pers. comm.) reports cattle especially in the winter months to feed on *C. mariscus* after leaving the hayrack. We could not verify this observation in our biomass experiments. Sheep were never observed in the reeds. However, things looked slightly different for *Phragmitis australis*. The species also features hard leaves, but not to the extent as *C. mariscus*. Additionally, it was also found outside the reeds, even in heavily grazed areas, indicating a higher palatability compared to *C. mariscus*. This explains the dependency of PFG 7 on rather moderate tending to low GIs.

There are other PFGs featuring small canopy heights, but they show no consistency in preferring low nutrient supplies associated with high GIs. This is particularly striking for PFG 1 and 8, as they show the smallest plant heights of all PFGs (see Table 4.4). Their species were mainly recorded within the elevated extremely grazed area south–east of the Müritzhof which is also highly affected by excrements especially of sheep. Except for *B. hordeaceus* the species indicate moderate to high nitrogen contents, *P. annua* even being a genuine nitrogen indicator (Ellenberg *et al.* 1992). Fertilisation until 1986 and today's extreme grazing pressure are the reasons for the extremely high P– and N–concentrations, and therefore cause the annual strategy of the two PFGs. Sheep as the main grazers in the concerned area are very selective due to their small muzzles (Pott & Hüppe 1991). Biting off plants very close to the soil surface and even rooting them out causes physical disturbance. Also their hooves create open spaces, facilitating annuals as in PFG 1 and 8. Annuals are well adapted to swiftly changing vegetation patterns, provided they have a persistent seed bank or good dispersal capacities (Bakker 1998). Generally, it is hypothesised that seed mass will decrease with rising GI (Vesk *et al.* 2004) which in return stands for an increasing SLI. Both PFGs indeed show short– and long–term persistent seeds, respectively, enabling them to persist in the most intensively grazed areas.

PFG 9, solely consisting of *Cirsium arvense*, needs to be considered separately as it is the only PFG showing thorny physical defence. It occurs in highly winter grazed areas and reaches the tallest stature amongst the PFGs inhabiting dry soils. Being spiny prevents large herbivores feeding on it, allowing to complete the generative life cycle terminating in innumerable light–weighted seeds capable of flight. However, *C. arvense* is not dependent on generative reproduction, even though well capable of it especially on soil disturbances (Edwards *et al.* 2000). Below–ground spacers make it unsusceptible to trampling by animals and give best nutritional support to the vegetative offspring. Adventitious shoot recruitment is suppressed in intact vegetation but is facilitated by open spaces (Edwards *et al.* 2000) caused for example by intensive grazing. Spines are an effective defence against herbivory but need to be paid for by allocation of nutrients to their production. Therefore, *C. arvense* prefers nitrogen–rich habitats (Ellenberg *et al.* 1992) to finance its anti–herbivore strategy.

Also PFG 5 is exceptional, as it is the only group preferring different GIs in winter (low) and summer (high). This results from SWL in winter, which keeps the animals from intensive grazing as they avoid wet sites (Rozé 1993 for low stocking densities). The need for water is confirmed by Ellenberg *et al.* (1992), who assign all species within the group to wet conditions. GI increases with decreasing SWL during the vegetation period, resulting in small canopy height. Small plant height can also be explained by low and high, but no intermediate pH–levels, allowing the conclusion that there is little available P. Furthermore, the group shows transient seeds. This indicates, that emphasis is put on vegetative regeneration, here happening by means of above–ground spacers. Even though much more susceptible to trampling they are rather capable of invading closed vegetation covers than seeds are.

Conclusions

Overall, abiotic factors, such as nutrient status, ground water level and soil type often determine the nature of the impact of grazing on plant communities (Bakker 1998). In fact, within the investigation area SWL and nutrient status show a large impact on GI, which is the most important factor for the arrangement of the PFGs. There is a strong functionality of traits concerning GI and soil water. Not considering the exceptional PFG 9 as being the only group featuring strong physical defence mechanisms, it is obvious that herbivores prefer physically undefended plants in rather dry grazing habitats, which is suggested by a negative relationship between GI and the presence of aerenchymas (Figure 4.6 and 4.7). This supports findings of Rozé (1993), who found herbivores at low stocking densities to avoid wetter sites. Furthermore, we found a strong relationship between GI and seed longevity which is indirectly noted by Vesk *et al.* (2004) stating that seed mass will decrease with grazing. Figure 4.7 shows the more intuitive effect strong physical defence mechanisms have on GI as well as the effect grazing has on canopy height.

For the investigation area another important point needs to be considered. Even though especially the *Cladium mariscus* – reeds seem to be avoided by the grazing animals, we could not observe for natural succession such as the growth of birch or alder trees. According to Lerrack (pers. comm.) this is due to the occasional mechanical removal of small trees within the reeds at the Rederangkoppel, whereas the reeds in the vicinity of the Spukloch are being mowed in dry years. Obviously, especially in areas avoided by the animals irregular mechanical encroachment becomes necessary to prevent natural succession.

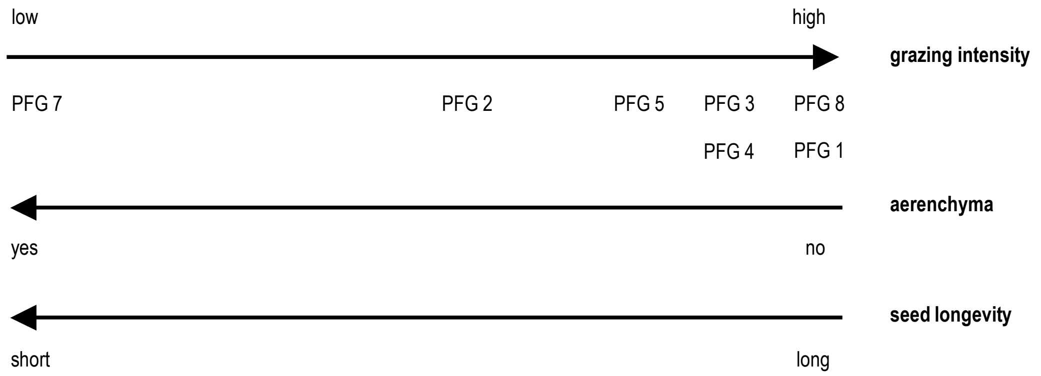

Figure 4.6: Grazing intensity and mutual effects of aerenchyma as an indicator of wet conditions and seed longevity as an indicator of grazing conditions. PFG 9 as the only group with strong physical defence is excluded from the considerations.

However, plant species richness (Olff & Ritchie 1998) and open spaces created in the vegetation cover (Noy-Meir *et al.* 1989; Bakker 1998) depend on the grazing animals as well as on stocking densities (Bakker 1998; Olff & Ritchie 1998). If productivity is high herbivores graze selectively (Rozé 1993). Multi–species grazing is likely to have other effects on the vegetation than grazing by a single species, as herbivores differ in terrain use, food habits and therewith in their potential to influence vegetation development (Bakker 1998). Especially horses are suitable for multi–species grazing as they eat plants avoided by cattle and sheep, e.g. *Deschampsia cespitosa* (Rahmann 1998). Bakker (1998) suggests that ‘where there is a diversity of plant communities there is also likely to be a diversity of niches for ungulate species to fill’, as they differ in body size or digestive system or use different parts of the vegetation (Gordon 1989a). Two or more herbivore species are likely to utilise a greater proportion of plant species in a community, which at high stocking rates could result in a more uniform vegetation pattern (Briske 1998). However, depending on the plant communities affected it could also lead to greater species richness (Bakker 1998).

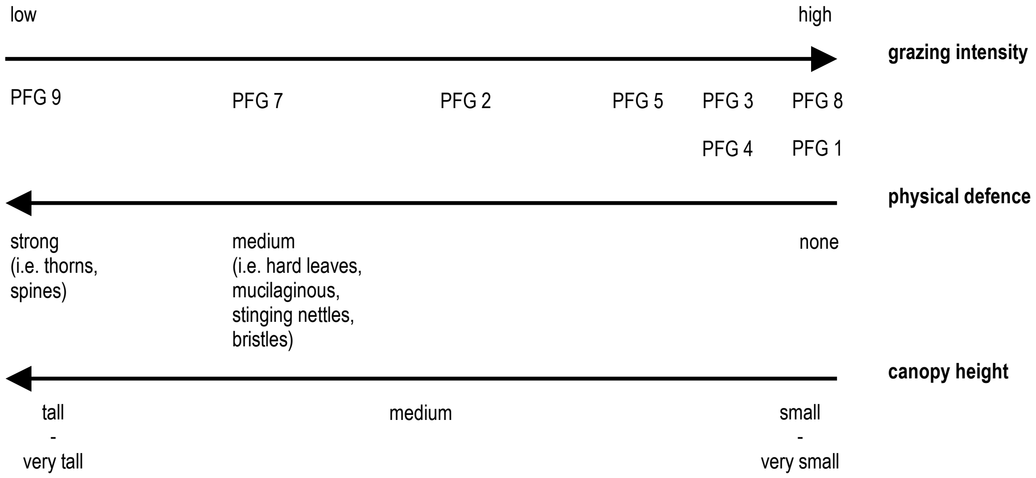

Figure 4.7: Grazing intensity and mutual effects of physical defence mechanisms on GI and of GI on canopy height. All PFGs are included into the consideration.

Finally, we conclude that plant composition within the investigated area has strongly adjusted to the grazing regime within the last three decades of continuously advancing extensive grazing. Ever since its emergence from the lake floor most of the area has been grazed more or less extensively which makes it the most continuously used system under grazing conditions in north–eastern Germany.

CHAPTER 5

TRANSFERABILITY OF TRAIT FUNCTIONALITY ACROSS LANDSCAPES WITH DIFFERENT DISTURBANCE REGIMES

Transferability of trait functionality across landscapes with different disturbance regimes

with Michael Kleyer

Abstract

For the presented investigation we analysed 240 study sites including environmental variables as well as presence/absence and biological trait data for 130 species. Comparable to fundamental trade–offs we suggest that large data sets and wide environmental gradients allow to identify fundamental plant attributes. For the considered data we identified 15 plant functional groups (PFGs) with 7 shared fundamental functional attributes and with a common response to disturbance parameters and fertility. The identified fundamental traits are attributes predominantly related to persistence rather than to regeneration, and are namely canopy height, aerenchyma, woodiness, spacers, seed longevity (SLI), specific leaf area (SLA) and physical defence other than spikes and thorns. They especially responded to effectively available water, disturbance frequency and disturbance magnitude. Because of sufficiently large environmental gradients we created habitat models for the PFGs which can be used for prediction in environmental planning assuming that shared attributes result in similar behaviour if the environment changes.

Comparing our results with Westoby's suggested LHS plant ecology strategy scheme which is based on only SLA, plant height and seed mass we came to the conclusion that pre–defining a small set of suspected 'fundamental' traits is not sufficient to capture enough life history variability to display the response to complex environmental factors. We suggest that in a given landscape there is indeed a limited set of functional traits, but there is no trait combination generally applicable to all regions and scales.

Nomenclature: Rothmaler (1994)

Introduction

The identification of ecologically meaningful functional plant traits is a prerequisite to understand and predict the abundance and distribution of plant species in natural habitats (Grime 1974; Grime 1979; Grime *et al.* 1988; Keddy 1992; Weiher *et al.* 1999). Comparing trait syndromes along environmental gradients might reveal general principles about functional plant–environment relations (Kleyer 2002). Gitay & Noble (1997) and McIntyre *et al.* (1999) suggest that such functional relations between environmental factors and trait sets should recur in other landscapes and even in other biogeographical regions.

Suites of physiological and morphological traits are thought to represent adaptations to environmental conditions (McIntyre *et al.* 1999) and numerous studies have demonstrated these trait–based functional responses (Kleyer 1999; McIntyre *et al.* 1999; Fonseca *et al.* 2000; Craine *et al.* 2001; Kleyer 2002; Jauffret & Lavorel 2003; Thuiller *et al.* 2004). However, it is rather unlikely that functions important for the long–term survival of plant populations (e.g. generative or vegetative regeneration, dispersal, expansion or persistence) share similar relevance across all possible environments (Lehsten & Kleyer subm.). Generally, dispersal or regenerative traits are likely to be less important in habitats stable in space and time than persistence traits, and vice versa (Grime *et al.* 1988; Shipley *et al.* 1989; Díaz & Cabido 1997).

Groups of plants sharing similar traits and responding to multiple environmental factors in the same way are defined as plant functional groups (PFGs) (Gitay & Noble 1997; Lavorel & Garnier 2001). Several sets of attributes are suggested to establish PFGs. Based on species performance trait hierarchies rank the consistency of traits across species pools and order the relevance of plant attributes for survival (Lehsten & Kleyer subm.). They exhibit the most functional features for species occurrence in given environments. In a simulation approach to predict SLA–, canopy height– and seed mass–combinations (following the LHS–scheme, see Westoby 1998) for different disturbance regimes on soils with low and high fertility Lehsten & Kleyer (subm.) tried to identify the combinations that perform best. They were interested in finding a hierarchy of these traits across different simulated environments. They identified plant height to always determine competitive success, while seed mass was more important than SLA at fertile sites and vice versa at infertile sites. However, finding a trait hierarchy in empirical data is rather difficult as trait states that are not appropriate to the environmental conditions are filtered out and plants with concerned trait combinations will not get the chance to exist. Studies conducted on traits rarely consider the same trait set and/or environmental parameters (Kleyer 1999; Landsberg *et al.* 1999; Díaz *et al.* 2001; Kleyer 2002; Lavergne *et al.* 2003; Vesk *et al.* 2004) and comparison between reported hierarchies is difficult. Our general analysis does not concentrate on the identification of trait hierarchies for the above mentioned reasons. It results in, what we call, 'fundamental' traits which can be identified by considering large data sets with wide environmental gradients. So far, consistent patterns of association between plant traits have only been found in local floras (e.g. Grime *et al.* 1988; Boutin & Keddy 1993; McIntyre *et al.* 1995; Díaz & Cabido 1997). However, using such large data sets containing species occurrences, species traits and environmental parameters recorded with similar methodology all over the world could eventually lead to a trait combination predicting a majority of plant distributions over worldwide environmental gradients.

As mentioned above environmental factors are responsible for the occurrence of PFGs with certain attributes. In the preceding chapters we identified two parsimonious trait sets relevant for two different environments. The presented analysis aims to identify general patterns and fundamental traits among the 130 species on all investigated sites in both investigation areas. With the aid of Ward's clustering and stepwise logistic regression we again identified a most parsimonious set of traits explaining a maximum number of species in well–calibrated PFG habitat models. The major differences between the areas concerning environmental factors were found in disturbance parameters such as frequency and magnitude as well as the effectively available amount of water. Above all we expect these parameters to determine the occurrence of PFGs. Considering our results from the single investigation areas (see Chapter 3 and 4) and additionally taking into account the three traits proposed by Westoby (1998) we assume plant height, SLA, seed mass, the presence of aerenchymas and some sort of physical defence mechanisms to play a vital role within our parsimonious trait combination. On one hand, we expect PFGs unique for each of the investigation areas reflecting environmental differences; on the other hand, it is likely that emerging groups will occurr in both landscapes indicating similar environmental conditions. Generally, we suggest that the larger the data set and the wider the environmental gradients the more fundamental are the identified traits concerning their general importance.

Methods

Investigation areas

Two investigation areas were sampled for plant traits, i.e. (1) the Rederang– and Spuklochkoppel at the eastern shore of Lake Müritz in Mecklenburg–Western Pomerania in north–eastern Germany (53° 29' N, 12° 44' E), and (2) the Hassberge at the western edge of the 'Hassberge' mountains in Lower Frankonia, southern Germany (50° 03' N, 10° 35' E). The latter covers approximately 25 km² of dry grasslands, fields, fallow vineyards and farmland and shrubland on clay stone, sandstones clays and clay marl stone as well as clay and marl slate with their interspersed sands and carbonates (Rutte 1981). The former area emerged from the Müritz waters only some 165 years ago, covers approximately 3 km² and is grounded on subhydric soils, fens, gleys, terrestrial soils, clay and Cambisols (brown earths). At the lake the mean annual precipitation from 1930–2002 was 583 mm (Wetterdienst des Nationalparkamt Müritz 2003); the maximum rain fall occurs in summer (July), the minimum in winter (Februar), and the mean annual temperature is 8,2°C. Mean annual precipitation in the Hassberge amounts to 650–700 mm, the mean annual temperature is 7.5–8.5°C with relatively high winter temperatures (Elsner 1994). Both climates are stamped by oceanic and continental influences.

Land use

Land use in the Hassberge can be traced back more than a thousand years. Beside farmland and pastures viticulture along the southward facing slopes was an important sources of income. The steep slopes as well as the Franconian way of bequest resulting in small land parcels and, hence, poorly workable land have prevented agriculture in the investigation area from becoming as intense as in other German regions

(Schlumprecht 2004). Instead the traditional rural cultivation created diverse habitats featuring a rich flora and fauna. Today's utilisation depends much on the slope gradient (Strauß 2002). Flat areas are predominantly used as farmland. Most of the sloped land is used as grassland or open orchard meadows, steep slopes are sporadically grown with grapes (Strauß 2002). Many of the pastures are still in use (i.e. mowing, grazing, both); fallow fields or pastures can be found in different successional stages.

At the Rederang– and Spuklochkoppel there has been a continuous extensive grazing history with horses and cattle ever since the 1880s (Deppe 1980; Jeschke 1993). In 1969 Fjell cattle were brought in on the Spuklochkoppel after a 15 year–period of animal exclusion in order to protect ground–breeding birds and consequently enhanced succession (Deppe 1980). Only the cattle were not sufficient to stop succession, so Gotland sheep and Shetland ponies were introduced some 20 years ago (Martin 1997). Nowadays, extensive grazing as traditional management is continued with 0.3–1.5 lifestock units per ha. Additionally, mechanical management like mowing and shrub encroachment became necessary and continue to date. From May to October the sheep are herded morning to midday in the north–western parts of the investigation area, i.e. Spuklochkoppel and semi–open *Juniperus communis*–stands (in the following called *Juniperus*–stands). Afternoons and nights they spend on the Rederangkoppel. Fjell cattle and Shetland ponies range free across the area. Part of the area is excluded from grazing from May to July for hay making. In winter this hay is fed as supplementary nutrition to the animals.

For a more detailed description of the investigation areas see Chapter 2.

Sampling design

For the sampling design see Chapter 3 for the Hassberge and Chapter 4 for the Müritz area.

Methodology

Explanatory and response variables were recorded for all 240 sampling plots. Investigations for the Rederang– and Spuklochkoppel were carried out in 2001, for the Hassberge in 2002.

Explanatory variables:

Environmental parameters: We considered all soil parameters as recorded in Chapters 3 and 4.

To avoid numerous single environmental parameters we calculated a value to account for soil water balance called 'effectively available water' (AW_{eff}). It numeralises the annual average amount of water effectively available for plants depending on

(a) climatic conditions, i.e. temperature, rainfall, evapotranspiration and sunshine duration
(b) topographical parameters, i.e. exposition and slope, and
(c) soil factors, i.e. plant available water (PAW), air capacity (AC), texture, groundwater and soil water logging in winter and in summer.

AW_{eff} is based on a soil profile depth of 60 cm and was calculated for the Hassberge based on the soil water balance module of the MOSAIK landscape model (Schröder *et al.* 2004) and for the Müritz area according to a modified version of this module for groundwater–influenced soils.

AW_{eff}–values in the Hassberge are only dependent on soil texture and equal the amount of water which can be held against gravity (i.e. PAW) as there is no groundwater influence and the pore volume of the AC is never filled. In contrast, the AW_{eff}–values for the Müritz are additionally influenced by groundwater. Therefore, AW_{eff} refers to the water stored within the pore volume of PAW and AC as well as to the water standing above the soil surface.

Table 5.1: Disturbance categories.

disturbance parameter	category	explanation
frequency	0.01	longer than every 10 years
	0.13	every 6 - 10 years
	0.27	every 2 - 5 years
	0.33	every 3rd year (roto-tilling)
	0.5	every 2nd year (roto-tilling)
	1	1x (roto-tilling 1x per year or mowing 1x per year)
	2	2x (mowing 2x per year or extensive year–round grazing)
	3	3x (mowing+grazing)
	4	4x (intensive grazing)
	5	5x (arable fields or vineyards)
magnitude	0-50	0-50% destroyed biomass (above ground disturbance) (mowing or grazing or mowing+grazing)
	100	ca. 100% destroyed biomass (below ground disturbance) (arable fields or vineyards or roto-tilling)
change in disturbance magnitude 1997 and 2002	0	no change in disturbance magnitude
	1	change in disturbance magnitude

Disturbance parameters: For the Rederang– and Spuklochkoppel area magnitude was recorded as winter grazing intensity (GI_{wint}) and summer grazing intensity (GI_{summ}). For methodology see Chapter 4. Magnitude ranged between 0% and 50%.

For the Hassbere disturbance parameters included frequency and magnitude. Magnitude was set 50% biomass destruction for above–ground disturbance (mowing, grazing, mowing and grazing), whereas 100% biomass destruction accounted for below–ground disturbance (arable fields, roto–tilling). Using stereo aerial photos from 1997 for the Hassberge area a change in disturbance magnitude within the last 5 years compared to the investigation year 2002 was recorded.

For disturbance variables see Table 5.1.

Part of the Hassberge area was randomly grazed by shifting flock of sheep. The impact on the vegetation is low and will not be considered further.

Response variables: Species composition was recorded as presence/absence data. Recording took place twice: the first time in May to define the spring flowering species, the second time in July for the complete summer species set. All species selected for Chapters 3 and 4 were taken into account for this analysis. This resulted in 130 species (see Appendix Table 14).

Biological traits were recorded as in Chapter 3 and 4. A short overview is given in Table 5.2.

Indices and statistical procedure

For calculation of indices and statistical procedure see Chapter 2. Also for the present analysis we checked for multicollinearity, this time the following parameters entered the eventual model calculation:

- soil parameters: relation between C and N (C/N), phosporus (P), potassium (K), water permeability in saturated soil (kf), pH, effectively available water (AW_{eff})
- disturbance parameters: magnitude, frequency, change in magnitude

Table 5.2: Traits and trait features. (*according to Bekker, R., pers. comm.)

trait	data type	trait features	literature source
SLA	numerical	mm^2*mg^{-1}	field measurements
canopy height	numerical	mm	field measurements
seed mass	numerical	mg per seed	partly field measurements and Eriksson & Jakobsson 1998; Kästner *et al.* 2001; Klotz *et al.* 2002; Cerabolini *et al.* 2003; Poschlod *et al.* 2003
start seed shedding	numerical	month	Poschlod *et al.* 2003
seed number	numerical	number	partly field measurements and Stakevitch 1988; Eriksson & Jakobsson 1998; Kästner *et al.* 2001; Poschlod *et al.* 2003
aerenchyma	categorical	0 – no aerenchyma 1 – aerenchyma	Eber, pers. comm.
thorny and other physical defence	categorical	0 – not present 1 – present	Klapp 1971; Rothmaler 1995; Kossegg 2001; Poschlod *et al.* 2003
clonality (length of tillers)	categorical	0 – not clonal 0.5 – < 10mm 1 – >10mm	Klimeš *et al.* 1997
plant life span	categorical	0 – annual 0.5 – biennial 1 – perennial	Rothmaler 1994; Kleyer 1995
spacers (above or below ground)	categorical	0 – no spacers 0.5 – above ground 1 – below ground	Klimeš *et al.* 1997; Poschlod *et al.* 2003
woodiness	categorical	0 – not woody 0.5 – woody at base 1 – woody	Poschlod *et al.* 2003
seed longevity	index	< 0.3* – transient 0.3–0.55* – short-term persistent > 0.55* – long-term persistent	Lefèbvre & Chandler-Mortimer 1984; Aarssen *et al.* 1986; Grunicke 1996; Kühner 1998; Oberdorfer 2001; Römermann 2002; Cerabolini *et al.* 2003; Poschlod *et al.* 2003; Fritzsch 2004

Again, three different matrices were set up: (1) ‘site x species matrix’ (Appendix Table 15), (2) ‘site x environmental factors matrix’ (Appendix Table 16), and (3) ‘species x trait matrix’ (Appendix Tables 14). For species codes see Appendix Table 17.

For the general clustering and logistic regression features see Chapter 2. Due to a higher number of species the SAS procedure was run for a number of 10, 11, 12, 13, 14, 15, 16 and 17 clusters. If the number of clusters is small, probability rises to receive very large clusters with 20 or more species. If the number of clusters is high many single species clusters can be expected.

Statistical analysis was conducted as in Chapter 2. The species taken into account were the selected species from Chapters 3 and 4.

Results

Resource supply

As for the single investigation areas also in the general consideration resource gradients range over several orders of magnitude (Table 5.3). However, the gradients are even wider as habitat parameters within the single areas differ. 89 sites contain no measurable inorganic carbonate, for the description see Chapters 3 and 4. The $CaCO_3$–content for the remaining 151 sites ranges between 2 546 kg*ha^{-1} and 2.8*10^{6} kg*ha^{-1}. The nutrient poorest soils contain no measurable plant available P, however, the nutrient–richest sites show values of over 4 400 kg*ha^{-1}. N–contents range from 210 kg*ha^{-1} to 9.6*10^{4} kg*ha^{-1}. The relation between C and N ranges between values of 0 and 65. Soil pH ranges between very acidic (3.3) and slightly alcaline (7.7) values.

	min	max	mean	std.dev.
CEC_{eff} [cmol$_c$*kg^{-1}]	2	52	17	15
C [kg*ha^{-1}]	0	1.5*10^{6}	1.0*10^{5}	1.8*10^{5}
N [kg*ha^{-1}]	210	9.6*10^{4}	8956	1.0*10^{4}
$CaCO_3$ [kg*ha^{-1}]	0	2.8*10^{6}	4.2*10^{5}	5.8*10^{5}
kf [cm*d^{-1}]	1	653	129	164
P [kg*ha^{-1}]	0	4424	368	520
K [kg*ha^{-1}]	33	1.4*10^{4}	1299	1705
C/N	0	65	11	9
pH	3.3	7.7	6.4	1.0
change	0 (no)	1 (yes)	-	-
frequency [a^{-1}]	0	5	2	1
magnitude [%]	0	100	47	29
avail. water [mm]	7	232	76	44

Table 5.3: Resource gradients and statistical values. Variables above the double line are not taken into regression analysis. (min. = minimum, max. = maximum, std.dev. = standard deviation, CEC_{eff} = effective cation exchange capacity, C = carbon, N = nitrogen, $CaCO_3$ = calcium carbonate, kf = water permeability in saturated soil, P = plant available phosphorus, K = plant available potassium, C/N = carbon–nitrogen–ratio, change = change in disturbance magnitude within the last 5 years of the investigation period (1997–2002), frequency = disturbance frequency, magnitude = disturbance magnitude, avail. water = effectively available water)

There are various correlations between soil factors, e.g. between CEC_{eff} and kf (-0.833). N was strongly correlated with C (0.655) and C/N showed associations with C (0.533). For pH and $CaCO_3$ we found another correlation (0.767). Even though also P and K were highly correlated (0.562), none of the two variables could be omitted as this would have resulted in a high loss of species. Because of the above mentioned associations the following variables were excluded from the analysis: C, N, $CaCO_3$ and CEC_{eff} (see Table 5.3 above the double line).

The annual average AW_{eff}–values range between 7 mm and 232 mm. The driest sites were found in the Hassberge area, the wettest conditions were recorded at the Müritz. We found strong a correlation between AW_{eff} and magnitude (-0.429).

Disturbance intensity

For the considered areas disturbance magnitude ranges from undisturbed, i.e. fallow, to intensely utilised sites, i.e. fields. There are no below–ground disturbances within the Müritz area. Magnitude was recorded as grazing intensity and ranges from 0 to 50% but never reaches 100%. In contrast, within the Hassberge area disturbance magnitude can be characterised with only two values, i.e. 50% and 100% as most sites have been or are still utilised as fields or mowed grasslands. A disturbance magnitude of 100% destroys the entire above– and below–ground biomass whereas a magnitude of 50% and less affects only above–ground biomass. Generally, fields are the most intensely utilised sites. Considering frequency grazed and mowed plots range from a disturbance of four times per year by intensive grazing to mowing once per year. The overall least disturbed sites are found in the Hassberge area as fallow grasslands with disturbance intervals of more than 10 years. For 22 sites a change in magnitude occurred (only in the Hassberge). This is especially the case for the roto–tilled plots which were formerly mowed once per year. The reverse direction applies for former fields which are now only being mowed once a year.

Responsive species

130 species (see Appendix Table 14) entered step 1 of the statistical analysis. Applying stepwise logistic regression resulted in 93 responsive species with sufficient quality models (see species in bold letters Appendix Table 14). Most of these species show sensitivities to pH and kf (see Figure 5.1). For regression coefficients of the single species see Appendix Table 19.

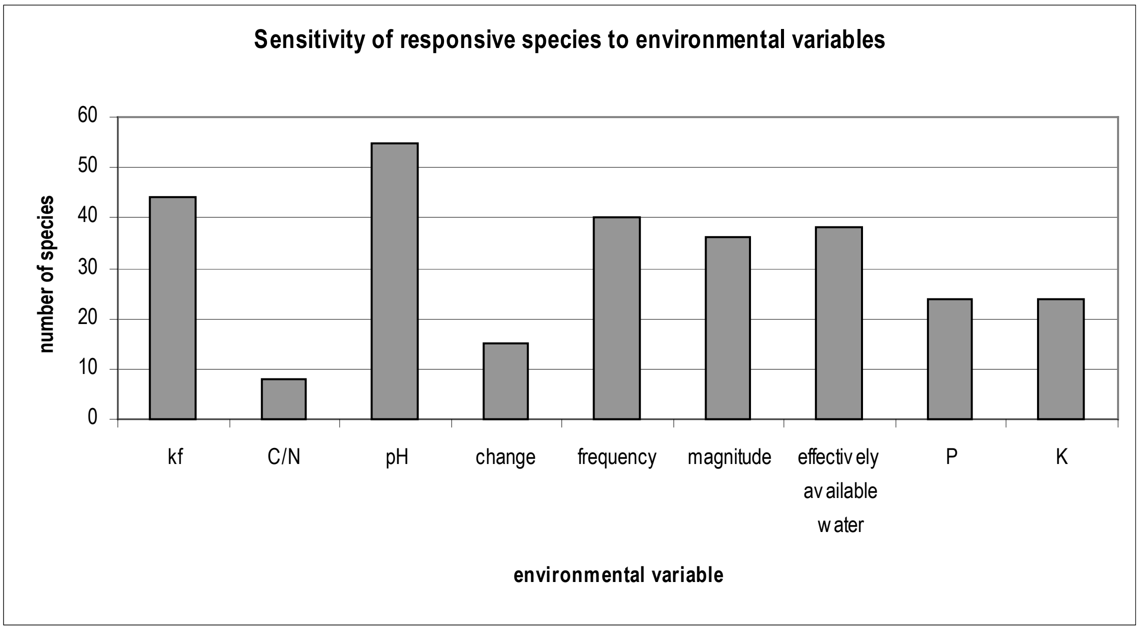

Figure 5.1: Sensitivity of responsive species to environmental variables.

Plant functional groups

After screening different numbers of clusters per cluster analysis we decided for a 15 cluster solution (data not shown) as they represent the largest number of species within the goodness of fit thresholds. Similar to Chapter 3 and 4 this solution avoided clusters comprising large species numbers as well as those with only one species. From our iterative analysis, the most parsimonious trait combination contained 88 responsive species and consisted of specific leaf area (SLA), canopy height, spacers, aerenchyma, woodiness, other physical defence than thorns and spikes (in the following called 'other pd') and SLI. 11 PFGs with a total number of 68 species met the goodness of fit thresholds (Table 5.4), one PFG was not modelled at all. 5 species were omitted by the programme due to missing SLI–values.

Table 5.4: Plant functional groups (=PFG). The grey marked groups are not meeting the goodness of fit criteria. PFG 12 was not modelled at all.

PFG	AUC	R^2_N	species prevalence	no. of species
1	0.899	0.4219	*Cirsium palustre* (10), *Danthonia decumbens* (26), *Juncus articulatus* (24), *Molinia caerulea* (35), *Potentilla anserina* (34), *Potentilla reptans* (64), *Ranunculus acris* (64), *Ranunculus flammula* (4), *Ranunculus repens* (35)	9
2	0.853	0.3090	*Bromus erectus* (26), *Bupleurum falcatum* (18), *Cynosurus cristatus* (38), *Knautia arvensis* (23), *Primula veris* (22), *Salvia pratensis* (34), *Sanguisorba minor* (52), *Trisetum flavescens* (44), *Viola hirta* (28)	9
3	0.873	0.3731	*Carex disticha* (12), *Carex flacca* (31), *Carex hirta* (41), *Carex nigra* (18), *Carex panicea* (32), *Deschampsia cespitosa* (38), *Succisa pratensis* (10)	7
4	0.831	0.3244	*Agrostis capillaris* (58), *Anthoxanthum odoratum* (56), *Cerastium arvense* (28), *Holcus lanatus* (84), *Lolium perenne* (43), *Lotus corniculatus* (55), *Luzula campestris* (50), *Rumex acetosa* (44), *Rumex acetosella* (30), *Saxifraga granulata* (13), *Stellaria graminea* (36), *Trifolium repens* (65), *Veronica chamaedrys* (49), *Viola canina* (7)	14
5	0.781	0.2283	*Fragaria viridis* (46), *Plantago lanceolata* (102), *Plantago media* (33), *Potentilla neumanniana* (17), *Ranunculus bulbosus* (30), *Trifolium pratense* (67)	6
6	0.899	0.3899	*Agrostis stolonifera* (32), *Hydrocotyle vulgaris* (24), *Lotus uliginosus* (19), *Mentha aquatica* (38), *Parnassia palustris* (13), *Potentilla erecta* (43), *Trifolium fragiferum* (17), *Valeriana dioica* (15)	8
7	0.900	0.3301	*Agrimonia eupatoria* (24), *Brachypodium pinnatum* (18), *Briza media* (36), *Eleocharis uniglumis* (24), *Falcaria vulgaris* (19), *Pimpinella saxifraga* (24), *Polygala vulgaris* (9)	7
8	0.806	0.2044	*Bromus hordeaceus* (40), *Capsella bursa-pastoris* (11), *Cerastium glomeratum* (32), *Erodium cicutarium* (10), *Rhinathus minor* (18), *Thlaspi perfoliatum* (24), *Veronica arvensis* (52)	7
9	0.829	0.3760	*Achillea millefolium* (107), *Alopecurus pratensis* (27), *Arrhenatherum elatius* (70), *Dactylis glomerata* (78), *Vicia cracca* (31)	5
10	0.871	0.3982	*Centaurea jacea* (70), *Centaurea scabiosa* (10)	2
11	0.968	0.6479	*Cladium mariscus* (9), *Phragmitis australis* (51)	2
12	unmodelled		*Euphorbia cyparissias* (23), *Hypericum perforatum* (15), *Inula conyza* (10), *Origanum vulgare* (10)	4
13	0.973	0.6395	*Cornus sanguinea* (10), *Prunus spinosa* (40), *Rosa canina* agg. (22)	3
14	0.975	0.6838	*Galium palustre* (29), *Galium uliginosum* (24)	2
15	0.860	0.1536	*Armeria maritima* ssp. *elongata* (8), *Genista tinctoria* (15), *Salix repens* (17)	3
unclustered species			*Calamagrostis stricta* (12), *Carex arenaria* (9), *Gentianella uliginosa* (13), *Taraxacum palustre* (6), *Vicia angustifolia* (46)	5

In Figure 5.2 the clustering procedure can be traced back and Table 5.5 shows the coefficients of variation for the biological traits. Especially other pd, but also aerenchyma and woodiness show clearly defined values (coefficient of variation = 0). High coefficients of variation indicate that not all species in one cluster display exactly the same traits. However, to be able to abstract all further implementations continue working with the medians for the respective traits.

The most differenciating functional traits are other physical defence than spikes and thorns, aerenchyma and woodiness (Table 5.5 and Figure 5.2). The most important distinguishing trait, however, is the presence or absence of aerenchymas, as it splits the groups into those inhabiting dry and those able to colonise wet and waterlogged habitats. PFG 1, 3, 6, 11 and 14 inhabit the latter habitat types. They are mainly distinguished by their SLAs, with PFG 11 featuring the overall smallest SLA and PFG 14 showing the overall highest SLA–value. Both PFG 1 and 3 show medium SLA–values but can be told apart by the position of spacers, presence of other physical defence than thorns and spikes and canopy height. PFG 6 features small statured species with high SLAs.

PFG 2, 4, 5, 7, 8, 9, 10, 12, 13 and 15 make up the second group showing no aerenchymas. PFG 8 can be distinguished from all others as it is the only PFG containing annuals. Furthermore, it features the overall smallest stature. In contrast, PFG 13 contains only woody species showing the tallest heights. Also PFG 15 contains woody plants, but can be told apart from PFG 13 by its above–ground spacers and its small canopy height. PFG 12 is the overall only group developing long–term persistent seeds, however, due to no predicted occurrences (except for 2 presences of *Euphorbia cyparissias*) the PFG was not modelled at all. PFG 10 is the only group featuring physical defence mechanisms in the form of bristly leaves (i.e. physical defence other than thorns and spikes). Of the remaining herbaceous groups PFG 2 is the only one developing above–ground spacers. PFG 7 and 9 show transient seeds and can be distinguished by their SLA and canopy heights. PFG 4 and 5 feature short–term persistent seeds and can be told apart by high and medium SLA–values, respectively.

PFG	**aeren-chyma**	**other physical defence**	**woodi-ness**	**spacers**	**seed longevity**	**SLA [mm²* mg⁻¹]**	**canopy height [mm]**
1	**0.00**	**0.00**	**0.00**	0.50	**0.29**	**0.11**	**0.27**
	yes	no	no	above	short	23.0	196
2	**0.00**	**0.00**	**0.00**	**0.00**	**0.81***	**0.19**	0.39
	no	no	no	above	transient	20.6	297
3	**0.00**	**0.00**	**0.00**	**0.28**	0.31	**0.13**	0.37
	yes	yes	no	below	short	20.8	267
4	**0.00**	**0.00**	**0.00**	**0.23**	**0.20**	**0.15**	0.33
	no	no	no	below	short	36.2	173
5	**0.00**	**0.00**	**0.00**	**0.27**	**0.14**	**0.13**	0.41
	no	no	no	below	short	20.5	191
6	**0.00**	**0.00**	**0.00**	**0.19**	0.76	**0.23**	0.40
	yes	no	no	above	short	35.8	160
7	**2.65***	**0.00**	**0.00**	**0.13**	**0.96***	**0.28**	0.37
	no	no	no	below	transient	21.5	327
8	**0.00**	**0.00**	**0.00**	**0.00**	0.34	**0.24**	0.65
	no	no	no	none	short	30.7	91
9	**0.00**	**0.00**	**0.00**	**0.13**	0.47	**0.20**	0.48
	no	no	no	below	transient	31.4	466
10	**0.00**	**0.00**	**0.00**	**0.20**	**0.19**	**0.21**	0.35
	no	yes	no	below	transient	21.5	307
11	**0.00**	**0.00**	**0.00**	**0.20**	**1.41**	0.45	**0.08**
	yes	yes	no	below	transient	9.2	1298
12 (unmodelled)	**0.00**	**0.00**	**2.00**	**0.09**	**0.15**	**0.25**	0.38
	no	no	no	below	long	28.4	425
13	**0.00**	**0.00**	**0.00**	**0.00**	1.08	**0.19**	**0.19**
	no	no	yes	below	transient	17.6	1221
14	**0.00**	**0.00**	**0.00**	0.47	0.57	**0.15**	**0.14**
	yes	yes	no	below	transient	53.9	208
15	1.73	**0.00**	0.35	0.87	**0.00**	**0.19**	0.43
	no	no	yes	above	transient	19.7	133

Table 5.5: Coefficients of variation (first line per PFG) and PFG–characteristics (second line per PFG). Grey marked PFGs are not meeting the quality requirements. PFG 12 was not modelled at all. Bold numbers indicate low variance within the single species characters in each cluster. (*Even though the coefficient of variation is poor, still a precise trait interpretation is possible; cf. Appendix Table 18) (none = no spacers; above = above–ground spacers; below = below–ground spacers; short = short–term persistent; long = long–term persistent)

Table 5.7 shows the regression coefficients of the PFGs. These coefficients are selected during stepwise logistic regression as they significantly improved the habitat models of the groups. Most PFGs (11) are sensitive to AW_{eff}. Also K (10 PFGs) and kf (10 PFGs) as well as frequency (9 PFGs) are important environmental factors. PFG 1 occurs at sites with a medium disturbance frequency with less than 50% of biomass destruction. Furthermore, the group prefers low K–concentrations at sandy soils (high kf–) and high pH–values[2]. PFG 2 is found on badly drainable soils with low nutrient (i.e. P– and K–) concentrations. It occurs on mowed or fallow sites along the whole magnitude gradient tending towards low values. PFG 3

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[2] Note: High pH–values refer only to the maximum value recorded within the two investigation areas, i.e. 7.7. The lowest pH–value is 3.3.

prefers semi–wet frequently disturbed habitats featuring high P–, pH–, C/N– and kf–values but low K–concentrations. PFG 4 and 5 occur on dry clayey or silty soils which are long–term mowed and/or grazed. PFG 4 additionally prefers low K– and pH–values. For PFG 6 habitats need to feature wet sandy soils of slightly alcaline pH– and low K–values. Furthermore, disturbance needs to take place above–ground (i.e. mowing and/or grazing). Fresh to dry slightly alcaline soils preferably with low K–values are inhabited by PFG 7–species. Also PFG 8 can be found on dry, potassium–poor sites, but additionally the disturbance regime needs to be of high magnitude (i.e. below–ground disturbance) at an intermediate disturbance frequency. Furthermore PFG 8 prefers medium P–supplied soils. PFG 9 can be found in habitats with dry clayey or silty soils with medium pH–values. Soil nutrient status is high with high P–and low C/N–values. However, K–concentration is low. Sensitivity to disturbance frequency is not very pronounced but tends towards low frequencies. Fresh soils with low kf– and P–values but high K–concentrations promote PFG 10–species. Additionally, disturbance frequency needs to be low to medium. PFG 11 prefers wet or waterlogged highly permeable soils containing little P. Disturbance magnitude is very low. PFG 13–species are found on dry sites with slightly alcaline pH–values. Disturbance frequency needs to be very low. Low disturbance magnitude and very wet soils promote the occurrence of species assembling PFG 14. High kf–values are the only significant pre–requisite for the occurrence of PFG 15.

Generally, the probability that all species of a group with similar biological traits co–occur is rather low. For half of the identified PFGs it lies below 0.4. However, PFG 8, 9, 10 and 14 show probalities of over 0.5.

trait	**Hassberge**	**Müritz**	**Hassberge and Müritz**
aerenchyma	n.i.	x	x
canopy height	x	x	x
SLA	x	-	x
spacers	-	x	x
SLI	-	x	x
seed number	x	-	-
plant life span	x	-	-
thorny physical defence	n.i.	x	-
other physical defence	n.i.	-	x
woodiness	-	n.i.	x

Table 5.6: Comparison between investigation areas and most parsimonious traits. (n.i. = not included into the analysis for the considered area)

Comparing the trait combinations of the two single investigation areas with the combined data set there are striking similarities (Table 5.6). For all three analyses canopy height is the most important resource acquisiting trait. For the Hassberge area we did not record any physical defence mechanisms and aerenchyma, however, both plant attributes are part of the parsimonious trait combination for the combined data set. Aerenchyma splits the species into those tolerating waterlogged conditions and those only growing in fresh and dry places. Spacers are represented for the Müritz area and for the combined analysis, the trait is highly correlated with plant life span featured for the Hassberge area (0.6, see Box 1) and therefore represents life span. This could also be shown in Chapter 3 and 4. SLA as another resource capturing trait is also part of the combined analysis but within the single investigation areas seems to be important only for the Hassberge. Seed number and SLI are both regenerative traits, SLI putting emphasis on seed dispersal in time, obviously more important at the Müritz than for the Hassberge and contained in the combined analysis. We did not take into account woodiness for the Müritz area and it did not prove important for the Hassberge, however, for the combined data set it shows to be of importance.

<table>
<tr><td>aerenchyma</td><td colspan="10">no</td><td colspan="5">yes</td></tr>
<tr><td>other physical defence</td><td colspan="9">no</td><td>yes</td><td colspan="2">no</td><td colspan="3">yes</td></tr>
<tr><td>woodiness</td><td colspan="7">no</td><td colspan="2">yes</td><td>no</td><td colspan="2">no</td><td colspan="3">no</td></tr>
<tr><td>spacers</td><td colspan="5">below</td><td>above</td><td>none</td><td>below</td><td>above</td><td>below</td><td colspan="2">above</td><td colspan="3">below</td></tr>
<tr><td>SLI</td><td colspan="2">transient</td><td colspan="2">short</td><td>long</td><td>transient</td><td>short</td><td>transient</td><td>transient</td><td>transient</td><td colspan="2">short</td><td colspan="2">transient</td><td>short</td></tr>
<tr><td>SLA</td><td>medium</td><td>high</td><td>high</td><td>medium</td><td>medium</td><td>medium</td><td>high</td><td>low</td><td>low</td><td>medium</td><td>medium</td><td>high</td><td>very low</td><td>very high</td><td>medium</td></tr>
<tr><td>canopy height</td><td>medium</td><td>tall</td><td>small</td><td>small</td><td>tall</td><td>medium</td><td>very small</td><td>very tall</td><td>small</td><td>medium</td><td>small</td><td>small</td><td>very tall</td><td>medium</td><td>medium</td></tr>
<tr><td>PFG</td><td>7</td><td>9</td><td>4</td><td>5</td><td>12</td><td>2</td><td>8</td><td>13</td><td>15</td><td>10</td><td>1</td><td>6</td><td>11</td><td>14</td><td>3</td></tr>
</table>

Figure 5.2: Derivation of PFGs during clustering. The grey marked PFGs shows poor quality measures. (SLA [mm²*mg^{-1}]: very low: < 10, low: 10–20, medium: 20–30, high: 30–50, very high: > 50; canopy height [mm]: very small: < 100, small: 100–200, medium: 200–400, tall: 400–800, very tall: > 800)

Table 5.7: Regression coefficients for environmental parameters after stepwise logistic regression. For parameter abbreviation see methodology. The appendix “2” labels the square of the variable. Grey marked PFGs are not meeting the quality requirements. PFG 12 was not modelled at all.

PFG	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
kf	0.003	-0.019	0.002	-0.003	-0.008	0.002	-	-	-0.014	-	-	-	-	-	0.006
kf2	-	2.3E-05	-	-	8.7E-06	-	-	-	1.7E-05	-7.1E-06	4.6E-06	-	-	-	-
pH	5.06	-	0.684	2.30	-	0.557	13.27	-	3.64	-	-	-	-	-	-
pH2	-0.288	-	-	-0.241	-	-	-0.921	-	-0.339	-	-	-	0.233	-	-
C/N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C/N2	-	-	3.3E-04	-	-	-	-	-	-6.5E-04	-	-	-	-	-	-
P	-	-0.003	-	-0.002	-	-	-	0.002	-0.002	-0.007	-0.005	-	-	-	-
P2	-	-	1.8E-07	7.0E-07	-	-	-	-3.7E-07	5.0E-07	-	-	-	-	-	-
K	-8.7E-04	0.002	-	-	0.001	-0.002	-0.003	-2.1E-04	8.4E-04	-	-	-	-	-	-
K2	-	-4.5E-07	-2.2E-06	-5.3E-08	-3.8E-07	-	2.3E-07	-	-1.6E-07	1.2E-07	-	-	-	-	-
frequency	5.48	-0.370	0.445	2.24	1.93	-	-	3.53	0.560	2.52	-	-	-1.86	-	-
frequency2	-1.030	-	-	-0.397	-0.415	-	-	-0.648	-0.148	-0.934	-	-	-	-	-
magnitude	0.128	-	-	-	-	0.120	-	0.036	-	-	-0.095	-	-	0.299	-
magnitude2	-0.002	-9.3E-05	-	-	-	-0.003	-	-	-	-	-	-	-	-0.008	-
effectively available water	-	-	0.028	-	-	0.030	0.074	-0.025	0.069	0.073	0.092	-	-0.067	0.373	-
effectively available water2	-	-	-1.2E-04	-6.8E-05	-1.0E-04	-8.4E-05	-3.9E-04	-	-6.0E-04	-4.0E-04	-2.1E-04	-	-	-0.001	-
change	-	-	-	-2.07	-1.59	-	-	-	-	-	-	-	-	-	-
Intercept	-30.902	-0.903	-8.485	-7.439	-2.445	-8.439	-52.110	-6.609	-11.064	-3.916	-7.064	-	-9.821	-32.929	-6.008

Discussion

Environmental conditions

As we considered both investigation areas for this chapter the resource gradient was expectedly wider than for the single investigation areas. However, we shall not discuss this any further as we have done this on the single investigation areas (Chapter 3 and 4).

Table 5.8: Species with insufficient quality of fit measures: prevalence within the data set.

species	prevalence in 240 plots
Agropyron repens	52
Avenula pubescens	33
Bromus sterilis	11
Calamagrostis epigejos	4
Cerastium brachypetalum	37
Cirsium arvense	49
Convolvulus arvensis	50
Crataegus monogyna	13
Daucus carota	36
Dianthus carthusianorum	11
Festuca ovina agg.	84
Festuca pratensis	63
Festuca rubra	77
Galium aparine	20
Galium mollugo	55
Galium verum	37
Geum urbanum	12
Juniperus communis	9
Lathyrus pratensis	28
Leontodon autumnalis	29
Leontodon hispidus	30
Leucanthemum vulgare	17
Linum catharticum	15
Medicago lupulina	36
Myosotis ramosissima	24
Odontites vulgaris	8
Ononis repens	16
Pinguicula vulgaris	4
Poa annua	20
Poa pratensis agg.	142
Poa trivialis	46
Prunella vulgaris	25
Rhinanthus serotinus	5
Taraxacum officinale agg.	68
Tragopopgon pratensis	12
Valerianella locusta	22
Vicia tetrasperma	10

Additionally, for this general analysis we considered the effectively available water. The annual average AW_{eff}–values range between 7 mm and 232 mm. These values include no statements on available air in the soils. For the Hassberge area this poses no problem as there is no groundwater influence and water will be stored at the most up to the PAW–capacity (i.e. the amount of water that the soil can hold against gravity), while AC will never be filled. In contrast, the Müritz area is strongly influenced by groundwater. Soils are dominated by sands and are rather uniform across the area. Therefore, the sites with the highest AW_{eff}–values are most likely to feature permanent or at least temporarily waterlogged conditions. However, to be able to give more detailed information on the amount of air still available in the soil it would take an additional variable to distinguish permanently flooded sites from temporarily flooded or well–aerated habitats.

Responsive species models

Of 130 species 93 showed a sufficient response to be included into the clustering procedure. There were 2 species not modelled at all in the first place, which are namely *Avenula pubescens* and *Festuca rubra*. There was no significant environmental variable to develop a valid model.

The remaining 35 species showed low quality models. As for the single consideration for the Hassberge and Müritz the main reasons are again (1) low prevalences in the investigation plots, (2) presence of species along the whole recorded disturbance and resource gradients independent of prevalence and (3) bimodal distributions. (1) applies to the following species occuring on 4–17 sites: *Bromus sterilis*, *Calamagrostis epigejos*, *Crataegus monogyna*, *Dianthus carthusianorum*, *Geum urbanum*, *Juniperus communis*, *Leucanthemun vulgare*, *Linum catharticum*, *Odontitis vulgaris*, *Ononis repens*, *Pinguicula vulgaris*, *Rhinanthus serotinus*, *Tragopogon pratensis* and *Vicia tetrasperma*. The following species occur along whole gradients and are present on 20–142 investigation plots: *Agropyron repens*, *Cerastium brachypetalum*, *Cirsium arvense*, *Convolvulus arvensis*, *Daucus carota*, *Festuca ovina* agg., *Festuca pratensis*, *Galium aparine*, *Galium mollugo*, *Galium verum*, *Lathyrus pratensis*, *Leontodon autumnalis*, *Leotodon hispidus*, *Medicago lupulina*, *Myosotis ramosissima*, *Poa annua*, *Poa pratensis* agg., *Poa trivialis*, *Prunella vulgaris*, *Taraxacum officinale* agg. and *Valerianella locusta*. Table 5.8 shows the prevalences of the non–modelled species. If there are species with bimodal distributions they cannot be modelled with unimodal logistic regressions (Kleyer 1999).

Table 5.9: Prevalences and EPV–values for the responsive species. Bold marked species fulfil the criterion of 10 events per variable.

species	**prevalence in 240 plots**	**no. of variables**	**EPV-value**
Achillea millefolium	107	4	**27**
Agrimonia eupatoria	24	3	8
Agrostis capillaris	58	6	**10**
Agrostis stolonifera	32	4	8
Alopecurus pratensis	27	2	**14**
Anthoxanthum odoratum	56	8	7
Armeria maritima ssp. *elongata*	8	3	3
Arrhenatherum elatius	70	5	**14**
Brachypodium pinnatum	18	3	6
Briza media	36	5	7
Bromus erectus	26	2	**13**
Bromus hordeaceus	40	5	8
Bupleurum falcatum	18	4	5
Calamagrostis stricta	12	1	**12**
Capsella bursa-pastoris	11	2	6
Carex arenaria	9	3	3
Carex disticha	12	3	4
Carex flacca	31	3	**10**
Carex hirta	41	8	5
Carex nigra	18	4	5
Carex panicea	32	4	8
Centaurea jacea	70	6	**12**
Centaurea scabiosa	10	3	3
Cerastium arvense	28	6	5
Cerastium glomeratum	32	8	4
Cirsium palustre	10	4	3
Cladium mariscus	9	3	3
Cornus sanguinea	10	1	**10**
Cynosurus cristatus	38	6	6
Dactylis glomerata	78	8	**10**
Danthonia decumbens	26	3	9
Deschampsia cespitosa	38	4	**10**
Eleocharis uniglumis	24	3	8
Erodium cicutarium	10	2	5
Euphorbia cyparissias	23	5	5
Falcaria vulgaris	19	2	**10**
Fragaria viridis	46	4	**12**
Galium palustre	29	2	**15**
Galium uliginosum	24	5	5
Genista tinctoria	15	3	5
Gentianella uliginosa	13	3	4
Holcus lanatus	84	5	**17**
Hydrocotyle vulgaris	24	4	6
Hypericum perforatum	15	1	**15**
Inula conyza	10	2	5
Juncus articulatus	24	5	5
Knautia arvensis	23	3	8
Lolium perenne	43	6	7
Lotus corniculatus	55	4	**14**
Lotus uliginosus	19	1	**19**
Luzula campestris	50	7	7
Mentha aquatica	38	3	**13**
Molinia caerulea	35	6	6
Origanum vulgare	10	1	**10**
Parnassia palustris	13	4	3
Phragmitis australis	51	4	**13**
Pimpinella saxifraga	24	3	8
Plantago lanceolata	102	6	**17**
Plantago media	33	5	7
Polygala vulgaris	9	2	5
Potentilla anserina	34	4	9
Potentilla erecta	43	4	**11**
Potentilla neumanniana	17	3	6
Potentilla reptans	64	6	**11**
Primula veris	22	6	4
Prunus spinosa	40	3	**13**
Ranunculus acris	64	5	**13**
Ranunculus bulbosus	30	3	**10**
Ranunculus flammula	4	1	4
Ranunculus repens	35	6	6
Rhinanthus minor	18	3	6
Rosa canina agg.	22	3	7
Rumex acetosa	44	6	7
Rumex acetosella	30	5	6
Salix repens	17	3	6
Salvia pratensis	34	6	6
Sanguisorba minor	52	5	**10**
Saxifraga granulata	13	2	7
Stellaria graminea	36	7	5
Succisa pratensis	10	3	3
Taraxacum palustre	6	5	1
Thlaspi perfoliatum	24	2	**12**
Trifolium fragiferum	17	3	6
Trifolium pratense	67	10	7
Trifolium repens	65	4	**16**
Trisetum flavenscens	44	3	**15**
Valeriana dioica	15	5	3
Veronica arvensis	52	9	6
Veronica chamaedrys	49	7	7
Vicia angustifolia	46	5	9
Vicia cracca	31	4	8
Viola canina	7	2	4
Viola hirta	28	6	5

Considering the habitat models of the responsive species one will recognise low EPV–values (for further explanations on the EPV–value see Chapter 3) for more than half of these species (Table 5.9) leading to habitat models of unrealistically good quality. This might have negative consequences for the single species habitat models but also for the PFG–models. However, again the PFG–habitat models are based on the predicted probabilities and do not go below the benchmark of 10 events per variable as given by Steyerberg *et al.* (2001) (Table 5.10).

PFG	prevalence sum for all species	variables/ PFG	EPV
1	296	5	59
2	285	5	57
3	182	7	26
4	618	7	88
5	295	5	59
6	201	5	40
7	154	3	51
8	187	5	37
9	313	7	45
10	80	5	16
11	60	4	15
12	58	-	-
13	72	3	24
14	53	2	27
15	40	1	40

Table 5.10: EPV–values for PFGs. Grey marked PFGs are not meeting the quality requirements. PFG 12 was not modelled at all.

Fundamental functional traits

Combining and clustering the species of the two investigation areas led to the following 7 traits as the most parsimonious trait combination: aerenchyma, other physical defence than thorns and spikes, woodiness, spacers, SLA, canopy height and SLI. Considering the trait combinations of the two single investigation areas compared to the combined data set (Table 5.6) we can identify 3 types of traits that can be distinguished: (1) traits of major (i.e. fundamental) importance, (2) traits of little importance and (3) traits of no importance for the investigated areas. We suggest that the larger the data set and the wider the environmental gradients the more fundamental are the outcoming attributes within the parsimonious trait combination. This is comparable to the fundamental trade–offs which can best be identified in large data sets (see Box 1). For small data sets it is rather possible to determine the important traits for local resource and disturbance gradients. Therefore, the 7 attributes identified within the most parsimonious trait set are of fundamental importance. This includes canopy height and SLA as resource acquisiting attributes which are part of the three–dimensional scheme for vegetation description based on the trade–offs between canopy height, SLA and seed mass (Westoby 1998). However, seed mass is not found in any of our analyses, it is represented only indirectly by seed number and SLI (see Chapter 3 and 4 and Box 1) with SLI being a fundamental attribute. Instead, there are other functional traits that are fundamentally important in our investigation, i.e. first of all the presence of aerenchymas as it characterises permanently or temporarily water–influenced habitats. Furthermore, our investigation brings forward spacers representing plant life span, and physical defence other than thorns and spikes suggesting a connection between magnitude and physical defence mechanisms as plants with such structures are avoided by herbivores (Milchunas & Noy-Meir 2002) and are therefore promoted by grazing. Woodiness as the last fundamental trait is responsible for vertical expansion and in connection with tall canopy heights stands for low disturbance magnitudes and frequencies.

As suggested above there is a second category of traits, i.e. those of little importance. ‘Little importance’ does not necessarily imply that these traits are generally of little importance, but they are for this analysis as they are only important for the single investigation areas, i.e. for the small data sets. Additionally, they are not represented in the general analysis. However, little important traits still show correlations to fundamentally important attributes. In our analysis seed number, plant life span and thorny physical defence are attributes of the second category as they are represented in SLI and SLA, respectively.

The third category are the attributes of no importance to our analyses. This includes all features that are not emergent within any of the parsimonious trait combinations, i.e. clonality, seed mass and start of seed shedding.

Plant functional groups

The most important environmental factor for the formed PFGs is AW_{eff}. This becomes obvious within the groups as they can be split into those preferring permanently to temporarily waterlogged conditions and those occurring on rather fresh or dry soils. PFG 1, 3, 6, 11 and 14 are characterised by the presence of aerenchymas and represent groups growing on at least temporarily waterlogged soils. They mostly contain species exclusively predicted for the Müritz area (Table 5.11). However, PFG 1 features *Potentilla reptans* and *Ranunculus acris* which were recorded in the Hassberge in larger numbers than predicted. Furthermore, PFG 3 contains *Carex hirta* which also is predicted for the Hassberge area but was not actually present there. The reason for the discrepancies between real and predicted occurrences are the other species found within the PFGs as both groups represent plants of fluctuating water levels in humid and wet habitats which are not found within the Hassberge. Therefore, the possibility of co–occurrence is low in the Hassberge area. However, the three species obviously show wide ecological amplitudes due to their capability to develop aerenchymas and are capable to occur on humid and wet but also on fresh soils.

The above mentioned PFGs show great similarities in their dependence on environmental parameters. All groups showing sensitivities to AW_{eff}, kf and disturbance magnitude respond similar to these factors. They are found at medium to high AW_{eff}– and kf–values and prefer above–ground disturbances from 0–50% of biomass destruction. PFG 11 which consists of two aquatic plant species occurs mainly on nearly undisturbed sites. Here, low disturbance magnitude, i.e. especially grazing, is caused on one hand by very low SLAs by which nutritional value is low. Furthermore, grazing is inhibited by very hard and sharply–edged leaves as well as the circumstance that herbivores avoid wetter sites (Rozé 1993). This missing disturbance leads to very tall canopy heights characterising the group. Regeneration takes place by below–ground spacers which are much more effective than seeds as they are transient and rarely find space to establish as mostly soils are waterlogged above the soil surface.

PFG 1 and 6 preferably grow on soils with high pH–values and low K–concentrations. Because of the low nutrient status canopy heights stay small. According to Ellenberg *et al.* 1992) all species contained in these PFGs are indicators for humid to wet soils resulting in medium (PFG 1) and high (PFG 6) SLA–values making the species attractive for grazers (Westoby 1999). Even though extensive grazing promotes the occurrence of the two PFGs, herbivores in these habitats will not graze year round as the soils are especially wet in winter and as mentioned above grazers will avoid wetter sites (Rozé 1993) giving plants time to recover from grazing pressure. Furthermore, small canopy heights are a mechanism for grazing avoidance (Milchunas & Noy-Meir

2002; Vesk *et al.* 2004). Concerning reproduction both groups develop only short–term persistent seeds as they mainly reproduce by above–ground spacers as vegetative spread is the more dominant regeneration strategy in grasslands (Eriksson & Jakobsson 1998; Kahmen & Poschlod 2004).

PFG 3 features species of wet habitats, at times even with the water level above the soil surface (Ellenberg *et al.* 1992). The plants are characterised by medium canopy heights and SLA and are promoted by high disturbance frequencies. Even though plant height and SLA make the species susceptible to grazing they are still avoided as they show physical defence mechanisms in the form of hard and bristly leaves causing low nutritional value. P–concentrations are high despite high pH (cf. Busman *et al.* 1998 and Diekmann & Falkengren-Grerup 2002), possibly due to high dung deposition. C/N–values are low indicating humus–rich soils, which is reasonable as many of the species were found on peaty soils, which is also confirmed by the high kf–value. Easy penetrable underground is beneficial for the development of below–ground spacers, and short–term persistent seeds again underline the importance of vegetative regeneration in these habitats as recruitment from seeds is rather unlikely in a closed vegetation cover.

Also, PFG 14 with medium canopy height and very high SLA–values resulting from high water availability shows physical defence mechanisms in the form of hooked leaves to avoid grazing. Above–ground disturbances between 0–50% of biomass destruction (i.e. grazing) will take place predominantly during the drier months. Even at the prevailing high water levels the below–ground spacers are supplied with nutrients and oxygen through the mother plant and again have a higher regenerative potential than the transient seeds. Furthermore, their below–ground position avoids the destruction by treading.

Considering the opposite end of the water gradient it is PFG 2, 4, 5, 7, 8, 9, 10, 12 and 13 preferring drier conditions. Here, looking at the species indicator values (Ellenberg *et al.* 1992) one will notice a gradient from fresh to very dry sites. PFG 4, 8, 9 and 13 preferably grow on fresh soils, whereas PFG 2, 5, 7, 10 and 12 favour rather dry soils. Generally, all these PFGs tend to inhabit nitrogen–poor sites, the only exception is PFG 9 which prefers moderately nitrogen–rich soils.

In the way there are PFGs unique for the Müritz area, there are also unique PFGs for the Hassberge. The dryest habitats feature PFGs with species predicted exclusively or in higher abundances for the Hassberge. This applies to PFG 2, 5, 9, 12 and 13. PFG 12 shall not be discussed further as we received no habitat model due to no predicted occurrences of the contained species (except for *Euphorbia cyparissias* with 2 predicted presences) (Table 5.11). PFG 2 contains *Cynosurus cristatus* and *Viola hirta*, PFG 5 includes *Plantago lanceolata* and *Trifolium pratense* and PFG 9 features *Achillea millefolium*, *Dactylis glomerata* and *Vicia cracca*; all of which are found also in the Müritz area. In PFG 2 the high number of predicted occurrences for *Cynosurus cristatus* at the Müritz had no effects on the general habitat model for the group. As most of the other group species are predicted exclusively for the Hassberge the probability of co–occurrence is high enough to deliver a good quality habitat model. The opposite is the case for PFG 5. Even though most of the species are predicted only for the Hassberge we received a high number of predicted occurrences especially for *Plantago lanceolata* and to a smaller extent for *Trifolium pratense* also for the Müritz area. This results in a general group habitat model strongly influenced by these two species consequently leading to a low probability of species co–occurrence indicated by low goodness of fit measures. Considering PFG 9 the numerous predicted occurrences of *Achillea millefolium* at the Müritz is outweighed by even more numerous predicted occurrences of this species in the Hassberge. However, the greatest influence on the habitat model putting emphasis on the Hassberge conditions comes from the other predicted group members which are mainly found in the Hassberge, resulting in a well calibrated habitat model.

Table 5.11: Real and predicted presences for the single investigation areas. Bold marked numbers indicate the investigation area the group can be assigned to. Grey marked PFGs are not meeting the quality requirements. PFG 12 was not modelled at all. (HAS = Hassberge, MÜR = Müritz, real = recorded presences, pred. = predicted occurrences)

PFG	species	HAS real	MÜR real	HAS pred.	MÜR pred.
1	*Cirsium palustre*	0	10	0	**3**
	Danthonia decumbens	0	26	0	**14**
	Juncus articulatus	0	24	0	**12**
	Molinia caerulea	0	35	0	**34**
	Potentilla anserina	0	34	0	**43**
	Potentilla reptans	17	47	5	**33**
	Ranunculus acris	18	46	1	**24**
	Ranunculus flammula	0	4	0	**0**
	Ranunculus repens	1	34	0	**36**
2	*Bromus erectus*	26	0	**0**	0
	Bupleurum falcatum	18	0	**12**	0
	Cynosurus cristatus	5	33	**1**	16
	Knautia arvensis	23	0	**11**	0
	Primula veris	22	0	**13**	0
	Salvia pratensis	34	0	**41**	0
	Sanguisorba minor	52	0	**65**	0
	Trisetum flavenscens	44	0	**17**	0
	Viola hirta	28	0	**22**	1
3	*Carex disticha*	0	12	0	**12**
	Carex flacca	2	29	0	**15**
	Carex hirta	0	41	3	**59**
	Carex nigra	0	18	0	**16**
	Carex panicea	0	32	0	**20**
	Deschampsia cespitosa	0	38	0	**45**
	Succisa pratensis	0	10	0	**0**
4	*Agrostis capillaris*	4	54	**4**	**52**
	Anthoxanthum odoratum	22	34	**20**	**36**
	Cerastium arvense	3	25	**3**	**11**
	Holcus lanatus	21	63	**19**	**85**
	Lolium perenne	9	34	**12**	**21**
	Lotus corniculatus	39	16	**45**	**11**
	Luzula campestris	26	24	**23**	**26**
	Rumex acetosa	31	13	**29**	**2**
	Rumex acetosella	0	30	**0**	**23**
	Saxifraga granulata	13	0	**15**	**0**
	Stellaria graminea	7	29	**2**	**21**
	Trifolium repens	19	46	**26**	**62**
	Veronica chamaedrys	27	22	**12**	**11**
	Viola canina	0	7	**0**	**0**
5	*Fragaria viridis*	46	0	**30**	0
	Plantago lanceolata	48	54	**43**	74
	Plantago media	33	0	**10**	0
	Potentilla neumanniana	17	0	**1**	0
	Ranunculus bulbosus	28	2	**2**	0
	Trifolium pratense	38	29	**40**	12
6	*Agrostis stolonifera*	3	29	0	**0**
	Hydrocotyle vulgaris	0	24	0	**13**
	Lotus uliginosus	0	19	0	**0**
	Mentha aquatica	0	38	0	**58**
	Parnassia palustris	0	13	0	**0**
	Potentilla erecta	0	43	0	**53**
	Trifolium fragiferum	0	17	0	**2**
	Valeriana dioica	0	15	0	**0**
7	*Agrimonia eupatoria*	24	0	**0**	0
	Brachypodium pinnatum	17	1	**0**	0
	Briza media	1	35	**1**	52
	Eleocharis uniglumis	0	24	**0**	0
	Falcaria vulgaris	19	0	**0**	0
	Pimpinella saxifraga	24	0	**0**	0
	Polygala vulgaris	0	9	**0**	0
8	*Bromus hordeaceus*	9	31	**1**	**17**
	Capsella bursa-pastoris	1	10	**0**	**0**
	Cerastium glomeratum	2	30	**1**	**29**
	Erodium cicutarium	0	10	**0**	**0**
	Rhinanthus minor	18	0	**0**	**0**
	Thlaspi perfoliatum	24	0	**13**	**0**
	Veronica arvensis	33	19	**40**	**19**
9	*Achillea millefolium*	66	41	**78**	55
	Alopecurus pratensis	26	1	**28**	0
	Arrhenatherum elatius	70	0	**89**	0
	Dactylis glomerata	66	12	**65**	4
	Vicia cracca	2	29	**0**	3
10	*Centaurea jacea*	29	41	**14**	44
	Centaurea scabiosa	10	0	**12**	2
11	*Cladium mariscus*	0	9	0	**3**
	Phragmitis australis	1	50	0	**35**
12	*Euphorbia cyparissias*	23	0	2	0
	Hypericum perforatum	15	0	0	0
	Inula conyza	10	0	0	0
	Origanum vulgare	10	0	0	0
13	*Cornus sanguinea*	10	0	**0**	0
	Prunus spinosa	38	2	**34**	0
	Rosa canina agg.	22	0	**16**	0
14	*Galium palustre*	0	29	0	**10**
	Galium uliginosum	0	24	0	**22**
15	*Armeria maritima* ssp. *elongata*	0	8	0	**4**
	Genista tinctoria	1	14	0	**0**
	Salix repens	0	17	0	**3**

Considering trait functionality it is especially PFG 13 catching the eye. Low SLA–values in connection with very tall woody canopies stand in direct relation to lowest disturbance frequencies and dry, slightly alcaline soils[3]. High, woody canopies can only develop if there are no biomass–destroying disturbances. Investing into permanent structures such as woody stems takes up a lot of nutrients obviously rarely available due to alcaline pH–values (cf. Busman *et al.* 1998). This fact and additionally, low water availability result in decreasing SLA–values, as high SLA indicating a fast leaf turn–over (Vesk *et al.* 2004) cannot be afforded. Below–ground spacers being supplied with nutrients and water by the mother plant are another advantage in dry habitats and substitute regeneration by seeds, which are of transient longevity.

PFG 2 contains herbeaceous species inhabiting clayey soils binding P and K resulting in a low nutrient status. Even though nutrient supply is poor low disturbance magnitude and frequencies (e.g. mowing once per year or short fallow periods) give plants the possibily to grow to a medium–tall stature and develop leaves with medium SLA–values to still acquire sufficient resources. The group persists in places where disturbance will not affect below–ground biomass, maintaining a closed vegetation cover where effort is put rather into regeneration by above–ground spacers than into seeds, which are transient.

Even though water availability is low medium disturbance frequencies (e.g. mowing twice per year or extensive year–round grazing) give the herbaceous PFG 5 with its low canopy height and medium SLA the possibility to capture sufficient light. Changing magnitude from above– to below–ground disturbance would result in a loss of PFG 5–species as their regenerative strategy with above–ground spacers and short–term persistent seeds is specialised on above–ground disturbed permanent grasslands. However, probability of species co–occurrence is low and the habitat model therefore reaches only low quality measures (see above).

Arrhenatherum elatius is the most abundantly predicted species for PFG 9. Due to this dominance and considering the other species contained in the group PFG 9 can be attributed to the Arrhenatheretum in further sense (Ellenberg 1996) and therefore to the Hassberge area. Even though water availability in the predominantly clayey soils is low, medium pH mainly leads to high P–concentrations resulting in high SLAs and tall canopy heights. Medium disturbance frequencies (e.g. mowing twice a year or extensive year–round grazing) again promote closed vegetation covers leading to below–ground vegetative regeneration being more effective than the transient seeds.

Another group not explicitely mentioned above for exclusively the Hassberge shall be considered here. Two species make up PFG 10, both are predicted for both investigation areas. *Centaurea jacea* shows the greater predicted number of occurrences and is most abundant in the Müritz area. Therefore, the habitat model is strongly influenced by this species. However, *C. jacea* is a species with a wide ecological amplitude concerning water and nitrogen shown by its indifferent indicator values (Ellenberg *et al.* 1992). Therefore, it is capable of occurring also in places preferred by *C. scabiosa*. For this reason we attribute PFG 10 to the Hassberge area and therewith generally to drier regions as it is more likely for the 2 species to co–occur there than at the Müritz. Low kf–values, indicating clayey soils, and medium available soil water tending to dryer conditions advocate this point of view. The presence of bristly leaves is then not only a mechanism to avoid herbivory but also to prevent stomata from high water loss by increasing air humidity underneath the bristles (Sitte *et al.* 2002). Other indicators for dry conditions are medium SLA and canopy height. Low disturbance

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[3] Note again: Slightly alcaline soils, i.e. pH = 7.7, are the upper limit of our recorded pH–gradient.

frequencies causing closed vegetation covers again promote asexual regeneration by below–ground spacers instead of falling back on the only transient seeds.

Considering PFG 7 the single species are mainly found in dry habitats (Ellenberg *et al.* 1992). There is only one exception, namely *Eleocharis uniglumis*. We have no explanation how this species was assigned to PFG 7 as considering its biological attributes and indicator values (Ellenberg *et al.* 1992) it would rather have fit into PFG 3. Therefore, *E. uniglumis* will be left out for further considerations. Predictions made for the other species reveal only occurrences for *Briza media*, and are made exceptionally for the Müritz area apart from 1 prediction for the Hassberge. These circumstances strongly influence the habitat model for the whole group and the predicted co–occurrences are very low reaching only 0.2 at the highest. However, low K–concentrations at slightly alcaline pH–values as well as medium to little available soil water explain for medium SLA and canopy height. All species are part of permanent grasslands again replacing regeneration by seeds, which are transient, by vegetative means, i.e. below–ground spacers. Generally, we would assign the PFG rather to dry habitats, i.e. in our case the Hassberge area, as species combination suggests. But, obviously, also the Müritz area features habitats dry enough for the occurrence of species such as *Briza media* preferring these dry conditions.

Considering the single species of the remaining PFGs 4 and 8 they represent fresh conditions (Ellenberg *et al.* 1992), i.e. intermediate water supply. Most of the included species are predicted for both investigation areas; there are only few species predicted for only one area (Table 5.11). Obviously, there are similar habitats in both investigation areas potentially featuring the same species. However, both PFGs show vital differences. PFG 4 prefers unchanged habitats concerning magnitude. Disturbance frequency needs to be medium, i.e. mowing twice per year or extensive year–round grazing promote the occurrence of the species, explaining for low canopy heights and high SLA–values. Low K–concentrations resulting from medium to low pH–values and little to medium available water in clayey soils are another explanation. The species mainly reproduce by below–ground spacers as again this strategy is more promising in closed grassland vegetation covers than reproduction by short–term persistent seeds. However, especially in places where treading is high and open soil exists, the latter way can become important, too.

In contrast to group 4 PFG 8 only consists of annuals which are characterised by very small canopy heights and medium SLA–values. Unlike all other groups the species show no vegetative reproduction but only regenerate by their short–term persistent seeds. All these attributes result from a very changeable environment with high disturbance magnitudes, i.e. below–ground disturbances such as ploughing or roto–tilling. Plants are specialised on fast, numerous sexual reproduction, and no resources can be put into plant height or structural supportive tissues. However, species are not predicted to co–occur indicated by a badly calibrated habitat model. This results from the different demands of the single species to their environment, especially concerning soil nutrient status (i.e. K– and P–concentrations) leading to different predictions of the species for different areas.

As the last group PFG 15 contains 3 contrasting species considering water supply, of which *Armeria maritima* ssp. *elongata* prefers dry habitats, but *Genista tinctoria* and *Salix repens* rather grow on humid soils

(Ellenberg *et al.* 1992). Only *A. maritima* ssp. *elongata* and *S. repens* are predicted in very low numbers exclusively for the Müritz area (Table 5.11). Low predictions and the unlikely case to find all 3 species co–occurring resulted in low goodness of fit measures for the habitat model. The PFG prefers high kf–values (i.e. sandy soils), however, they do not explain for any of the plant attributes. Still, it seems to be more likely to find the species of this group at the Müritz area as suggested by the predicted but especially by the real occurrences.

Conclusions

Considering large data sets with wide environmental gradients results in habitat models for PFGs (Morrison *et al.* 1998; Kleyer *et al.* 1999/2000) and reveals fundamental functional plant traits. These traits determine the occurrence of the PFGs as they are crucial considering the group's adaptation to certain environmental conditions (see Lavorel *et al.* 1997). 88 of our responsive species were clustered according to 7 traits into 15 PFGs, of which 4 did not meet the goodness of fit thresholds (i.e. PFG 5, 8, 12, 15). 5 of the remaining groups can be assigned to the Müritz (i.e. PFG 1, 3, 6, 11, 14), 5 are unique to the Hassberge area (i.e. 2, 7, 9, 10,13). These groups therefore reflect environmental differences between the two investigation areas. One well–calibrated group (i.e. PFG 4) could be assigned to both Müritz and Hassberge area. This group characterises sites with similar environmental conditions.

Of the 7 identified fundamental attributes 4 are linked gradient–like to some environmental parameters. First of all there is the presence of aerenchymas which are necessary for the occurrence of plants in areas with very high effectively available water (Figure 5.3). They ensure the oxygen transport down to the anaerobic root zone and are therefore vital for plant survival.

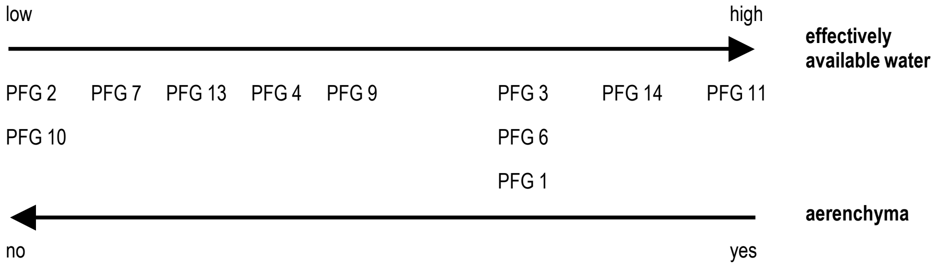

Figure 5.3: The occurrence of aerenchymas directly depends on the effectively available water.
Only PFGs with well–calibrated models are shown.

In our investigation areas wet soils (Müritz area) are exclusively used under an above–ground disturbance magnitude (i.e. grazing) which at the most destroys 50% of the biomass but will not create extensive open spaces. Disturbance frequency is medium as stocking density is low and animals are free–ranging within a very large area. In fresh to dry regions such as the Hassberge disturbance magnitude and frequency become more variable. Fresh soils are used as fertilised meadows as well as for growing crops, while drier areas are predominantly mowed for nature conservation or lie idle. However, considering the whole gradient of disturbance frequency reaching from undisturbed, fallow habitats to intensively grazed or even repeated below–ground disturbances we recognised a trend also within some fundamental functional traits (Figure 5.4). Solely considering the PFGs with well–calibrated models it becomes obvious that disturbance frequency has a direct effect on SLA, canopy height and woodiness. If disturbance frequency rises herbaceous species with high SLA–values and low canopy heights increase in abundance. At frequent disturbances plants can no longer afford to invest into structural supportive tissues but have to acquire as many resources as fast as possible to complete their life cycle inbetween disturbances. This strategy is especially pronounced in annual weed communities. At the opposite end plants have the time and need to develop persistent structures such as woody stems combined with tall stature and low SLA–values as competition especially for light intensifies. This finally results in tall shrub and forest communities where short–growing species fill in time gaps to acquire necessary resources to complete their life cycle (e.g. *Anemone nemorosa* in beech forests) or that are tolerant of e.g. low light availability (e.g. *Geum urbanum*).

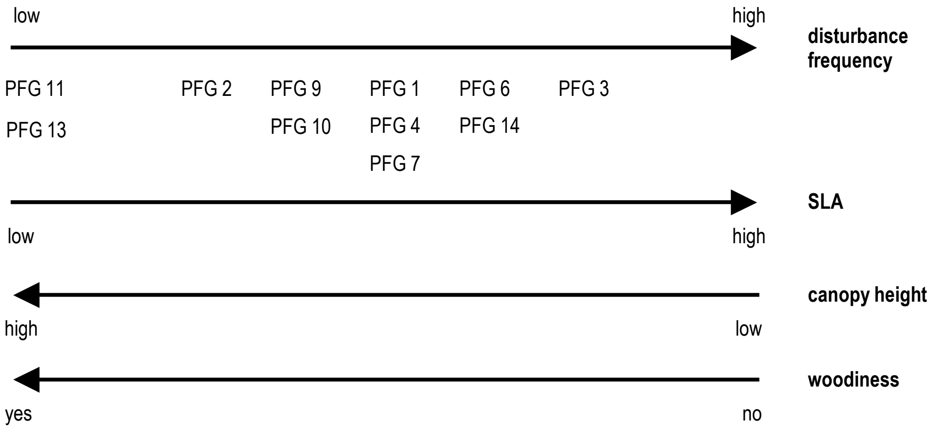

Figure 5.4: Functional traits directly dependend on disturbance frequency. Only PFGs with well–calibrated models are shown.

Furthermore, also reproduction can be related to disturbance frequency and magnitude. Even though our recorded disturbance gradients are wide and open spaces should be expected to be sufficiently available for generative regeneration this kind of offspring production is rather unimportant. Grazing with low stocking densities in large areas such as the Müritz does rarely create extensive open spaces and disturbances take place predominantly above the soil surface in wet as well as well–aerated or dry grasslands. Also, roto–tilling as the new kind of management did not result in the expected highly variable plant communities. The reason therefor was that the method was applied only once on established formerly mowed grasslands and could not yet lead to communities rather adapted to this form of regular below–ground disturbance, e.g. weed communities, as many individuals of the original flora survived and recovered (see Fritzsch 2004). Furthermore, we did not include low–prevalent species possibly part of such communities into our measurements.

As open spaces are rare and reproduction by seeds is rather ineffective as they depend on gaps to establish within the closed vegetation cover (Kunzmann 2000) PFGs produce only transient or short–term persistent seeds and rather supply vegetative above– or below–ground spacers with water and nutrients from the mother plant to ensure successful establishment of their offspring. Generally, it has been found that grassland species have a low seed longevity (Bossuyt & Hermy 2003) and vegetative regeneration is more dominant in grasslands (Eriksson & Jakobsson 1998; Kahmen & Poschlod 2004).

Considering seed–related traits such as seed mass and number they are of no importance in our general analysis. The reasons are as afore mentioned predominantly above–ground disturbances or recently changed management regimes having not yet resulted in a stable adapted community. However, transient or short–term persistent seeds indicate high seed masses (there is a trade–off between the two attributes, see Box 1). According to the competition–colonisation trade–off larger–seeded species have lower recruitment rates than smaller–seeded ones, while the latter are consistenly less competitive than the former (Rees 1995; Turnbull *et al.* 1999; Turnbull *et al.* 2004). In fact, numerous studies showed large–seeded species to have an establishment advantage (e.g. Gross & Werner 1982; Gross 1984; Eriksson & Eriksson 1997; Leishman 2001). However, even this advantage will not support generative regeneration within our investigation areas as environmental conditions are not favourable.

Westoby (1998) suggested a plant ecology strategy scheme based on only 3 traits, i.e. SLA, canopy height and seed mass. As outlined above our fundamental traits contain only the former two, whereas the latter is only indirectly represented within SLI. Furthermore, our investigations bring forward 4 additional attributes within our most parsimonious trait combination, i.e. aerenchyma, spacers, physical defence other than spikes and thorns and woodiness. Generally, we suggest that exceptionally recording only the 3 traits recommended by Westoby (1998) will not suffice to adequately capture enough plant variability to functionally represent the floristic diversity along the recorded environmental gradients. Different management systems and environmental conditions require different trait sets for plant species to survive. This becomes especially obvious in habitats strongly influenced by water. Without the existence of aerenchymas plants would not be able to survive such conditions. Furthermore, traits such as physical defence mechanisms allow plants to avoid grazing and to persist in habitats strongly influenced by herbivores. Our investigation additionally suggests spacers to be of great importance within mowed and/or grazed grasslands as vegetative regeneration appears to be more important in these systems than regeneration by seeds. The last trait contained in our investigation is woodiness, which becomes important as soon as utilisation subsides. All the identified traits are attributes related to persistence rather than to regeneration which is explicable by the habitats the species are found in and the applied disturbance regime as outlined above.

Finally, we conclude that pre–defining a small set of suspected 'fundamental' traits will not capture enough life history variability to display the response to complex environmental factors. Our investigations suggest that there might be a limited set of functional plant attributes in a given landscape, but it is unlikely to identify a trait combination generally applicable to all regions and scales as many plant features directly depend on the landscape that they are identified for.

BOX 1

PRIMARY AND SECONDARY TRADE–OFFS

Primary and secondary trade–offs

Background and objectives

Environmental constraints such as soil resources, light or herbivory shape the evolution of traits of individuals and affect interactions among species. This will influence patterns of community structure and ecosystem processes (Chapin *et al.* 1997; Díaz & Cabido 2001; Grime 2001; Rees *et al.* 2001; Lavorel & Garnier 2002). Plants show trade–offs in their abilities to respond to one or more of these constraints (Grubb 1977; Cody 1986) and therefore, trade–offs are supposed to be important for structuring ecological assemblages (Mooney 1972; Tilman 1990). On a biologically possible multidimensional surface they limit the number of species traits to a small subset of all potential combinations and therewith simplify theory (Tilman 1990).

There are numerous trade–offs between plant traits which have been reported in the literature. Here, I shall mention only a few of the best–known of them. Primary, i.e. genetically constrained trade–offs have been identified mainly within major plant functions such as persistence or regeneration. First of all, there is the trade–off between seed size and seed mass which has been found by many authors, e.g. Westoby *et al.* (1992), Thompson *et al.* (1993), Westoby *et al.* (2002) or Cerabolini *et al.* (2003). Other examples are changes in seed persistence which are often (but not always) accompanied by changes in seed size (Thompson *et al.* 1998), and long leaf life span entailing low SLA–values (e.g. Poorter 1994; Westoby *et al.* 2002).

According to Suding *et al.* (2003) there are four different trait response levels:

(a) organismal response (i.e. species characteristics due to genetic and physiological constraints),
(b) specific process response (i.e. ability to deal with a particular isolated process, varying among species and environments),
(c) net demographic response (i.e. demographic success under the net influence of all possible interactions), and
(d) abundance response (i.e. variation of population dynamics and abundance across environments).

Species traits, especially those representing organismal response, relate to and are responsible for abundance patterns (e.g. Denslow 1985; Lavorel *et al.* 1997; Westoby 1998; Weiher *et al.* 1999). These relationships can predict how communities will respond to changes in climate, resources or management (MacArthur & Wilson 1967; Weiher *et al.* 1999; Grime 2001). For the development of predictive ecological theory Tilman (1990) calls for (1) determination of environmental constraints, (2) determination of the trade–offs that organisms face in dealing with these constraints, and (3) explicit inclusion of these constraints and trade–offs as the mechanisms of intra– and interspecific interaction.

For the present investigation primary and secondary trade–offs will be considered with the former representing organismal response and the latter specific process response. The objective of the present study was to identify primary genetically constrained (i.e. fundamental) trade–offs by considering all recorded trait data of the 130 selected species for both investigation areas. By separately considering the species–trait data of each investigation area I intended to identify secondary trade–offs which are more dependent on biotic and abiotic conditions. I will compare my findings with those reported in the literature and finally, try to determine environmental constraints.

Methodology

Investigations were carried out for 13 different plant traits on a total of 130 species from both investigation areas (see Appendix Table 14). Trait values were obtained by field measurements and by means of literature (see Table B1). For the whole data set of all investigated species in both investigation areas I expected to identify the primary trade–offs between plant traits. Consideration of the species of the single investigation areas will deliver the secondary trade–offs. However, one will notice that a few of the 13 traits are missing depending on the investigation area. This applies to aerenchyma, thorny and other physical defence and start of seed shedding. The reason for these differences are environmental conditions. Soil water logging, for example, occurred only in the Müritz area. There, presence of aerenchymas was included in the selected traits as aerenchymas ensure the internal gas transport and therewith the survival of species on frequently or permanently waterlogged soils (e.g. Colmer 2003). Start of seed shedding was not considered for the Müritz area, as for most plots there was no uniform utilisation such as mowing. Thorny and other physical defence were left out for the Hassberge as grazing was only a minor disturbance factor and mostly combined with mowing. However, 9 traits were consistently recorded in both investigation areas, namely specific leaf area (SLA), canopy height, spacers, clonality, woodiness, seed mass, seed number, seed longevity in soil (SLI) and plant life span.

Table B1: Traits and trait features. (*according to Bekker, R., pers. comm.)

trait	data type	**trait features**	**literature source**
specific leaf area (SLA)	numerical	mm^2*mg^{-1}	field measurements
canopy height	numerical	mm	field measurements
woodiness	categorical	0 – not woody	Poschlod *et al.* 2003
		0.5 – woody at base	
		1 – woody	
thorny and other physical defence	categorical	0 – not present 1 – present	Klapp 1971; Rothmaler 1995; Kossegg 2001; Poschlod *et al.* 2003
aerenchyma	categorical	0 – not present 1 – present	Eber, pers. comm.
clonality (length of tillers)	categorical	0 – not clonal	Klimeš *et al.* 1997
		0.5 – < 10mm	
		1 – > 10mm	
plant life span	categorical	0 – annual	Rothmaler 1994; Kleyer 1995
		0.5 – biennial	
		1 – perennial	
spacers (above or below ground)	categorical	0 – no spacers	Klimeš *et al.* 1997; Poschlod *et al.* 2003
		0.5 – above ground	
		1 – below ground	
seed number	numerical	number	partly field measurements, Stakevitch 1988; Eriksson & Jakobsson 1998; Kästner *et al.* 2001; Poschlod *et al.* 2003
seed mass	numerical	mg per seed	partly field measurements, Eriksson & Jakobsson 1998; Kästner *et al.* 2001; Poschlod *et al.* 2003
seed longevity in soil (SLI)	index	< 0.3* – transient 0.3–0.55* – short-term persistent > 0.55* – long-term persistent	Lefèbvre & Chandler-Mortimer 1984; Aarssen *et al.* 1986; Grunicke 1996; Kühner 1998; Oberdorfer 2001; Römermann 2002; Cerabolini *et al.* 2003; Poschlod *et al.* 2003; Fritzsch 2004
start of seed shedding	numerical	month	Poschlod *et al.* 2003

I applied a Spearman correlation analysis as a number of the recorded traits were categorical.

Results and discussion

Generally, correlating the traits of all investigated species of both investigation areas in a Spearman–correlation analysis showed rather poor correlation coefficients for trade–offs (–0.198 to –0.397) with most coefficients under the absolute value of 0.25 (see Table B2). Most of the negative associations were found in connection with specific leaf area (SLA). Positive correlations, however, show rather high correlation coefficients (0.187 to 0.665) with most coefficients above 0.25, and are predominantly found for the start of seed shedding. Positive correlations will not be considered any further.

Table B2: Correlation coefficients *r* after the Spearman–correlation of all traits for all investigated species recorded in the Müritz and in the Hassberge (** p < 0.01; * 0.01 < p < 0.05). Bold numbers mark primary trade–offs. Due to missing values there are only 129 data sets for seed mass, 123 for SLI, 119 for seed number, and 117 for start of seed shedding. (SLA = specific leaf area, SLI = seed longevity in soil)

trait	SLA	canopy height	woodiness	thorny physical defence	other physical defence	aerenchyma	plant life span	spacers	clonality	seed mass	seed number	SLI
canopy height	__-0.281**__	-	-	-	-	-	-	-	-	-	-	-
woodiness	__-0.248**__	0.212*	-	-	-	-	-	-	-	-	-	-
thorny physical defence	__-0.238**__	0.288**	0.576**	-	-	-	-	-	-	-	-	-
other physical defence	__-0.211*__	0.127	-0.116	-0.096	-	-	-	-	-	-	-	-
aerenchyma	-0.097	-0.132	-0.117	-0.075	0.488**	-	-	-	-	-	-	-
plant life span	__-0.232**__	0.234**	0.126	0.023	0.112	0.187*	-	-	-	-	-	-
spacers	-0.129	0.280**	-0.048	-0.037	0.265**	0.137	0.600**	-	-	-	-	-
clonality	-0.146	0.263**	0.025	-0.048	0.094	0.118	0.642**	0.665**	-	-	-	-
seed mass	__-0.295**__	0.344**	0.301**	0.290**	-0.019	__-0.274**__	0.058	0.052	-0.020	-	-	-
seed number	-0.099	0.234*	0.092	0.138	0.068	0.033	-0.091	-0.050	0.042	__-0.320**__	-	-
SLI	0.310**	__-0.219*__	__-0.250**__	-0.126	-0.129	-0.010	-0.130	-0.039	-0.099	__-0.397**__	0.039	-
start seed shedding	__-0.198*__	0.369**	0.276**	0.202*	0.195*	0.187*	0.308**	0.209*	0.285**	0.017	0.258**	__-0.203*__

Primary trade–offs

Based on 11 species Suding *et al.* (2003) found species with high SLA and low seed mass to be more abundant in gap environments whereas species with low SLA and heavy seeds characterise undisturbed conditions. In such undisturbed (i.e. later successional) environments tall plants out–compete small species in number and abundance (Kahmen & Poschlod 2004). These two studies indirectly confirm my findings considering the trade–off between **SLA** and **canopy height** as, i.e. tall plants show low SLA–values. Even though both SLA and canopy height are measures for a plant's capacity for resource acquisition (e.g. Westoby 1998; Wilson *et al.* 1999) and contribute to its vertical expansion canopy height is the most space– and light–taking feature and hence the competitively more successful trait (cf. Givnish 1982; Gaudet & Keddy 1988; Lehsten & Kleyer subm.). Therefore, SLA appears to step back in favour of canopy height.

Furthermore, Suding *et al.* (2003) and Austrheim & Eriksson (2001) found a negative association between **SLA** and **seed mass**, which I can confirm for my considered data set. Suding *et al.* (2003) suggest this relation to be an indication of the trade–off between growth and reproductive allocation. Westoby *et al.* (1992) assign this trade–off to be the common pattern of slow growth rates in large–seeded species.

Furthermore, I found a negative correlation between **SLA** and **woodiness**. Growing woody stems and branches means investing into tall permanent structures aiming at the persistence over a longer period of time. Therefore, a fast leaf turnover, characterised by high SLA (e.g. Vesk *et al.* 2004), cannot be afforded and leaves need to function for at least one vegetation period (e.g. evergreenness) which entails structurally more persistent and therewith heavier leaves with lower SLA. This also indirectly confirms the trade–off between SLA and canopy height therein, that tall species mainly develop in later successional stages which also promote the growth of woody plants.

Another trade–off was found between **SLA** and **physical defence** mechanisms. The latter include thorns and spikes (i.e. thorny physical defence) as well as hooks, bristles, nettles, hard and mucilaginous leaves (i.e. other physical defence). Hard leaves can be caused by sclerification of vascular bundles, presence of collenchyma strands or a thick epidermis providing protection against herbivores (Cunningham *et al.* 1999). These supporting tissues and the production of thorns or spikes lead to higher leaf weight and therefore lower SLA–values. However, as also considered above concerning the trade–off between SLA and woodiness, anti–herbivore defence may in parts be a by–product of defence against the physical environment (Grime *et al.* 1996; Cunningham *et al.* 1999).

Another result of my analysis was a decreasing **plant life span** entailing an increasing **SLA**. As mentioned above high SLA is linked to faster leaf turnover (Vesk *et al.* 2004). For short–lived species there is no need to invest into structural persistence of leaves as their most important intention would be to reproduce. Therefore, SLA–values are rather high especially in ephemeral communities such as frequently disturbed habitats (e.g. heavily grazed areas (Vesk *et al.* 2004) or weed communities on fields (Kleyer 1999; Kleyer 2002). The opposite case of long plant life span and low SLA–values can be found in evergreen species.

Considering **SLI** as a regenerative trait it shows a number of interesting correlations. First of all, there are trade–offs with the **start of seed shedding** as a phenological trait and with **seed mass** being a regenerative trait. As all traits are directly linked by being reproductive features, the consideration of these two trade–offs reasons that bigger seeds will be shed later than smaller ones. However, I could find no direct positive relation between the start of seed shedding and seed mass. Still, I consider the above mentioned trade–offs to be an indirect confirmation regarding investigations of Castro-Díez *et al.* (2003) who found bigger reproductive organs to require longer time periods to ripen; similar results were published by Eriksson & Ehrlen (1991) for north European plants. In line with the association between seed mass and SLI goes the well–known established trade–off between **seed number** and **seed mass**. Both trade–offs confirm findings of e.g. Westoby *et al.* (1992), Thompson *et al.* (1993), Westoby *et al.* (2002) and Cerabolini *et al.* (2003).

Another trade–off concerning **SLI** was detected with **woodiness**. This implies that seeds of woody species, e.g. *Juniperus communis* or *Prunus spinosa*, are not capabale of extended survival in the soil seed bank. Also Middleton (2003) suggests that herbaceous species may live longer in seed banks than woody species.

Additionally, I found a trade–off between the **start of seed shedding** and **SLA**. This leads to the conclusion that woodiness (which is negatively correlated with SLA) entails late seed shedding which I found confirmed in a positive relationship between the two.

Another negative relation was found between **SLI** and **canopy height**. This supports the finding of the trade–off between SLI and woodiness and start of seed shedding and SLA as it again implies that the late–shedded seeds of tall plants (including woody species) are generally not capable of long survival in the soil. Again, this is supported by the positive relationships between canopy height and woodiness as well as between canopy height and the start of seed shedding.

Finally, I could detect a trade–off between **seed mass** and **aerenchyma**, the latter indirectly representing water availability. Within my investigation areas I covered the whole soil water gradient from very dry to waterlogged conditions. Aerenchymas, however, were only recorded as a binomial variable, i.e. present or absent. Therefore, the relation implies that plants with aerenchymas feature lighter seeds. This is contrary to the findings of Hampe (2003). Considering his investigated species, he obviously only looked at plants from dry to humid habitats and reports fruit diameter and fresh mass of 63 mainly woody plant species to peak at the, what he considers, wettest sites. The difference between our findings might result from two reasons. (i) Hampe (2003) obviously considered only dry to humid sites, whereas I looked at the whole gradient from dry to waterlogged conditions. However, I did not record aerenchymas as a continuum reaching from present over facultative development if necessary to absent. This could mean that both our findings are part of a hidden unimodal relationship between seed mass and water availability with seed mass peaking at humid sites and decreasing towards both dry and wet to waterlogged conditions. (ii) As Hampe (2003) did not take apart the single seeds but only considered the fresh weight of whole fruit which were ‘berry–‘ or ‘pome–like’, this could account for another explanation, that his results obscure the negative relationship between seed mass and water availability as detected by my findings.

Secondary trade–offs

Secondary trade–offs were detected applying a Spearman correlation analysis to the species data set of the single investigation areas. If there are different negative associations compared to the total species data set they are likely to represent specific process responses, i.e. the ability to deal with a particular isolated process, varying among species and environments (Westoby *et al.* 2002; Suding *et al.* 2003). These negative associations are called secondary trade–offs.

Table B3: Correlation coefficients after Spearman correlation analysis for the species data set in the Hassberge investigation area (** p < 0.01; * 0.01 < p < 0.05). The grey marked cell indicates an additional trade–off compared to the total species data set. Bold numbers mark primary trade–offs. Due to missing values there are only 74 data sets for SLI, 73 for start of seed shedding, and 64 for seed number. (SLA = specific leaf area, SLI = seed longevity in soil)

	SLA	canopy height	woodi-ness	plant life span	spacers	clonality	seed mass	seed number	SLI
canopy height	0.022	-	-	-	-	-	-	-	-
woodiness	-0.178	0.427**	-	-	-	-	-	-	-
plant life span	**-0.260***	0.314**	0.128	-	-	-	-	-	-
spacers	-0.080	0.349**	0.122	0.580**	-	-	-	-	-
clonality	-0.212	0.176	0.101	0.636**	0.665**	-	-	-	-
seed mass	-0.162	0.274*	0.313**	-0.044	0.028	-0.067	-	-	-
seed number	-0.262*	0.260*	0.249*	0.010	0.027	0.035	**-0.272***	-	-
SLI	0.218	**-0.274***	-0.139	-0.058	-0.051	-0.143	**-0.393****	-0.038	-
start seed shedding	-0.180	0.571**	0.444**	0.335**	0.346**	0.301**	0.197	0.107	**-0.266***

For the Hassberge investigation area I detected one trade–off inconsistent with the whole data set, i.e. the negative relationship between SLA and seed number (Table B3). Similar to the general trait analysis for all species there also is a trade–off between seed mass and seed number. However, this is not necessarily contradictory to the general finding of the trade–off between SLA and seed mass as the product between both traits is not necessarily constant. Environmental conditions such as light or nutrient availability could cause variations in seed number without changing seed mass.

For the Müritz investigation area I found two trade–offs obviously associated with environmental conditions (Table B4). It is namely the negative association between SLA and aerenchyma and between woodiness and spacers. At first sight the trade–off between SLA and aerenchyma seems to be contradictory to the general acceptance that species living in wet and humid environments would rather show large SLA–values (e.g. Sitte *et al.* 2002). Considering water supply, one would expect high turgor pressure to substitute supporting tissues which entails high SLA–values. This indeed seems to be the case for smaller wetland species such as *Potamogeton* spp. or *Ranunculus* spp. (D. Krüger, pers. comm.). Possibly, in taller species aerenchymas in leaves take over the funtion of supporting tissue which in turn is responsible for low SLA–values. In the littoral also mechanical forces, e.g. water movements, may be responsible for tougher leaves, e.g. in *Cladium mariscus* or in *Sparganium* spp.

Table B4: Correlation coefficients after Spearman correlation analysis for the species data set in the Müritz investigation area (** p < 0.01; * 0.01 < p < 0.05). The grey marked cells indicate the additional trade–offs compared to the total species data set. Bold numbers mark primary trade–offs. Due to missing values there are only 87 data sets for plant life span, 87 for seed mass, and 82 for SLI. (SLA = specific leaf area, SLI = seed longevity in soil)

trait	SLA	canopy height	woodi-ness	thorny physical defence	other physical defence	aeren-chyma	plant life span	spacers	clonality	seed mass	seed number
canopy height	**-0.332****	-	-	-	-	-	-	-	-	-	-
woodiness	**-0.249***	-0.055	-	-	-	-	-	-	-	-	-
thorny phyical defence	**-0.228***	0.206	0.263*	-	-	-	-	-	-	-	-
other physical defence	**-0.336****	0.304**	-0.103	-0.089	-	-	-	-	-	-	-
aerenchyma	-0.284**	0.172	-0.074	-0.033	0.494**	-	-	-	-	-	-
plant life span	-0.175	0.183	0.083	-0.100	0.180	0.189	-	-	-	-	-
spacers	-0.098	0.253*	-0.251*	-0.112	0.359**	0.099	0.548**	-	-	-	-
clonality	0.001	0.266*	-0.083	-0.147	0.209	0.198	0.601**	0.619**	-	-	-
seed mass	**-0.292****	0.136	0.259*	0.188	0.040	-0.154	0.182	0.161	-0.040	-	-
seed number	0.007	0.191	-0.026	0.171	0.139	0.104	-0.134	-0.106	-0.022	**-0.381****	-
SLI	0.328**	-0.129	**-0.345****	-0.030	-0.196	-0.052	-0.194	-0.082	-0.105	**-0.380****	0.112

Considering the trade–off Talbot *et al.* (1987) and Dale & Causton (1992) showed that the possibility of increasing SLA is inhibited by water logging. Also Lenssen *et al.* (2003) found 3 of 4 wetland plant species to decrease SLA in waterlogged and full light conditions. In contrast, they found the species to increase SLA when shaded. For SLA measurements I only chose leaves of plants in full light conditions (Cornelissen *et al.* 2003). In shade, leaves might expand their photosynthetic capacity at the expense of supporting tissue resulting in higher SLA–values. Therefore, my results of waterlogged conditions entailing low SLA–values confirm the findings of Talbot *et al.* (1987), Dale & Causton (1992) and Lenssen *et al.* (2003).

Considering the other secondary trade–off between woodiness and spacers, this association could be an artefact created by the selected–species composition within the Müritz investigation area. The result implies that woody species always show only above–ground spacers or none at all. My data set indeed features only woody species showing these two associations but there are other woody species occurring in the aera showing below–ground spacers, e.g. *Prunus spinosa* or *Rosa* spec. However, these species are rare and are rather confined to drier areas whereas most of the investigation area is strongly influenced by high groundwater levels. Other species occuring in the area are e.g. *Salix aurita* or *S. purpurea* (Jeschke 1962) which also feature no spacers at all (Klimeš *et al.* 1997). Obviously, there is in fact an environmentally induced trade–off, which appears to be the groundwater level. It prevents woody plants with below–ground spacers from inhabiting wet and waterlogged sites and rather promotes the growth of woody species showing no or above–ground spacers. Generally, tree and shrub growth in the wet and waterlogged areas is rather scarce also owing to a mechanical shrub management required by the management plan for the Müritz investigation area.

Finally, comparing primary and secondary trade–offs not only emphasises additional negative relationships but also shows missing associations for the single investigation areas. The most important reason for this phenomenon is likely to be the small number of species within the separate considerations. Another reason could be that those species giving a primary trade–off for the whole data set do not occur to a sufficient number within the single areas, resulting in non–significant relationships. However, the strongest primary trade–offs, i.e. seed mass – seed number and seed mass – SLI, are also represented in the single data sets. This underlines their generally accepted existence.

In contrast, some trade–offs exhibit stronger relationships within the single areas, e.g. for the Müritz area between SLA and physical defence other than thorns and spikes. The reason in this case is that most species featuring physical defence other than thorns and spikes occur only within the Müritz area.

Other primary trade–offs cannot re–occur for the single investigation areas as the traits were not considered there (see methodology).

Conclusions

The obtained results show the strongest correlations to be positive relations within the group of vegetative attributes. The strongest negative correlations were detected within the group of regenerative traits (seed biology), i.e. between seed mass – SLI and seed mass – seed number. These two trade–offs confirm findings of e.g. Westoby *et al.* (1992), Thompson *et al.* (1993), Westoby *et al.* (2002) and Cerabolini *et al.* (2003) and are well–known today in plant research. There are a number of positive and negative correlations between the vegetative and regenerative attributes, but on average these associations are rather weak. Similarly, Shipley *et al.* (1989) (for 25 species of emergent macrophytes) and Leishman & Westoby (1992) (for 300 species of semi–arid Australian woodlands) found more strong relations within the group of vegetative attributes, than within the regenerative traits or between the two groups. Also Grime *et al.* (1988) observed only weak correlations between vegetative and regenerative attributes for 273 herbaceous species of the Sheffield flora.

Considering the trade–offs I will try to specify the most important environmental constraints that become obvious for the considered investigation areas. Most trade–offs are found in connection with SLA. The trait stands for relative growth rate of a species and is positively correlated to resource richness (e.g. Garnier & Aronson 1998; Westoby 1998; Wilson *et al.* 1999; Aerts & Chapin 2000; Kahmen & Poschlod 2004). It is responsible for vertical expansion and light acquisition. Therefore, for the investigated grassland species the most important environmental constraint appears to be light availability. That means that in the closed vegetation cover first of all plants seek to hold their ground, i.e. to persist in space. This also becomes obvious within the trade–offs between vegetative and generative traits. For example, plants invest more into biomass (i.e. woody stems, canopy height, SLA) to acquire light than in durable seeds.

In direct relation to light availability stands the form of management as it determines when and which amount of light is available in time and space. For example, extensive grazing as applied at the Müritz causes a patchy light regime throughout the year because of feeding selectivity, whereas mowing completely removes biomass once or twice per year creating the same light conditions for all plant species for a short time.

I conclude that for organismal response management strategy is the most important environmental constraint within the investigated landscapes as it directly influences light availability as the most important physiologically effective variable.

The Müritz area shows a complete gradient from permanently waterlogged to very dry places. I found an environmentally–induced secondary trade–off underlining the significance of water as an environmental constraint for the considered area. According to my findings I suggest that aerenchyma not only assures gas transport in temporarily or permanently waterlogged soils but in taller plants also functions as supporting tissue which results in low SLA–values. Furthermore, in wet and waterlogged conditions light availability again has strong effects on SLA (Talbot *et al.* 1987; Dale & Causton 1992; Lenssen *et al.* 2003).

For the Hassberge area I found an additional trade–off combining regenerative and vegetative traits. Considering the investigated species light again seems to play a major role as an environmental constraint as most of them are grassland species which mainly seek to persist in space. I suggest that with favourable light conditions plants will develop leaves with lower SLA–values and will produce more seeds of comparatively high mass. In unfavourable light conditions, however, the trade–off between SLA and seed number will shift towards higher SLA–values to maintain photosynthetic activity on the cost of less seeds with comparatively low seed mass.

Generally, correlating the traits of as many species as possible in a correlation analysis should reveal fundamental (i.e.primary) trade–offs consistent for the whole plant kingdom. Apart from the meanwhile well–established trade–off between seed mass and seed number, however, I would like to point out again that most of the detected primary as well as secondary trade–offs are significant but very weak and might therefore not be unconfinedly valid. For the present study I considered 130 species of two areas, i.e. the Hassberge and the Müritz as desribed in Chapter 2. However, I assert no claim to completeness of this analysis concerning the detected trade–offs as I only considered 13 traits. I rather consider them as part of a larger entity. The trade–offs found here are especially valid for and possibly restricted to the investigated areas.

CHAPTER 6

MAIN RESULTS AND CONCLUDING REMARKS

Main results and concluding remarks

Semi–natural grasslands are an important part of the landscape. They belong to the most species–rich habitats featuring numerous light–demanding and/or thermophilic plants (Poschlod & Schumacher 1998). However, with the abandonment of traditional land–use these landscapes were intensified and afforested or left to succession, and preservation and protection of such unique habitats is nowadays a major goal for nature conservation (Poschlod & WallisDeVries 2002). Due to rising costs for the management (i.e. predominantly by mowing) of semi–natural grasslands cheaper alternatives need to be found. This thesis presents the results of investigations done on two alternative management concepts, i.e. (a) permanent grazing with low stocking densities on the Spukloch– and Rederangkoppel at the lake Müritz in Mecklenburg–Western Pomerania in north–eastern Germany, and (b) roto–tilling in the Hassberge in Bavaria in southern Germany. The study aimed on detecting the most important environmental factors that determine the occurrence of plant functional groups (PFGs) and on creating habitat models for the identified groups. The overall objective was to predict the local and regional extinction risk for plants within the resulting semi–open landscape allowing limited natural succession and providing various spatial and temporal habitat qualities for the flora. The thesis was part of the MOSAIK–project (see http://www.uni-oldenburg.de/mosaik/mosaik.htm).

On 120 investigation plots in each area I recorded presence/absence data of vascular plant species along with disturbance and soil parameters as well as topographical variables. Using stepwise logistic regression I identified responsive species (i.e. single species with well–calibrated habitat models) followed by the iterative search for a most parsimonious set of traits combining into PFGs that exhibit significant response to the environmental factors and represent as many of the responsive species as possible. Finally, habitat models for the groups were built. PFGs consist of species exhibiting similar biological traits and responding in similar ways to multiple environmental factors (Gitay & Noble 1997; Lavorel *et al.* 1997). Such groups are a way of reducing the diversity of single species and help to abstract to a coarser level of organisation due to the fact that every organism features certain morphological and reproductive attributes and therefore can be classified according to these traits. Traits become functional if they are strategically important for a species or crucial considering its adaptation to certain environmental factors (McIntyre *et al.* 1999).

Main results

Hassberge

For the Hassberge the trait combination of plant life span, specific leaf area (SLA), canopy height and seed number per ramet showed the maximum number of responsive species in well–calibrated PFGs. Altogether the statistical procedure identified 8 groups containing 48 out of 51 responsive species. Trait functionality was mostly related to disturbance history, whereby mainly above–ground disturbance was important. The incorporation of SLA, canopy height and plant life span into the trait combination indicates a strong influence of persistence attributes on the occurrence of plant species, whereby the former two stand for resource acquisition, and the latter puts emphasis on the persistence of plants at a certain place mostly implying vegetative regeneration. This is supported by the high within–group variability and therefore rather unimportant feature of seed number. Persistence appears to be the more important strategy in communities such as grasslands, thermophilic fringes or hedges as found in the Hassberge area. One PFG represents amongst others species of annual weed communities as found on fields, however, the quality of fit measures are poor and therefore group members are unlikely to co–occur as they prefer different habitat qualities. Roto–tilling as the new management regime took place only once, and no stable community has yet developed but is rather strongly influenced by the before established grassland community. Therefore, there is no distinct PFG for such habitats. For the well–calibrated groups (i.e. 6 PFGs predominantly containing grassland species) I found consistent responses of SLA and canopy height in relation to disturbance magnitude and frequency. Decreasing canopy heights and at the same time increasing SLA–values can be attributed to relatively short intervalls between above–ground disturbances (i.e. mostly mowing twice per year or mowing and grazing). Due to a regular biomass destruction there is no or only little need for plants to invest into supportive tissues as light availability is sufficient. In contrast, tall woody canopies with low SLA–values are able to grow at long disturbance intervals.

The results corroborate the hypotheses initially proposed. It was hypothesised that natural succession mainly depends on the various disturbance parameters, i.e. disturbance frequency, disturbance magnitude and disturbance date. Above–ground disturbances are indeed an appropriate way to maintain open grasslands. The management regime needs to be applied in the form of mowing once or twice per year, even alternating mowing annually and every other year should be sufficient to maintain the typical communities. Also extensive grazing alone or in combination with mowing is appropriate. Biomass removal is important to provide space and light for short–growing species and to avoid eutrophication. Disturbance date only plays a limited role for the maintainance of the typical flora and solely 3 PFGs are slightly sensitive to disturbance week tending to prefer early management in the year. Management especially affects the generative reproduction and promotes those species having finished seed production by the time the site is used agriculturally (Kahmen 2003). However, as mentioned above, generative reproduction plays only a minor role for the investigated habitats as vegetative regeneration is more important in grasslands (see Eriksson & Jakobsson 1998 and Kahmen & Poschlod 2004).

As hypothesised the identified traits are in fact functionally related to disturbance frequency and magnitude. Persistence is most important to the species (see above) and SLA and canopy height follow a gradient of disturbance magnitude and frequency (see Chapter 3). Perennial plant life span is prevailing in the investigated habitats and concerning this study, is implying vegetative reproduction.

Roto–tilling as the new management concept is a below–ground disturbance. It was applied only once and the results are therefore strongly influenced by the before established mowed grasslands. However, as mentioned above my analyses indicate that the typical grassland communities only occur on regularly above–ground disturbed sites. This finding and also the results of Fritzsch (2004) lead to the conclusion that roto–tilling is no appropriate method to manage and maintain the typical flora of semi–natural grasslands. Furthermore, I suggest, that regular below–ground disturbance by roto–tilling will result in changed environmental filters leading to a different plant community than present today (see therefor also Tilman 1994; Tilman 1997).

Mowing as the appropriate and most frequently applied management strategy within the Hassberge does not result in a spatio–temporal mosaic of habitat qualities as the method uniformly affects the communities. The only way to create such a mosaic would be to irregularly mow the grasslands or to introduce permanent extensive grazing as a management concept with animals capable to diminish shrubs such as *Prunus spinosa* or *Cornus sanguinea* (see Reiser & Kaminsky 2003) which would increase in abundance and density with ongoing succession. Especially the option of grazing would lead to habitats variable in space and time and a vegetation mosaic would develop (as can be seen in the following sections) combined with temporary local extinctions of typical floral elements depending on food availability.

Müritz

The maximum number of responsive species in well–calibrated PFGs was shown for the trait composition of aerenchyma, thorny physical defence, position of spacers, canopy height and seed longevity (SLI). 9 PFGs contained 48 out of 53 responsive species. Grazing intensity (GI) and soil water supply were found to be the most important environmental factors. As a waterstress–tolerating feature aerenchyma splits the PFGs into those able to persist in temporarily or permanently water logged soils and those unable to do so. Thorny physical defence is another important persistence trait avoiding grazing pressure owing to the management regime. Putting emphasis on the acquisition of resources canopy height again belonged to the trait combination. SLI as a reproductive trait is rather unimportant compared to persistence traits as most investigation sites are grasslands with a closed vegetation cover. At the Müritz below–ground disturbance is rare and only small–scale due to the extensive grazing regime, hence reproduction by vegetative means represented by above– or below–ground spacers is more successful than generative reproduction. The occurrence of all PFGs depends on GI, most of the groups are sensitive to grazing in winter. This indicates that grazing suppresses or even inverts natural succession especially during the winter months when regrowth does not occur and food is scarce. Strong functionality for plant traits was found for aerenchymas which occurred in permanently or temporarily water logged conditions. Water level strongly influences GI, wet sites are rarely grazed. Tall canopy heights result from sufficient water supply and avoidance by grazers due to the water level but are also due to physical defence mechanisms. Furthermore, I found a strong relation between GI and SLI; SLI increases with increasing GI.

Also for the Müritz area the results corroborate the initially proposed hypotheses. I hypothesised that natural succession depends on GI. This indeed is the case within the investigation area. Considering its history shrubs and *Juniperus communis*–heath established only after grazing by cattle was abandoned in the 1950s (see Chapter 2). However, also in recent times colonisation by shrubs (e.g. *Juniperus communis*) and trees (e.g. *Betula* spp.) or other woody plants (e.g. *Rubus* spp.) can be observed in areas were grazing intensity is rather low (i.e. semi–open forest east of the Spuklochkoppel or *Juniperus communis*–heath, see also Chapter 4, Figure 4.2). Looking at the above examples of species not being eaten by herbivores it becomes obvious that most of them exhibit physical defence mechanisms avoiding grazing pressure. The occurrence of physical defences was indeed found to be strongly functional to GI. Species featuring thorns and spikes on leaves or stems or with hard, sharply–edged leaves were avoided by grazers. This sometimes coincides with high water levels which are avoided by herbivores (see Chapter 4 and Rozé 1993). This fact corroborates the hypothesis that GI depends on soil resource availability in the way that it declines with rising water supply. Considering nutrient availability I could find a strong relation between GI and potassium–content (GI in winter – K: 0.433; GI in summer – K: 0.431) indicating that high K–concentrations entail high GIs as this possibly increases the plant's nutritional value.

Comparing summer and winter GI it becomes obvious that grazing in winter removes much more biomass than does grazing in summer (Chapter 4, Figure 4.2). As hypothesised this indicates that high GIs during the winter months indeed suppress or even invert natural succession as there is no biomass regrowth and food is scarce. This is the case even though animals receive additional food close to the Müritzhof harvested during the summer from the Lange Koppel.

The identified plant traits in fact exhibit strong functionality along the environmental gradients, especially GI and water availability, and therewith represent the PFGs. In wet areas aerenchymas ensure the survival by maintaining the gas transport into the anaerobic root zone. Canopy height depends on GI as well as on water level, the tallest plants occur in water logged areas hardly frequented by grazers. Additionally physical defence mechanisms influence GI, grazers avoid sharply–edged leaves as much as spikes and thorns. GI does rarely create open spaces for seedling establishment, therefore spacers are the predominant strategy to reproduce in the grasslands (see Eriksson & Jakobsson 1998 and Kahmen & Poschlod 2004).

Permanent grazing at low stocking densities can be expressly recommended as a low cost alternative to mowing. Succession will lead to local extinctions of plant species predominantly in less grazed areas. However, especially in hard winters plant biomass will be reduced and new sites are created for populations to re–establish. Furthermore, I suggest to promote a multi–species grazing regime as practiced in the Müritz area as different animal species prefer different plants and communities, and due to their muzzle size have different capabilities to inflict damage on plants.

Large data sets

Generally, habitat models based on stepwise logistic regression allow a rigorous identification of environmental factors that determine the niche of species and PFGs. According to the concept of essentiality, all plants require a certain amount of water, light and a number of essential nutrients to maintain physiological function (Marscher 1995). Likewise, plants are limited by the same physical factors (e.g. pH, disturbance). Hence, one would expect that all factors contribute some explanation to the regression models. However, the results of this thesis show that single species as well as PFGs respond to very different factors and that there is no factor that stands out to determine the occurrence of all species or PFGs. This does not invalidate theory. An obvious reason is that many gradients are not large enough to include limits of habitat suitability although they extend over several orders of magnitude. Niche breadth with respect to these factors can only be determined on larger scales with even greater environmental variation (Thuiller *et al.* 2004).

The conducted analyses for the single investigation areas also represent only short sections of the possible environmental gradients. As implied above analysing large data sets of various investigation areas leads to wider environmental gradients increasing the possibility to fully display the niche breath of single species or PFGs. To do so I put the data of both investigation areas into one analysis to identify the fundamental functional traits important along the wider environmental gradients. I received 7 traits explaining a maximum number of responsive species in well–calibrated PFG habitat models. 15 clusters contained 88 out of 93 responsive species. The identified fundamental attributes are aerenchyma, physical defence other than thorns and spikes, woodiness, spacers, SLI, SLA and canopy height. Persistence traits expectedly were found to be most important confirming the results of the single investigation areas. Trait functionality was mostly related to disturbance frequency and to the effectively available water (AW_{eff}), i.e. the annual average amount of water effectively available for plants depending on various climatic, topographical and soil parameters. Most of the PFGs are sensitive to AW_{eff}, and aerenchyma separates wet from dry conditions. Frequency is the most important disturbance parameter. It is especially reflected in SLA, canopy height and woodiness. High disturbance frequencies expectedly again result in high SLA–values and low canopy heights as resource acquisition is easy due to frequent biomass removal. Hence, there is no need to invest into supportive structures. Woody stems are grown at low disturbance frequencies. Above– and below–ground spacers and SLI again indicate the importance of vegetative reproduction in the predominantly above–ground disturbed grasslands as they feature a closed vegetation cover. Physical defence other than thorns and spikes put emphasis on avoidance mechanisms against herbivory.

Generally, combining data from all possible environments could identify few fundamental traits represented over and over again within the trait combinations found for all PFGs worldwide. However, I suggest that it is unlikely to identify the trait combination generally applicable to all regions and scales as many plant features directly depend on the landscape that they are identified to be important for. In my investigations canopy height is the trait that is found within all three trait combinations. Therefore, there is a chance that it is likely to be important in many if not all trait combinations for all PFGs worldwide (see Chapter 3, 4 and 5, and major trait within the LHS–scheme suggested by Westoby 1998). Generally, my investigations suggest that there might be a limited set of functional plant attributes in a given landscape, but pre–defining a small set of suspected ‘fundamental’ traits (e.g. SLA, canopy height and seed mass as suggested by Westoby 1998) will not capture enough life history variability to display the response to complex environmental factors.

Methodology and its limits

In the presented study, PFGs were identified by first filtering for responsive species and then by searching a parsimonious trait combination. The basic assumption behind the latter optimisation procedure is that there is one functional trait set with its environment–enforced trade–offs for a whole landscape. The identified combination assembles most of the responsive species to PFGs with well–calibrated habitat models. The procedure allowed to include 94% (Hassberge), 91% (Müritz) and 95% (combined analysis) of the responsive species to PFGs with habitat models of sufficient calibration. The assumption is that for different landscape types representing sections of a large–scale disturbance/fertility plane, e.g. arable, pasture and forested as well as dry, fresh and wet landscapes different trait sets are functional. This results in landscape–specific PFGs (Kleyer 1999, Chapter 3 and 4) and others that apply across landscape types (Kleyer 2002, Chapter 5). During the statistical procedure all possible trait combinations were calculated. There also were sets of attributes that differed by only one species included in the PFGs with habitat models of sufficient calibration from the trait combination containing most species. Sometimes, these sets of attributes are very similar to the selected combination, i.e. they contain one feature more or less, but they can also be very different. For the presented thesis, major emphasis was put on the amount of species represented in PFGs with well–calibrated habitat models, and there was never the case that two sets of attributes showed the same number of species in models of sufficient calibration. However, various other approaches are possible, e.g. putting emphasis on the smallest trait set representing most species in the PFGs independent from the quality of the habitat models, but other selection criteria would lead to biased choices or low quality habitat models for the PFGs.

The PFG habitat models predict the possibility of co–occurrence of the single species along the recorded environmental gradients. The models are based on the predicted probabilities of the single species contained in one group. Sometimes the predicted occurrences of the single species in one PFG strongly differ in numbers, or species prefer different habitat qualities. However, these facts are not necessarily a reason to deliver poorly–calibrated habitat models. They rather lead to the phenomenon that the PFG habitat model is influenced mainly by the more prevalent species. One example of this phenomenon is given in Chapter 3 for PFG 5 (Figure 3.4). This bias towards one or two species of the group becomes only visible if the habitat models for the single species are compared with the general PFG model. Low model qualities can on one hand result from different preferences of the most abundantly predicted species or on the other hand from low predicted prevalences for all species contained in one group.

Implications of habitat models for nature conservation and perspectives

Not only in times of high unemployment nature conservation rises the question of how reasonable the management efforts are to protect and preserve landscape elements such as semi–natural grasslands. Enormous amounts of money are spend to maintain habitats that once were created by humans, and why not leave nature its way to take possession again of areas now gradually abandoned? The most important argument in my opinion is to preserve the biodiversity that has originated from cultural and historical human activities. Additionally, these areas hold a large gene bank in the species present there. They are part of the landscape just as much as cities and roads are and they are nice to look at in the natural scenery with often colourful impressions. Furthermore, they are part of human history and should not be eradicated like it is not done with old churches or stone circles.

However, even nature conservation authorities realise that only conserving cannot be the way to go as landscapes are kept in a certain state and no dynamical developments are possible (Kleyer *et al.* 2002). Besides, applied management regimes such as mowing are expensive in the way that they require personell, machinery and dumping space (Kleyer *et al.* 2002). Research programmes were brought into being to find low

cost alternatives, the MOSAIK–project is part of one of them. Alternatives include e.g. burning, grazing or mulching (e.g. Schiefer 1981; Briemle *et al.* 1991; Plachter 1995; Schreiber 1997). However, financial support rarely lasts longer than 3 or 4 years but results and predictions on long–term effects need to cover time frames longer that the research period. To find an appropriate solution, models such as individual–based models are used to extrapolate data into the future. Habitat models are statistical models and here are based on stepwise logistic regression; they are static and predict species occurrences along environmental gradients as recorded in the investigation areas (cf. Kleyer 1997; Kleyer 2002). They do not extrapolate the observations into space and time but can be used to predict species occurrences under certain environmental and disturbance conditions. The presented thesis even abstracted the individual species into plant functional groups as then predictions need not to be performed individually but only for a much smaller number of groups. However, prognoses derived from habitat models solely describe potential scenarios of the possible distribution, whether and how these predicted conditions can be achieved can only be simulated by dynamical models (Schröder & Reineking 2004). Habitat models do not allow to picture population dynamics combined with predictions concerning the size of a population (Schamberger & O'Neil 1986). This only becomes possible by linkage with models for spacial (meta–) population dynamics (e.g. Wahlberg *et al.* 1996; Collingham *et al.* 2000; Wadsworth *et al.* 2000; Söndgerath & Schröder 2002).
Still, habitat models are a mean by which nature conservation authorities are given an instrument to predict species occurrences along the recorded environmental gradients. However, the models are only valid for the area that they have been created for and transferability to other areas is limited (Schröder & Richter 1999/2000). As long as it has not been tested and verified, statements on spatio–temporal aspects are only possible for the data the model is based on (Fielding & Haworth 1995). Especially the utilised grasslands in the Hassberge as well as in the Müritz area underlied their management regime for more than two decades. These grasslands are the target habitats to be preserved in the presented study. Obviously, mowing in the Hassberge and grazing in the Müritz are well able to maintain the characteristic flora of these grasslands and suppress natural succession. This can be seen in the habitat models for the PFGs as the most important disturbance factor was found to be magnitude, i.e. above–ground disturbance.

In the Hassberge mowing stays the most important way to manage the semi–natural grasslands. Trying to create more spatio–temporal variability in these habitats would mean to vary the mowing interval from annually or twice per year to alternating annually and every two years. Roto-tilling is not considered as an appropriate alternative as firstly continuous above–ground disturbance was found to be most important for semi–natural grasslands. Another possibility of above–ground disturbance would be to introduce permanent grazing with low stocking densities. Goats appear to be very effective in reducing *Prunus spinosa*, *Prunus domestica* and *Cornus sanguinea* (Reiser & Kaminsky 2003), however, they cannot be left on site during the winter due to the sensitivity of their hooves to humiditiy. Another limit to usable animals are the steep sites and slippery clayey soils, and furthermore, animals would have to be able to cope with thorny shrubs such as *Prunus spinosa* invading less utilised areas.

At the Müritz the wheel to turn is stocking density of grazers as I found grazing intensity to be the most important disturbance factor. Fencing animals in certain areas would lead to more intensive grazing for a selectable time frame and would therewith result in a larger biomass removal and suppress succession. Other than that the herding hours of the flock of sheep should be changed to promote grazing as during the investigation period they mainly concurred with low grazing activity of the animals (Ewert 2001). This resulted in less biomass removal especially in the major target area, i.e. the *Juniperus communis*–heath. To decrease the grazing pressure on the intensively grazed parts of the Rederangkoppel (i.e. the higher elevated areas close to the Müritzhof and in the very east) which is predominantly exerted by sheep, possibly a reduction of the animal number (2001: ca. 300 animals, I. Heinzel, pers. comm.) would be a solution. Not only in summer but especially in winter, when herding does not take place, biomass removal reaches 100% especially within the drier parts of the Rederangkoppel (see Chapter 4, Figure 4.2). The area is practically over–grazed. Smaller animal numbers would also still be able to reduce biomass in the *Juniperus communis*–heath in summer if herding hours were changed.

As succession is suppressed or even inverted especially during the winter months, additional hay feeding during this time leads to less standing biomass removal than could be possible. For the large flock of sheep on the Rederangkoppel the additional food is necessary as there is no remaining standing biomass in the frequented drier areas. However, especially in mild winters additional feeding is not as essential as in hard winters, where a closed snow cover limits food availability and starvation is more likely. Therefore, additional feeding should be adapted to winter temperatures, snow cover and therewith food availability as it strongly negatively influences winter grazing intensity and therewith promotes ongoing natural succession.

Furthermore, multi–species grazing is an appropriate solution to maintain semi–natural grasslands. Bakker (1998) stated that grazing by different species may be of value for the management of plant communities as herbivores differ in 'food habits, terrain use and their potential to influence vegetation development'. However, the impact of specific combinations of herbivores has yet to be investigated. Muzzle size (e.g. Lutz 1990; Pott & Hüppe 1991), hoof impact (e.g. Betteridge *et al.* 1999) and weight (e.g. Betteridge *et al.* 1999) are important features of animals considering their potential impact on various grassland types, e.g. wet or dry, steep slopes or flat areas. At the Müritz herbivore species–specific effects cannot be distinguished, however, obviously the multi–species concept seems to proove its value for this type of semi–natural grassland as plant species diversity is high. Some more goats would possibly be a useful supplement of the existing animal species as they are very effective against shrub encroachment (e.g. Reiser & Kaminsky 2003; Rahmann 2004), but need high veterinary efforts as their hooves are very sensitive to humiditiy (D. Martin, pers. comm.). Furthermore, herding effort is large.

Generally, grazing is an effective way to preserve open grasslands. It leads to higher species numbers (e.g. Bakker 1989; Rieger 1996; Sternberg *et al.* 2000) by creating a spatio–temporal mosaic of habitats. Even at the risk of local extinctions of certain species under temporarily unsuitable conditions regional preservation of target species is possible.

SUMMARY

SUMMARY

Semi–natural grasslands are important habitats for numerous endangered plants. A major goal of nature conservation is to protect their species–richness and preserve their unique floristic and faunistic composition. Natural succession leading to over–growing by shrubs and trees imposes the need for management strategies to keep the landscape open. At present mowing is the predominantly applied regime consuming enormous amounts of money and time. In recent times alternative methods such as burning, mulching or grazing have been tested for their potential to substitute mowing. The presented investigation is part of the MOSAIK–project which aimed on the study of two of these alternative management concepts to preserve semi–natural grasslands. The alternatives are namely permanent pastures of low stocking densities creating a spatio–temporally uncontrolled small–scale vegetation mosaic, and roto–tilling as a massive cyclic disturbance resulting in spatio–temporally controlled large–scale mosaic patterns. Both management approaches will lead to a semi–open landscape allowing limited natural succession and providing various spatial and temporal habitat qualities for flora and fauna. The presented thesis aims to detect the most important environmental factors that determine the occurrence of plant functional groups (PFGs) and to create habitat models for the identified groups. The overall objective was to predict the local and regional extinction risk for plants when the alternative management systems are used.

Investigations were conducted in two areas; (a) in the Hassberge in Bavaria in southern Germany and (b) on the Spukloch– and Rederangkoppel at the Lake Müritz in Mecklenburg–Western Pomerania in north–eastern Germany. In each area 120 investigation plots were established and presence/absence data of vascular plant species were recorded along with disturbance, topographical and soil parameters. Using stepwise logistic regression 'responsive species' (i.e. single species with well–calibrated habitat models) were identified which were grouped with the aid of Ward's clustering into plant groups with similar biological attributes. Again applying stepwise logistic regression identified the most important environmental factors and resulted in habitat models for PFGs. The analysis identified a most parsimonious set of functional traits combining into PFGs that exhibit significant response to the environmental factors and represent as many of the responsive species as possible. All this was done for each investigation area and for both areas in one analysis.

For the Hassberge 51 responsive species were identified of which 48 were represented within 8 PFGs. The parsimonious trait set consisted of 4 traits, i.e. plant life span, specific leaf area (SLA), canopy height and seed number per ramet. SLA and canopy height stand for resource acquisition, plant life span puts emphasis on the persistence of plants at a certain place mostly implying vegetative regeneration. All 3 attributes indicate a strong influence of persistence traits on the occurrence of plants. This is supported by the rather unimportant feature seed number which is highly variable between the members of one PFG. Obviously, persistence is the more important strategy in communities as found in the Hassberge area, e.g. grasslands, thermophilic fringes or hedges. Species of annual weed communities as found on fields were represented in one PFG, however, the group members prefer different habitat qualities and are therefore unlikely to co–occur. Utilisation of the roto–tilled plots took place only once, therefore, they have not yet developed a stable community

but are strongly influenced by the before established grassland community and hence are not bringing forward a distinct PFG. For the well–calibrated PFGs (i.e. predominantly groups containing grassland species) consistent responses of SLA and canopy height were found in relation to disturbance magnitude and frequency. Relatively short intervalls between above–ground disturbances (i.e. mostly mowing twice per year or mowing and grazing) cause canopy heights to decrease whereas SLA increases. Due to a regular biomass destruction short canopy heights and high SLA–values mean little or no need to invest into supportive tissues as light availability is sufficient. In contrast, long disturbance intervals result in tall woody plants with low SLA–values.

For the Müritz area 53 responsive species were identified of which 48 emerged in 9 PFGs. Here, the most parsimonious set of attributes consisted of 5 traits, namely aerenchyma, thorny physical defence, position of spacers, canopy height and seed longevity (SLI). Aerenchyma as a stress–tolerating feature split the PFGs into those being able to persist in permanently or temporarily waterlogged soils and those unable to do so. Owing to the management regime another persistence trait is important, i.e. thorny physical defence, avoiding grazing pressure. Again, canopy height belonged to the trait combination putting emphasis on the acquisition of resources. This time it is SLI bringing in a reproductive trait, however, as for the Hassberge reproductive attributes are rather unimportant compared to persistence traits as most investigation sites are grasslands with a closed vegetation cover. Due to the extensive grazing regime at the Müritz below–ground disturbance is rare and only small–scale, hence generative reproduction is less successful than reproduction by vegetative means represented by above– or below–ground spacers. The occurrence of all PFGs depended on grazing intensity (GI), most of them were sensitive to grazing in winter. This means that grazing suppresses or even inverts natural succession especially during the winter months when regrowth does not occur and food is scarce. Considering the relations between environmental gradients and plant traits strong functionality was found for aerenchymas which occurred in temporarily or permanently waterlogged conditions. GI is strongly influenced by water level, wet sites are rarely grazed. Sufficient water and avoidance by grazers due to the water level but also due to physical defence mechanisms result in tall canopy heights. Furthermore, a strong relation between SLI and GI was found; with increasing GI also SLI increases.

Both of the above presented analyses consider only short sections of the possible environmental gradients. Therefore, the identified features are only important for one of the considered areas. However, among these attributes are possibly fundamental functional traits generally important for the occurrence of PFGs. To identify such traits a third analysis was conducted on a large data set implying both investigation areas and widening the environmental gradients. 15 PFGs were identified containing 88 out of 93 responsive species. For each, Müritz and Hassberge area 5 unique well–calibrated groups were found, distinguishable by the presence or absence of aerenchymas representing wet and waterlogged conditions on one hand, and on the other hand dry habitats. One group contained species predicted for both investigation areas. The 7 identified fundamental attributes of the most parsimonious trait combination are aerenchyma, physical defence other than thorns and spikes, woodiness, spacers, SLI, SLA and canopy height. Confirming the results of the single investigation areas persistence traits again were found to be most important. Considering trait functionality it is aerenchyma separating wet from dry conditions, as most of the PFGs are sensitive to the effectively available

water, i.e. the annual average amount of water effectively available for plants depending on various climatic, topographical and soil parameters. The most important disturbance parameter is frequency. It is especially reflected in SLA, canopy height and woodiness. High disturbance frequencies again result in high SLA–values and low canopy heights. Woody stems are grown at low disturbance frequencies.
Summarising the results of the general analysis the occurrence of PFGs in the considered investigation areas mainly depends on disturbance frequency and effectively available water. The fundamental functional traits are aerenchyma, separating wet from dry habitats, SLA, canopy height and woodiness reflecting high or low disturbance frequencies, physical defence other than thorns and spikes putting emphasis on avoidance mechanisms against herbivory, and finally spacers and low SLI underlining the importance of vegetative reproduction in the predominantly above–ground disturbed habitats.

For the successional sere within the Hassberge area it can be stated that depending on disturbance magnitude and frequency grassland species populations will locally disappear due to unfavourable environmental conditions, and there is a local extinction risk for the typical flora. However, the present form of utilisation, i.e. mowing, regionally well preserves open grasslands and prevents the growth of shrubs. Considering the new management regime of roto–tilling no clear statement can be made on the possibility of preservation of the flora as the method was applied only once on established grassland communities and repetition did not take place. Thereby, stable communities could not yet establish. However, the analysis showed most of the grassland species to depend on regular above–ground disturbances (i.e. mowing and/or grazing) resulting in closed vegetation covers and putting emphasis on vegetative regeneration. Their dispersal ability in time is poor (i.e. transient or short–term persistent seeds). High frequencies of roto–tilling (i.e. every 1 to 3 years) will soon deplete the anyway small seed bank and repeatedly damage the adult plants not giving them enough time to recover from the below–ground disturbance. Finally, populations will die out. Low roto–tilling frequencies result in the growth of more competitive shrubs especially changing light regime and therewith outcompeting typical grassland species in the long run. According to these results roto–tilling cannot be suggested as an alternative to the conventional mowing. In order to reduce costs mowing could take place alternately annually and every other year.

Permanent pastures of low stocking densities as the second alternative to mowing paint another picture. Different grazing intensities create a small–scale vegetation mosaic ranging from intensively grazed dry to avoided shrubby or wet areas. The long–term grazing management at the Müritz has created species–rich communities in habitats of diverse spatial and temporal quality. Grazing intensity and soil water logging are the most important factors for the occurrence of PFGs and natural succession, whereby especially grazing in winter leads to a considerable damage by browsing and a biomass reduction of up to 100% in large sections. Grazing animals tend to avoid permanently wet areas, which can also be attributed to physical defence mechanisms and low nutritional value of plants occurring there. Permanent extensive grazing can expressly be recommended as an alternative management regime to mowing. Multi–species grazing as practiced in the Müritz area is even more effective as different animals prefer different plants and communities, and due to their muzzle size have different capabilities to inflict damage on plants.

ZUSAMMENFASSUNG

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Halb–natürliches Grünland ist bedeutsamer Lebensraum für zahlreiche gefährdete Arten. Der Schutz dieses Artenreichtums und der Erhalt der einzigartigen Flora und Fauna sind Hauptziele des Naturschutzes. Natürliche Sukzession führt zur Zunahme von Büschen und Bäumen und macht den Einsatz von Managementmaßnahmen nötig, um die Landschaft offen zu halten. Die derzeit am häufigsten angewandte Methode ist die Mahd, die einen enormen zeitlichen und finanziellen Aufwand bedeutet. In jüngerer Zeit wurden alternative Managementsysteme, z.B. Brennen, Mulchen oder Beweidung, als Ersatz für das gegenwärtige Mähen getestet. Die vorliegende Arbeit ist Teil des MOSAIK–Projektes, das zum Ziel hat, zwei dieser alternativen Managementkonzepte zum Erhalt halb–natürlichen Grünlandes zu untersuchen. Es handelt sich zum einen um ganzjährige Beweidung bei geringer Besatzdichte, durch die ein raum–zeitlich ungesteuerter kleinräumiger Mosaikzyklus geschaffen wird. Die zweite Methode beinhaltet zyklische, massive Eingriffe in die Vegetationsdecke durch Fräsen, wodurch ein raum–zeitlich gesteuerter großmaßstäbiger Mosaikzyklus entsteht. Beide Maßnahmen führen zu einer halboffenen Landschaft, wobei natürliche Sukzession begrenzt zugelassen wird, wodurch wiederum mannigfaltige Bedingungen in Raum und Zeit für Flora und Fauna geschaffen werden. Die vorliegende Dissertation hatte zum Ziel, die wichtigsten Umweltfaktoren zu erfassen, die das Vorkommen von funktionellen Pflanzengruppen (PFGs) bestimmen. Desweiteren wurden Habitatmodelle für diese Gruppen erstellt. Das Gesamtziel was die Vorhersage der lokalen und regionalen Aussterbewahrscheinlichkeit für Pflanzen unter den untersuchten Managementmaßnahmen.

Die Untersuchungen erfolgten in zwei Gebieten: (a) in den Hassbergen in Bayern in Süddeutschland, und (b) auf der Spukloch– und Rederangkoppel am Müritzsee in Mecklenburg–Vorpommern in Nordostdeutschland. In jedem Gebiet wurden auf 120 Untersuchungsflächen Präsenz/Absenz–Daten der höheren Pflanzen sowie Boden–, Störungs– und topografische Parameter aufgenommen. Mit Hilfe der schrittweisen logistischen Regression wurden sogenannte ‚responsive species', d.h. Einzelarten mit gut kalibrierten Modellen, ermittelt, die dann durch Ward's Cluster–Methode in Gruppen mit ähnlichen biologischen Merkmalen eingeteilt wurden. Unter erneuter Zuhilfenahme der schrittweisen logistischen Regression wurden die wichtigsten Umweltfaktoren ermittelt und Habitatmodelle für die PFGs erstellt. Die Analyse ermittelte die sparsamste Merkmalskombination, die zu PFGs führte, die signifikante Reaktionen auf die Umweltfaktoren zeigten und die die meisten Arten in gut kalibrierten Habitatmodellen enthielten. Dieses Verfahren wurde sowohl für beide Untersuchungsgebiete im einzelnen als auch für einen gemeinsamen Datensatz aus beiden Gebieten angewandt.

Für die Hassberge wurden 51 ‚responsive species' ermittelt, von denen 48 Arten in 8 PFGs repräsentiert waren. Die sparsamste Merkmalskombination bestand aus Lebensdauer, spezifischer Blattoberfläche (SLA), Wuchshöhe und Samenzahl pro Ramet. SLA und Wuchshöhe repräsentieren die Nutzung von Ressourcen, die Lebensdauer unterstreicht die Persistenz von Pflanzen an einem Ort und ist meistens mit der Fähigkeit zu vegetativer Reproduktion verbunden. Alle 3 Eigenschaften weisen darauf hin, dass Persistenzmerkmale einen starken Einfluss auf das Vorkommen von Pflanzen haben. Dies wird weiterhin unterstützt durch die relative Bedeutungslosigkeit der Samenzahl, denn diese ist innerhalb der PFGs sehr variabel. Offenbar ist Persistenz

in Pflanzengesellschaften wie denen der Hassberge (z.B. Grünland, thermophile Säume oder Hecken) die bedeutsamere Überlebensstrategie. Arten annueller Unkrautgesellschaften, wie sie beispielsweise auf Äckern vorkommen, waren Teil einer PFG, deren Arten sich jedoch in ihren Habitatpräferenzen so stark unterschieden, dass ein gemeinsames Auftretens unwahrscheinlich ist. Gefräst wurde nur ein einziges Mal, daher konnte sich noch keine stabile Pflanzengesellschaft einstellen, sondern die Standorte waren noch sehr stark durch die vorher etablierte Grünlandgesellschaft beeinflusst. Daher konnte keine PFG für diese Standorte ermittelt werden. Für die gut kalibrierten Habitatmodelle (das sind vor allem Gruppen, die Grünlandarten enthalten) konnte eine konsistente Reaktion von SLA und Wuchshöhe auf Störungsfrequenz und –intensität festgestellt werden. Relativ kurze Intervalle zwischen oberirdischen Störungen (meist handelt es sich um zweimalige Mahd oder Mahd und spätere Beweidung) führen zu geringen Wuchshöhen und steigenden SLA–Werten. Da die Biomasse regelmäßig entfernt wird, gibt es keine Notwendigkeit für die Pflanzen, in Stützgewebe zu investieren, da ausreichend Licht verfügbar ist. Im Gegensatz dazu führen lange Störungsintervalle zum Vorkommen hoher verholzter Arten mit geringen SLA–Werten.

An der Müritz wurden 53 ‘responsive species’ ermittelt, von denen 48 in 9 PFGs enthalten waren. Die sparsamste Merkmalskombination bestand aus Aerenchym, mechanischer Abwehr mittels Dornen oder Stacheln, Lage der Ausläufer, Wuchshöhe und Lebensdauer der Diasporen (SLI). Aerenchyme als stresstolerantes Merkmal teilen die PFGs in solche, die ständig oder zeitweise wasserüberstaute Böden besiedeln und in solche trockener Standorte. Die mechanische Abwehr ist aufgrund des Bewirtschaftungsregimes ein weiteres Persistenzmerkmal von Bedeutung, da es Fraß verhindert. Wuchshöhe ist erneut Teil der Merkmalskombination und hebt wiederum die Nutzung von Ressourcen hervor. In diesem Fall ist SLI als Reproduktionsmerkmal vertreten, allerdings ist diese Eigenschaft auch an der Müritz eher unbedeutend verglichen mit den Persistenzmerkmalen, da es sich auch hier hauptsächlich um Grünland mit einer geschlossenen Vegetationsdecke handelt. Durch extensive Beweidung treten unterirdische Störungen nur sehr selten und kleinräumig auf, was dazu führt, dass die generative Reproduktion weniger erfolgreich stattfindet als die vegetative durch ober– und unterirdische Ausläufer. Das Vorkommen aller PFGs ist abhängig von der Beweidungsintensität (GI), die meisten Gruppen reagierten besonders empfindlich auf Beweidung im Winter. Das bedeutet, dass die natürliche Sukzession besonders in den Wintermonaten, wenn das Futter nicht nachwächst und knapp wird, durch Beweidung unterdrückt oder gar umgekehrt wird. Die Beziehungen zwischen Umweltgradienten und Pflanzenmerkmalen lassen sich eine starke Funktionalität bei den Aerenchymen feststellen, die bei zeitweise oder ständig wasserüberstauten Bedingungen zu finden sind. Die GI wird stark durch den Wasserstand beeinflusst, nasse Standorte werden wenig befressen. Ausreichend Wasser und Ablehnung durch Herbivore wegen hohen Wasserstandes, aber auch wegen physikalischer Abwehrmechanismen führen zu großen Wuchshöhen. Desweiteren wurde eine starke Beziehung zwischen SLI und GI festgestellt: hohe GI geht einher mit langer Diasporen–Lebensdauer.

Beide der oben dargestellten Analysen betrachten lediglich kurze Teilstücke der möglichen Umweltgradienten. Daher sind die ermittelten Merkmale auch nur bedeutsam für eines der betrachteten Gebiete. Jedoch sind unter diesen Eigenschaften möglicherweise solche, die grundlegend wichtig für das Vorkommen von

PFGs sind. Um diese zu ermitteln, wurde eine dritte Analyse an einem großen Datensatz aus beiden Untersuchungsgebieten und damit einem erweiterten Umweltgradienten durchgeführt. 15 PFGs wurden ermittelt, die 88 von 93 'responsive species' enthielten. Jeweils 5 gut kalibrierte PFGs wurden sowohl für die Müritz als auch für die Hassberge gefunden, sie unterschieden sich im Vorhandensein oder Fehlen von Aerenchymen. Eine weitere Gruppe enthielt Arten, die für beide Untersuchungsgebiete vorhergesagt wurden. Die 7 ermittelten fundamentalen Merkmale der sparsamsten Kombination waren Aerenchym, andere physikalische Abwehrmechanismen als Dornen und Stacheln, Verholzung der Sprossachse, Lage der Ausläufer, SLI, SLA und Wuchshöhe. Wie für die einzelnen Untersuchungsgebiete, so wurden auch hier Persistenzmerkmale als die wichtigsten ermittelt. Insbesondere Aerenchyme zeigen eine hohe Funktionalität, da sie nasse Lebensräume von trockenen trennen. Die meisten PFGs reagieren auf die Menge des effektiv verfügbaren Wassers (d.h. die Menge an Wasser, die Pflanzen in Abhängigkeit von klimatischen, topografischen und Bodenparametern effektiv zur Verfügung steht). Der wichtigste Störungsfaktor ist die Häufigkeit der Eingriffe. Dies spiegelt sich vor allem in SLA, Wuchshöhe und Verholzung der Sprossachse wider. Häufige Störungen führen zu hohen SLA–Werten und geringen Wuchshöhen. Verholzte Sprossachsen treten bei geringer Störungshäufigkeit auf. Zusammenfassend kann für die allgemeine Analyse gesagt werden, dass das Auftreten der PFGs in den untersuchten Gebieten hauptsächlich von der Störungshäufigkeit und dem effektiv verfügbaren Wasser abhängt. Die grundlegenden funktionalen Merkmale sind Aerenchym, das trockene von nassen Lebensräumen trennt, SLA, Wuchshöhe und Verholzung der Sprossachse, die hohe oder geringe Störungshäufigkeit widerspiegeln, andere physikalische Abwehrmechanismen als Dornen und Stacheln, die die Bedeutung solcher Strukturen gegen Herbivorie hervorheben, sowie die Lage der Ausläufer und SLI, die die Wichtigkeit der vegetativen Regeneration in den hauptsächlich oberirdisch gestörten Lebensräumen unterstreichen.

In der Sukzessionsreihe der Hassberge verschwinden Arten lokal durch ungeeignete Umweltbedingungen in Abhängigkeit von Störungsfrequenz und –intensität. Somit gibt es ein lokales Aussterberisiko für die typische Flora. Allerdings ist die derzeitige Mahd geeignet, den regionalen Artenpool des offenen Grünlandes zu erhalten und dem Aufwuchs von Sträuchern vorzubeugen. Für das Fräsen als neue Managementmaßnahme kann keine klare Aussage bezüglich des Erhalts der Flora gemacht werden, da die Methode erst ein einziges Mal auf etablierten Grünlandstandorten angewandt wurde und keine Wiederholung stattfand. Daher konnten sich noch keine angepassten Pflanzengesellschaften entwickeln. Allerdings zeigte die Datenanalyse, dass die meisten Grünlandarten abhängig von regelmäßigen oberirdischen Störungen sind (z.B. Mahd und/oder Beweidung). Dies führt zu geschlossenen Vegetationsdecken unter denen vegetative Reproduktion wichtig ist. Die Lebensdauer der Diasporen ist gering. Häufige Störungen durch Fräsen (d.h. alle 1 bis 3 Jahre) werden bald zu einer Erschöpfung der ohnehin kleinen Diasporenbank führen. Desweiteren wird die wiederholte Schädigung adulter Individuen nicht genügend Zeit für eine ausreichende Regeration nach der unterirdischen Störung geben. Beide Faktoren werden letztendlich zum Aussterben der Populationen führen. Im Gegensatz dazu resultieren geringe Fräshäufigkeiten in verstärktem Aufwuchs konkurrenzstarker Büsche, womit sich die Lichtbedingungen verändern und die typischen Grünlandarten auf lange Sicht verschwinden. In Anlehnung an diese Ergebnisse kann Fräsen nicht als Alternative zur konventionellen Mahd empfohlen werden. Um jedoch die Kosten der Mahd zu senken, könnte abwechselnd jährlich und jedes zweite Jahr gemäht werden.

Permanente Standweiden mit geringer Besatzdichte bieten dagegen ein völlig anderes Bild. Unterschiedliche Beweidungsintensitäten führten zu einem kleinräumigen Vegetationsmosaik, das von intensiv beweideten bis zu gemiedenen verbuschten oder nassen Bereichen reicht. Das schon lange etablierte Beweidungsmanagement an der Müritz schuf artenreiche Pflanzengesellschaften in Lebensräumen von unterschiedlicher raum–zeitlicher Qualität. Beweidungsintensität und Vernässung sind hier die wichtigsten Faktoren für das Fortschreiten der natürlichen Sukzession und das Auftreten von PFGs, wobei insbesondere die Beweidung im Winter zu einer erheblichen Schädigung führt und die Biomasse in großen Teilen zu 100% verbissen wird. Die Weidetiere meiden ständig überflutete Bereiche, was aber auch an physikalischen Abwehrmechanismen und geringem Nährstoffgehalt der dort vorkommenden Arten liegt. Permanente extensive Beweidung kann ausdrücklich als Alternative zur konventionellen Mahd empfohlen werden. Dabei ist eine Beweidung durch mehrere Tierarten, wie sie an der Müritz stattfindet, besonders effektiv, da verschiedene Herbivore unterschiedliche Pflanzenarten oder –gesellschaften bevorzugen und die Pflanzen durch unterschiedliche Maulgröße auf verschiedene Art und Weise geschädigt werden.

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APPENDIX

Appendix

The appendix can be found on the attached CD. It contains the following tables in PDF–format:

Appendix Table 1:	Values for seed number and seed weight.
Appendix Table 2:	Hassberge: Site x species matrix.
Appendix Table 3:	Hassberge: Site x environmental parameters matrix.
Appendix Table 4:	Hassberge: Species x trait matrix.
Appendix Table 5:	Hassberge: Species codes.
Appendix Table 6:	Müritz: Site x species matrix.
Appendix Table 7:	Müritz: Site x environmental parameters matrix.
Appendix Table 8:	Müritz: Species x trait matrix.
Appendix Table 9:	Müritz: Species codes.
Appendix Table 10:	Hassberge: Sensitivity of responsive species to environmental factors.
Appendix Table 11:	Hassberge: Plant functional groups with statistical values and their species with traits.
Appendix Table 12:	Müritz: Sensitivity of responsive species to environmental factors.
Appendix Table 13:	Müritz: Plant functional groups with statistical values and their species with traits.
Appendix Table 14:	Hassberge and Müritz: Species x trait matrix.
Appendix Table 15:	Hassberge and Müritz: Site x species matrix.
Appendix Table 16:	Hassberge and Müritz: Site x environmental parameters matrix.
Appendix Table 17:	Hassberge and Müritz: Species codes.
Appendix Table 18:	Hassberge and Müritz: Plant functional groups with statistical values and their species with traits.
Appendix Table 19:	Regression coefficients and goodness of fit measures for the responsive species.

Appendix Table 1: Values for seed number and seed weight. (*seeds unripe or destroyed due to predation, 1=only seed number recorded for the Hassberge)

No.	**species**	**inflorescences per ramet**	**number of weighed seeds**	**seed weight per seed [mg]**	**seed number per ramet**
1	*Achillea millefolium*	1	338	0.132	745
2	*Achillea millefolium*	1	35	0.102	219
3	*Achillea millefolium*	1	115	0.134	326
4	*Achillea millefolium*	1	316	0.151	316
5	*Achillea millefolium*	1	491	0.155	949
6	*Achillea millefolium*	1	98	0.123	421
1	*Agropyron repens*	1	25	2.420	16
2	*Agropyron repens*	1	6	0.958	16
3	*Agropyron repens*	1	11	2.325	16
4	*Agropyron repens*	1	3	1.820	18
5	*Agropyron repens*	1	4	0.770	14
6	*Agropyron repens*	1	8	2.094	17
1	*Agrostis capillaris*	1	55	0.038	60
2	*Agrostis capillaris*	1	71	0.003	71
3	*Agrostis capillaris*	1	100	0.049	100
4	*Agrostis capillaris*	1	115	0.078	120
5	*Agrostis capillaris*	1	120	0.005	120
6	*Agrostis capillaris*	1	190	0.044	190
1	*Agrostis stolonifera*	1	6	0.053	860
2	*Agrostis stolonifera*	1	114	0.084	492
3	*Agrostis stolonifera*	1	85	0.081	642
4	*Agrostis stolonifera*	1	101	0.099	791
5	*Agrostis stolonifera*	1	272	0.044	272
6	*Agrostis stolonifera*	1	205	0.013	205
1	*Anthoxanthum odoratum*	1	6	0.203	59
2	*Anthoxanthum odoratum*	1	46	0.041	84
3	*Anthoxanthum odoratum*	1	25	0.386	63
4	*Anthoxanthum odoratum*	1	*	*	0
5	*Anthoxanthum odoratum*	1	*	*	0
6	*Anthoxanthum odoratum*	1	*	*	0
1	*Armeria maritima* spp. *maritima*	1	11	0.657	74
2	*Armeria maritima* spp. *maritima*	1	16	0.711	80
3	*Armeria maritima* spp. *maritima*	1	4	0.533	48
4	*Armeria maritima* spp. *maritima*	1	9	0.836	96
5	*Armeria maritima* spp. *maritima*	1	47	1.853	72
6	*Armeria maritima* spp. *maritima*	1	64	1.563	64
1	*Avenula pubescens*	1	3	0.637	68
2	*Avenula pubescens*	1	2	0.540	29
3	*Avenula pubescens*	1	*	*	0
4	*Avenula pubescens*	1	*	*	0
5	*Avenula pubescens*	1	*	*	0
6	*Avenula pubescens*	1	*	*	0
1	*Brachypodium pinnatum* [1]	1	-	-	97
2	*Brachypodium pinnatum* [1]	1	-	-	83
3	*Brachypodium pinnatum* [1]	1	-	-	91
4	*Brachypodium pinnatum* [1]	1	-	-	60
5	*Brachypodium pinnatum* [1]	1	-	-	72
6	*Brachypodium pinnatum* [1]	1	-	-	97
1	*Briza media*	1	24	0.219	24
2	*Briza media*	1	23	0.180	37
3	*Briza media*	1	5	0.248	8
4	*Briza media*	1	5	0.234	7
5	*Briza media*	1	3	0.333	13
6	*Briza media*	1	9	0.368	19

Appendix Table 1 continued.

No.	species	inflorescences per ramet	number of weighed seeds	seed weight per seed [mg]	seed number per ramet
1	*Bromus hordeaceus*	1	38	1.201	42
2	*Bromus hordeaceus*	1	41	2.256	47
3	*Bromus hordeaceus*	1	69	1.470	69
4	*Bromus hordeaceus*	1	31	0.176	40
5	*Bromus hordeaceus*	1	22	3.496	66
6	*Bromus hordeaceus*	1	22	1.668	22
1	*Bromus erectus*[1]	1	-	-	85
2	*Bromus erectus*[1]	1	-	-	73
3	*Bromus erectus*[1]	1	-	-	101
4	*Bromus erectus*[1]	1	-	-	152
5	*Bromus erectus*[1]	1	-	-	36
6	*Bromus erectus*[1]	1	-	-	51
1	*Bromus sterilis*[1]	1	-	-	108
2	*Bromus sterilis*[1]	1	-	-	164
3	*Bromus sterilis*[1]	1	-	-	121
4	*Bromus sterilis*[1]	1	-	-	112
5	*Bromus sterilis*[1]	1	-	-	145
6	*Bromus sterilis*[1]	1	-	-	178
1	*Bupleurum falcatum*[1]	8	-	-	568
2	*Bupleurum falcatum*[1]	32	-	-	3168
3	*Bupleurum falcatum*[1]	5	-	-	375
4	*Bupleurum falcatum*[1]	whole plant	-	-	196
5	*Bupleurum falcatum*[1]	whole plant	-	-	596
6	*Bupleurum falcatum*[1]	13	-	-	1027
1	*Calamagrostis epigejos*	1	*	*	1510
2	*Calamagrostis epigejos*	1	*	*	2100
3	*Calamagrostis epigejos*	1	*	*	4985
4	*Calamagrostis epigejos*	1	*	*	2570
5	*Calamagrostis epigejos*	1	*	*	6110
6	*Calamagrostis epigejos*	1	5	0.118	2028
1	*Calamagrostis stricta*	1	7	0.156	293
2	*Calamagrostis stricta*	1	2	0.180	485
3	*Calamagrostis stricta*	1	11	0.158	538
4	*Calamagrostis stricta*	1	59	0.202	902
5	*Calamagrostis stricta*	1	6	0.235	430
6	*Calamagrostis stricta*	1	7	0.213	477
1	*Capsella bursa-pastoris*	205	80	0.057	3342
2	*Capsella bursa-pastoris*	87	40	0.114	853
3	*Capsella bursa-pastoris*	94	100	0.107	2435
4	*Capsella bursa-pastoris*	208	60	0.116	3536
5	*Capsella bursa-pastoris*	12	90	0.101	188
6	*Capsella bursa-pastoris*	50	70	0.114	675
1	*Carex arenaria*	1	25	0.512	90
2	*Carex arenaria*	1	15	0.553	57
3	*Carex arenaria*	1	34	0.477	88
4	*Carex arenaria*	1	12	0.606	52
5	*Carex arenaria*	1	35	0.549	69
6	*Carex arenaria*	1	10	0.493	44
1	*Carex disticha*	1	30	0.540	262
2	*Carex disticha*	1	30	0.461	252
3	*Carex disticha*	1	*	*	251
4	*Carex disticha*	1	*	*	183
5	*Carex disticha*	1	*	*	93
6	*Carex disticha*	1	*	*	274

Appendix Table 1 continued.

No.	species	inflorescences per ramet	number of weighed seeds	seed weight per seed [mg]	seed number per ramet
1	*Carex flacca*	1	*	*	292
2	*Carex flacca*	1	115	0.772	119
3	*Carex flacca*	1	118	0.593	121
4	*Carex flacca*	1	146	0.634	154
5	*Carex flacca*	1	227	0.777	227
6	*Carex flacca*	1	257	0.885	257
1	*Carex hirta*	1	34	2.050	38
2	*Carex hirta*	1	23	2.015	35
3	*Carex hirta*	1	7	3.000	21
4	*Carex hirta*	1	14	2.421	15
5	*Carex hirta*	1	25	2.000	29
6	*Carex hirta*	1	48	1.898	70
1	*Carex nigra*	1	12	0.596	156
2	*Carex nigra*	1	12	0.828	175
3	*Carex nigra*	1	2	0.545	114
4	*Carex nigra*	1	12	0.809	82
5	*Carex nigra*	1	14	0.607	199
6	*Carex nigra*	1	14	0.693	147
1	*Carex panicea*	1	23	2.050	23
2	*Carex panicea*	1	13	0.866	19
3	*Carex panicea*	1	21	1.928	28
4	*Carex panicea*	1	*	*	43
5	*Carex panicea*	1	*	*	23
6	*Carex panicea*	1	*	*	25
1	*Centaurea jacea*	9	17	2.115	351
2	*Centaurea jacea*	8	30	2.138	376
3	*Centaurea jacea*	8	5	1.700	456
4	*Centaurea jacea*	6	8	1.975	228
5	*Centaurea jacea*	10	*	*	200
6	*Centaurea jacea*	11	26	1.062	286
1	*Cerastium arvense*	1	33	0.129	91
2	*Cerastium arvense*	1	87	0.197	245
3	*Cerastium arvense*	1	50	0.152	443
4	*Cerastium arvense*	1	23	0.198	158
5	*Cerastium arvense*	1	80	0.146	375
6	*Cerastium arvense*	5	15	0.107	125
1	*Cerastium brachypetalum* [1]	85	-	-	5568
2	*Cerastium brachypetalum* [1]	7	-	-	270
3	*Cerastium brachypetalum* [1]	19	-	-	1058
4	*Cerastium brachypetalum* [1]	6	-	-	282
5	*Cerastium brachypetalum* [1]	26	-	-	936
6	*Cerastium brachypetalum* [1]	11	-	-	396
1	*Cerastium glomeratum*	19	57	0.113	393
2	*Cerastium glomeratum*	12	70	0.070	536
3	*Cerastium glomeratum*	25	41	0.106	938
4	*Cerastium glomeratum*	20	*	*	833
5	*Cerastium glomeratum*	26	*	*	806
6	*Cerastium glomeratum*	30	9	0.056	1058
1	*Cirsium arvense*	36	40	0.072	1656
2	*Cirsium arvense*	21	43	0.470	903
3	*Cirsium arvense*	15	47	0.436	705
4	*Cirsium arvense*	13	69	1.138	897
5	*Cirsium arvense*	10	75	1.241	750
6	*Cirsium arvense*	10	83	0.943	830

Appendix Table 1 continued.

No.	species	inflorescences per ramet	number of weighed seeds	seed weight per seed [mg]	seed number per ramet
1	*Cirsium palustre*	8	9	0.699	128
2	*Cirsium palustre*	35	*	*	1820
3	*Cirsium palustre*	20	24	0.981	580
4	*Cirsium palustre*	21	*	*	1239
5	*Cirsium palustre*	12	*	*	720
6	*Cirsium palustre*	9	*	*	396
1	*Cladium mariscus*	1	100	1.287	2329
2	*Cladium mariscus*	1	100	1.268	2393
3	*Cladium mariscus*	1	540	3.310	800
4	*Cladium mariscus*	1	576	2.552	992
5	*Cladium mariscus*	1	1040	3.183	1070
6	*Cladium mariscus*	1	1419	2.537	2036
1	*Convolvulus arvensis*	12	4	9.013	28
2	*Convolvulus arvensis*	18	9	11.874	60
3	*Convolvulus arvensis*	8	6	8.880	14
4	*Convolvulus arvensis*	10	8	8.673	25
5	*Convolvulus arvensis*	6	6	12.487	12
6	*Convolvulus arvensis*	14	1	16.720	45
1	*Cynosurus cristatus*	1	193	0.035	212
2	*Cynosurus cristatus*	1	28	0.540	145
3	*Cynosurus cristatus*	1	2	0.300	187
4	*Cynosurus cristatus*	1	39	0.428	44
5	*Cynosurus cristatus*	1	46	0.574	96
6	*Cynosurus cristatus*	1	46	0.600	151
1	*Dactylis glomerata*	1	20	0.737	810
2	*Dactylis glomerata*	1	5	0.724	900
3	*Dactylis glomerata*	1	2	0.490	810
4	*Dactylis glomerata*	1	2	0.545	420
5	*Dactylis glomerata*	1	6	0.745	309
6	*Dactylis glomerata*	1	6	0.817	1377
1	*Danthonia decumbens*	1	100	0.704	24
2	*Danthonia decumbens*	1	*	*	18
3	*Danthonia decumbens*	1	*	*	15
4	*Danthonia decumbens*	1	*	*	25
5	*Danthonia decumbens*	1	*	*	23
6	*Danthonia decumbens*	1	*	*	27
1	*Daucus carota*	6	100	0.929	414
2	*Daucus carota*	6	100	0.118	624
3	*Daucus carota*	6	100	0.952	2118
4	*Daucus carota*	2	100	0.810	950
5	*Daucus carota*	6	230	1.083	1446
6	*Daucus carota*	6	536	1.047	3450
1	*Deschampsia cespitosa*	1	62	0.275	994
2	*Deschampsia cespitosa*	1	51	0.325	530
3	*Deschampsia cespitosa*	1	160	0.278	983
4	*Deschampsia cespitosa*	1	40	0.133	60
5	*Deschampsia cespitosa*	1	135	0.235	165
6	*Deschampsia cespitosa*	1	171	0.204	185
1	*Eleocharis uniglumis*	1	265	0.585	30
2	*Eleocharis uniglumis*	1	100	0.771	18
3	*Eleocharis uniglumis*	1	*	*	18
4	*Eleocharis uniglumis*	1	*	*	9
5	*Eleocharis uniglumis*	1	*	*	25
6	*Eleocharis uniglumis*	1	*	*	45

Appendix Table 1 continued.

No.	species	inflorescences per ramet	number of weighed seeds	seed weight per seed [mg]	seed number per ramet
1	*Erodium cicutarium*	28	9	0.502	140
2	*Erodium cicutarium*	25	*	*	125
3	*Erodium cicutarium*	31	*	*	31
4	*Erodium cicutarium*	22	*	*	15
5	*Erodium cicutarium*	30	*	*	30
6	*Erodium cicutarium*	33	*	*	77
1	*Falcaria vulgaris*	5	28	1.860	880
2	*Falcaria vulgaris*	32	48	1.733	8192
3	*Falcaria vulgaris*	45	16	1.833	8550
4	*Falcaria vulgaris*	35	22	2.070	4760
5	*Falcaria vulgaris*	10	33	1.558	3180
6	*Falcaria vulgaris*	6	39	1.597	1032
1	*Festuca ovina* agg.	1	33	0.592	89
2	*Festuca ovina* agg.	1	60	0.792	103
3	*Festuca ovina* agg.	1	19	0.852	69
4	*Festuca ovina* agg.	1	64	0.754	109
5	*Festuca ovina* agg.	1	13	0.612	92
6	*Festuca ovina* agg.	1	31	0.657	77
1	*Festuca pratensis*	1	18	1.434	108
2	*Festuca pratensis*	1	27	1.524	91
3	*Festuca pratensis*	1	10	1.730	105
4	*Festuca pratensis*	1	6	1.620	78
5	*Festuca pratensis*	1	30	1.481	81
6	*Festuca pratensis*	1	26	0.861	46
1	*Festuca rubra*	1	11	0.700	57
2	*Festuca rubra*	1	3	0.800	80
3	*Festuca rubra*	1	3	0.937	120
4	*Festuca rubra*	1	22	0.649	80
5	*Festuca rubra*	1	10	0.143	45
6	*Festuca rubra*	1	17	0.262	105
1	*Galium aparine*[1]	123	-	-	246
2	*Galium aparine*[1]	163	-	-	326
3	*Galium aparine*[1]	64	-	-	128
4	*Galium aparine*[1]	54	-	-	108
5	*Galium aparine*[1]	57	-	-	114
6	*Galium aparine*[1]	109	-	-	218
1	*Galium mollugo*	194	156	0.399	388
2	*Galium mollugo*	530	77	0.523	1060
3	*Galium mollugo*	310	81	0.505	620
4	*Galium mollugo*	352	74	0.423	704
5	*Galium mollugo*	273	535	0.307	546
6	*Galium mollugo*	167	233	0.395	334
1	*Galium palustre*	379	16	1.179	758
2	*Galium palustre*	361	16	1.051	722
3	*Galium palustre*	431	16	1.001	862
4	*Galium palustre*	264	32	1.269	528
5	*Galium palustre*	255	20	1.543	510
6	*Galium palustre*	246	15	1.334	492
1	*Galium uliginosum*	289	60	0.203	578
2	*Galium uliginosum*	708	150	0.227	1416
3	*Galium uliginosum*	156	40	0.184	312
4	*Galium uliginosum*	324	20	0.247	648
5	*Galium uliginosum*	96	192	0.014	192
6	*Galium uliginosum*	69	137	0.137	138

Appendix Table 1 continued.

No.	species	inflorescences per ramet	number of weighed seeds	seed weight per seed [mg]	seed number per ramet
1	*Galium verum*	457	33	0.185	914
2	*Galium verum*	1369	138	0.314	2738
3	*Galium verum*	798	16	0.292	1596
4	*Galium verum*	1681	21	0.366	3362
5	*Galium verum*	457	62	1.380	914
6	*Galium verum*	103	205	0.413	206
1	*Genista tinctoria*	25	3	1.717	60
2	*Genista tinctoria*	12	10	1.590	30
3	*Genista tinctoria*	9	21	2.762	35
4	*Genista tinctoria*	15	5	2.220	15
5	*Genista tinctoria*	10	7	2.614	14
6	*Genista tinctoria*	10	22	3.750	37
1	*Gentianella uliginosa*	7	34	0.150	238
2	*Gentianella uliginosa*	7	43	0.105	301
3	*Gentianella uliginosa*	4	76	0.133	304
4	*Gentianella uliginosa*	13	158	0.146	685
5	*Gentianella uliginosa*	7	350	0.133	613
6	*Gentianella uliginosa*	10	220	0.080	550
1	*Holcus lanatus*	1	6	0.212	195
2	*Holcus lanatus*	1	53	0.111	53
3	*Holcus lanatus*	1	10	0.130	188
4	*Holcus lanatus*	1	55	0.162	58
5	*Holcus lanatus*	1	93	0.237	125
6	*Holcus lanatus*	1	52	0.140	114
1	*Hydrocotyle vulgaris*	1	12	0.240	32
2	*Hydrocotyle vulgaris*	1	*	*	16
3	*Hydrocotyle vulgaris*	1	*	*	20
4	*Hydrocotyle vulgaris*	1	*	*	26
5	*Hydrocotyle vulgaris*	1	*	*	26
1	*Juncus articulatus*	10	232	0.005	2320
2	*Juncus articulatus*	12	128	0.017	1776
3	*Juncus articulatus*	19	374	0.016	7581
4	*Juncus articulatus*	1	1604	0.024	1711
5	*Juncus articulatus*	14	263	0.023	4172
6	*Juncus articulatus*	1	629	0.022	1495
1	*Juniperus communis*	220	24	17.372	220
2	*Juniperus communis*	300	18	16.169	300
3	*Juniperus communis*	250	15	12.718	250
4	*Juniperus communis*	200	52	11.868	200
5	*Juniperus communis*	250	15	12.715	250
6	*Juniperus communis*	120	18	7.956	120
1	*Lathyrus pratensis*	8	6	11.858	48
2	*Lathyrus pratensis*	6	*	*	48
3	*Lathyrus pratensis*	11	9	14.720	58
4	*Lathyrus pratensis*	47	17	9.965	341
5	*Lathyrus pratensis*	35	10	15.391	289
6	*Lathyrus pratensis*	41	13	15.138	226
1	*Leontodon autumnalis*	4	13	0.268	200
2	*Leontodon autumnalis*	3	24	0.225	72
3	*Leontodon autumnalis*	3	34	0.447	102
4	*Leontodon autumnalis*	6	45	0.207	270
5	*Leontodon autumnalis*	4	53	0.177	212
6	*Leontodon autumnalis*	5	75	0.348	375

Appendix Table 1 continued.

No.	species	inflorescences per ramet	number of weighed seeds	seed weight per seed [mg]	seed number per ramet
1	*Leontodon hispidus*	1	*	*	98
2	*Leontodon hispidus*	1	32	0.793	86
3	*Leontodon hispidus*	1	22	0.227	22
4	*Leontodon hispidus*	2	32	0.334	66
5	*Leontodon hispidus*	5	72	0.092	360
6	*Leontodon hispidus*	1	99	0.385	99
1	*Linum catharticum*	11	48	0.086	77
2	*Linum catharticum*	15	64	0.163	102
3	*Linum catharticum*	15	77	0.095	105
4	*Linum catharticum*	10	17	0.076	57
5	*Linum catharticum*	11	24	0.104	84
6	*Linum catharticum*	14	29	0.117	81
1	*Lolium perenne*	1	3	0.300	17
2	*Lolium perenne*	1	31	1.368	31
3	*Lolium perenne*	1	49	1.735	52
4	*Lolium perenne*	1	63	1.017	66
5	*Lolium perenne*	1	76	1.245	76
6	*Lolium perenne*	1	57	1.404	103
1	*Lotus corniculatus*	18	37	0.418	234
2	*Lotus corniculatus*	7	23	1.074	158
3	*Lotus corniculatus*	3	9	0.898	50
4	*Lotus corniculatus*	39	46	1.073	449
5	*Lotus corniculatus*	10	36	0.444	183
6	*Lotus corniculatus*	17	44	0.425	187
1	*Lotus uliginosus*	24	40	0.520	344
2	*Lotus uliginosus*	12	7	0.567	156
3	*Lotus uliginosus*	8	*	*	32
4	*Lotus uliginosus*	10	27	0.556	270
5	*Lotus uliginosus*	12	102	0.315	102
1	*Luzula campestris*	1	44	0.576	49
2	*Luzula campestris*	1	23	0.435	32
3	*Luzula campestris*	1	62	0.768	63
4	*Luzula campestris*	1	53	0.554	63
5	*Luzula campestris*	1	70	0.438	79
6	*Luzula campestris*	1	193	0.246	194
1	*Medicago lupulina*	6	18	0.795	108
2	*Medicago lupulina*	3	21	1.071	63
3	*Medicago lupulina*	9	24	1.196	216
4	*Medicago lupulina*	6	24	1.225	144
5	*Medicago lupulina*	7	27	1.781	238
6	*Medicago lupulina*	5	62	1.277	155
1	*Mentha aquatica*	3	222	0.112	666
2	*Mentha aquatica*	3	45	0.076	135
3	*Mentha aquatica*	3	57	0.058	171
4	*Mentha aquatica*	3	182	0.074	546
5	*Mentha aquatica*	3	190	0.119	570
6	*Mentha aquatica*	3	253	0.152	759
1	*Molinia caerulea*	1	344	0.215	344
2	*Molinia caerulea*	1	50	0.190	55
3	*Molinia caerulea*	1	197	0.266	812
4	*Molinia caerulea*	1	173	0.491	497
5	*Molinia caerulea*	1	91	0.154	91
6	*Molinia caerulea*	1	680	0.288	680

Appendix Table 1 continued.

No.	species	inflorescences per ramet	number of weighed seeds	seed weight per seed [mg]	seed number per ramet
1	*Odontites vulgaris*	238	50	0.182	4046
2	*Odontites vulgaris*	213	22	0.295	2876
3	*Odontites vulgaris*	142	67	0.131	2379
4	*Odontites vulgaris*	198	82	0.117	3247
5	*Odontites vulgaris*	177	253	0.179	2985
6	*Odontites vulgaris*	167	420	0.158	2733
1	*Parnassia palustris*	2	640	0.023	2148
2	*Parnassia palustris*	3	367	0.018	1101
3	*Parnassia palustris*	2	570	0.015	1140
4	*Parnassia palustris*	4	1060	0.035	4240
5	*Parnassia palustris*	2	1200	0.047	2400
6	*Parnassia palustris*	1	800	0.024	800
1	*Phragmites australis*	1	17	0.162	579
2	*Phragmites australis*	1	*	*	1064
3	*Phragmites australis*	1	*	*	1167
4	*Phragmites australis*	1	14	0.093	1400
5	*Phragmites australis*	1	19200	0.068	19200
6	*Phragmites australis*	1	1100	0.157	1100
1	*Pinguicula vulgaris*	1	450	0.015	450
2	*Pinguicula vulgaris*	1	117	0.009	117
3	*Pinguicula vulgaris*	2	190	0.023	460
4	*Pinguicula vulgaris*	1	62	0.018	62
5	*Pinguicula vulgaris*	1	52	0.014	52
6	*Pinguicula vulgaris*	1	211	0.019	213
1	*Plantago lanceolata*	4	30	1.366	272
2	*Plantago lanceolata*	4	26	1.050	104
3	*Plantago lanceolata*	3	41	0.593	123
4	*Plantago lanceolata*	4	58	0.652	232
5	*Plantago lanceolata*	3	60	1.025	180
6	*Plantago lanceolata*	3	62	1.029	186
1	*Poa annua*	1	38	0.279	57
2	*Poa annua*	1	8	0.179	188
3	*Poa annua*	1	31	0.275	31
4	*Poa annua*	1	7	0.263	57
5	*Poa annua*	1	19	0.288	60
6	*Poa annua*	1	22	0.277	22
1	*Poa pratensis* agg.	1	2	0.295	528
2	*Poa pratensis* agg.	1	44	0.254	372
3	*Poa pratensis* agg.	1	4	0.315	387
4	*Poa pratensis* agg.	1	15	0.349	294
5	*Poa pratensis* agg.	1	81	0.037	228
6	*Poa pratensis* agg.	1	23	0.131	317
1	*Poa trivialis*	1	553	0.158	266
2	*Poa trivialis*	1	*	*	158
3	*Poa trivialis*	1	*	*	163
4	*Poa trivialis*	1	*	*	184
5	*Poa trivialis*	1	*	*	243
6	*Poa trivialis*	1	17	0.162	191
1	*Polygala vulgaris*	28	*	*	56
2	*Polygala vulgaris*	23	*	*	46
3	*Polygala vulgaris*	30	*	*	60
4	*Polygala vulgaris*	34	*	*	68
5	*Polygala vulgaris*	19	*	*	38
6	*Polygala vulgaris*	11	13	2.208	22

Appendix Table 1 continued.

No.	species	inflorescences per ramet	number of weighed seeds	seed weight per seed [mg]	seed number per ramet
1	*Potentilla anserina*	1	16	0.650	18
2	*Potentilla anserina*	1	8	0.788	16
3	*Potentilla anserina*	1	10	0.330	10
4	*Potentilla anserina*	1	14	0.729	14
5	*Potentilla anserina*	1	18	0.989	18
6	*Potentilla anserina*	1	10	0.710	10
1	*Potentilla erecta*	10	9	0.211	130
2	*Potentilla erecta*	7	10	0.400	35
3	*Potentilla erecta*	10	20	0.415	133
4	*Potentilla erecta*	20	34	0.382	109
5	*Potentilla erecta*	100	57	0.018	1900
1	*Potentilla neumanniana* [1]	12	-	-	124
2	*Potentilla neumanniana* [1]	10	-	-	138
3	*Potentilla neumanniana* [1]	16	-	-	176
4	*Potentilla neumanniana* [1]	20	-	-	490
5	*Potentilla neumanniana* [1]	9	-	-	87
1	*Potentilla reptans*	2	9	0.466	179
2	*Potentilla reptans*	1	42	0.278	70
3	*Potentilla reptans*	1	31	0.329	95
4	*Potentilla reptans*	1	95	0.235	95
5	*Potentilla reptans*	1	58	0.307	58
6	*Potentilla reptans*	1	64	0.308	64
1	*Prunella vulgaris*	4	20	1.932	428
2	*Prunella vulgaris*	3	344	0.622	405
3	*Prunella vulgaris*	4	92	0.520	568
4	*Prunella vulgaris*	7	168	0.497	1876
5	*Prunella vulgaris*	3	14	0.586	312
6	*Prunella vulgaris*	3	36	0.792	168
1	*Prunus spinosa*	80	10	389.234	80
2	*Prunus spinosa*	200	10	370.453	200
3	*Prunus spinosa*	100	10	437.353	100
4	*Prunus spinosa*	25	10	506.493	25
5	*Prunus spinosa*	150	10	432.140	150
1	*Ranunculus acris*	23	77	3.818	590
2	*Ranunculus acris*	3	10	0.600	30
3	*Ranunculus acris*	3	15	0.840	45
4	*Ranunculus acris*	5	25	0.808	125
5	*Ranunculus acris*	8	52	0.098	208
6	*Ranunculus acris*	3	20	0.815	60
1	*Ranunculus flammula*	48	*	*	984
2	*Ranunculus flammula*	96	*	*	1968
3	*Ranunculus flammula*	81	*	*	1863
4	*Ranunculus flammula*	51	*	*	1326
5	*Ranunculus flammula*	72	*	*	1800
6	*Ranunculus flammula*	30	66	0.102	495
1	*Ranunculus repens*	4	38	2.626	180
2	*Ranunculus repens*	3	*	*	27
3	*Ranunculus repens*	3	*	*	36
4	*Ranunculus repens*	3	3	0.997	54
5	*Ranunculus repens*	3	*	*	27
6	*Ranunculus repens*	3	*	*	36

Appendix Table 1 continued.

No.	species	inflorescences per ramet	number of weighed seeds	seed weight per seed [mg]	seed number per ramet
1	*Rhinanthus serotinus*	92	160	1.744	1518
2	*Rhinanthus serotinus*	59	*	*	708
3	*Rhinanthus serotinus*	9	*	*	108
4	*Rhinanthus serotinus*	15	*	*	435
5	*Rhinanthus serotinus*	19	*	*	209
6	*Rhinanthus serotinus*	16	*	*	240
1	*Rosa canina* agg.[1]	100	-	-	2400
2	*Rosa canina agg.* [1]	100	-	-	2900
3	*Rosa canina* agg.[1]	150	-	-	4200
4	*Rosa canina* agg.[1]	40	-	-	1440
5	*Rosa canina* agg.[1]	300	-	-	9900
6	*Rosa canina* agg.[1]	30	-	-	900
1	*Rumex acetosa*	1	66	0.327	651
2	*Rumex acetosa*	1	50	0.321	1125
3	*Rumex acetosa*	1	110	0.312	787
4	*Rumex acetosa*	1	21	0.717	1807
5	*Rumex acetosa*	1	100	0.475	1383
6	*Rumex acetosa*	1	100	0.462	1408
1	*Rumex acetosella*	1	60	0.311	346
2	*Rumex acetosella*	1	150	0.300	460
3	*Rumex acetosella*	1	150	0.325	870
4	*Rumex acetosella*	1	101	0.315	101
5	*Rumex acetosella*	1	224	0.172	224
6	*Rumex acetosella*	1	343	0.223	343
1	*Salix repens*	3	*	*	1440
2	*Salix repens*	3	*	*	1740
3	*Salix repens*	3	*	*	1140
4	*Salix repens*	3	*	*	1890
5	*Salix repens*	3	*	*	1740
6	*Salix repens*	4	*	*	1240
1	*Salvia pratensis*	87	18	1.922	360
2	*Salvia pratensis*	180	11	3.188	720
3	*Salvia pratensis*	168	11	2.555	672
4	*Salvia pratensis*	150	19	3.366	600
5	*Salvia pratensis*	72	3	2.060	288
6	*Salvia pratensis*	129	55	2.252	528
1	*Sanguisorba minor* [1]	4	-	-	140
2	*Sanguisorba minor* [1]	6	-	-	147
3	*Sanguisorba minor* [1]	6	-	-	143
4	*Sanguisorba minor* [1]	4	-	-	79
5	*Sanguisorba minor* [1]	6	-	-	66
6	*Sanguisorba minor* [1]	3	-	-	62
1	*Stellaria graminea*	46	299	0.189	276
2	*Stellaria graminea*	34	*	*	196
3	*Stellaria graminea*	34	*	*	442
4	*Stellaria graminea*	168	*	*	773
5	*Stellaria graminea*	56	*	*	196
6	*Stellaria graminea*	18	*	*	90
1	*Succisa pratensis*	2	25	0.658	94
2	*Succisa pratensis*	2	*	*	82
3	*Succisa pratensis*	3	*	*	159
4	*Succisa pratensis*	3	*	*	132
5	*Succisa pratensis*	2	*	*	108
6	*Succisa pratensis*	3	*	*	168

Appendix Table 1 continued.

No.	species	inflorescences per ramet	number of weighed seeds	seed weight per seed [mg]	seed number per ramet
1	*Taraxacum officinale* agg.	4	78	0.035	312
2	*Taraxacum officinale* agg.	6	118	0.579	774
3	*Taraxacum officinale* agg.	5	67	0.625	390
4	*Taraxacum officinale* agg.	6	20	0.533	498
5	*Taraxacum officinale* agg.	2	10	0.617	196
6	*Taraxacum officinale* agg.	11	10	0.448	1089
1	*Taraxacum palustre*	3	15	0.697	189
2	*Taraxacum palustre*	2	15	0.509	170
3	*Taraxacum palustre*	1	15	0.737	39
4	*Taraxacum palustre*	1	15	0.683	45
5	*Taraxacum palustre*	1	15	0.597	52
6	*Taraxacum palustre*	1	15	0.285	45
1	*Thlaspi perfoliatum* [1]	159	-	-	159
2	*Thlaspi perfoliatum* [1]	38	-	-	38
3	*Thlaspi perfoliatum* [1]	35	-	-	35
4	*Thlaspi perfoliatum* [1]	51	-	-	51
5	*Thlaspi perfoliatum* [1]	78	-	-	78
6	*Thlaspi perfoliatum* [1]	424	-	-	424
1	*Trifolium fragiferum*	1	35	1.316	35
2	*Trifolium fragiferum*	1	21	1.181	21
3	*Trifolium fragiferum*	1	46	0.948	46
4	*Trifolium fragiferum*	1	47	1.087	47
5	*Trifolium fragiferum*	1	49	0.592	49
6	*Trifolium fragiferum*	1	49	1.320	49
1	*Trifolium pratense*	7	21	2.062	147
2	*Trifolium pratense*	4	22	1.205	88
3	*Trifolium pratense*	7	31	1.006	217
4	*Trifolium pratense*	5	36	0.483	180
5	*Trifolium pratense*	4	46	0.791	184
6	*Trifolium pratense*	7	50	0.968	175
1	*Trifolium repens*	1	25	0.334	27
2	*Trifolium repens*	1	59	0.417	59
3	*Trifolium repens*	1	7	0.343	24
4	*Trifolium repens*	1	13	0.231	13
5	*Trifolium repens*	1	20	0.315	20
6	*Trifolium repens*	1	29	0.424	30
1	*Trisetum flavescens* [1]	1	-	-	204
2	*Trisetum flavescens* [1]	1	-	-	86
3	*Trisetum flavescens* [1]	1	-	-	242
4	*Trisetum flavescens* [1]	1	-	-	333
5	*Trisetum flavescens* [1]	1	-	-	223
6	*Trisetum flavescens* [1]	1	-	-	460
1	*Valeriana dioica*	1	100	0.530	69
2	*Valeriana dioica*	1	*	*	92
3	*Valeriana dioica*	1	*	*	169
4	*Valeriana dioica*	1	*	*	153
5	*Valeriana dioica*	1	*	*	51
6	*Valeriana dioica*	1	*	*	78
1	*Veronica arvensis*	1	3277	0.085	549
2	*Veronica arvensis*	1	*	*	454
3	*Veronica arvensis*	1	*	*	190
4	*Veronica arvensis*	1	36	0.118	231
5	*Veronica arvensis*	1	11	0.118	407
6	*Veronica arvensis*	1	57	0.090	467

Appendix Table 1 continued.

No.	species	inflorescences per ramet	number of weighed seeds	seed weight per seed [mg]	seed number per ramet
1	*Veronica chamaedrys*	18	100	0.187	54
2	*Veronica chamaedrys*	30	*	*	230
3	*Veronica chamaedrys*	34	*	*	249
4	*Veronica chamaedrys*	36	*	*	120
5	*Veronica chamaedrys*	30	*	*	360
6	*Veronica chamaedrys*	31	42	0.148	326
1	*Vicia angustifolia*	7	80	13.514	79
2	*Vicia angustifolia*	9	49	13.673	90
3	*Vicia angustifolia*	7	42	13.609	56
4	*Vicia angustifolia*	8	*	*	88
5	*Vicia angustifolia*	8	*	*	72
6	*Vicia angustifolia*	6	*	*	69
1	*Vicia cracca*	122	11	12.617	259
2	*Vicia cracca*	224	86	11.935	560
3	*Vicia cracca*	104	*	*	390
4	*Vicia cracca*	105	*	*	105
5	*Vicia cracca*	122	*	*	168
6	*Vicia cracca*	105	*	*	195
1	*Viola canina*	4	60	1.023	80
2	*Viola canina*	5	*	*	105
3	*Viola canina*	6	21	1.133	102
4	*Viola canina*	5	28	0.914	47
5	*Viola canina*	5	58	0.709	142
6	*Viola canina*	5	40	0.473	100

Appendix Table 2: Hassberge: Site x species matrix. For species codes see Appendix Table 5.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31	sp32
SE01	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SE02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SE03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SE04	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE05	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE07	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0
SE08	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	1	0	0	1	1	0	0	1	1	0	0	0	0	0	0	1
SE09	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	0	0	1	1	0
SE10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE11	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
SE12	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0
SE13	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	1	1	0	1	0
SE14	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0
SE15	1	0	0	0	0	1	0	1	1	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	0	0	1	0	0	0	0
SE16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0
SE17	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE18	1	1	0	0	0	1	0	0	1	0	0	1	1	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0
SE19	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	1	0	1	1	0	0	0	0
SE20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE21	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
SE22	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0
SE23	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	1	0
SE24	1	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	1	1	0	1	0	0	1	0	0	1	0
SE25	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0	1	0	0	1	0	0	1	0
SE26	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	1	1	1	0	0
SE27	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
SE28	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	1	0	0
SE29	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
SE30	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SE31	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE32	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	1	1	0	0
SE33	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE34	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0

Appendix Table 2 continued.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31	sp32
SE35	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SE36	1	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0
SE37	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1
SE38	1	0	1	0	0	1	0	0	0	0	0	0	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
SE39	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
SE40	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	1	1	0	1	0	0
SE41	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1
SE42	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0
SE43	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SE44	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
3	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	1	0	0
4	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	1	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	1	0	0	0	1	0	1	1	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	1	0
69	0	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1
77	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
91	1	1	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	0
92	0	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	1	0
97	1	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0
115	1	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	1	0	0	1	0	1	0	0
117	1	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1	1	1	1	0	1	0	0
120	1	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0
136	1	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
138	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0
147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
151	1	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0	1	0	0	1	1	0	0	0	1	1	1	0	0	1	0	0
168	1	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	1	0	0
171	1	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	1	0	0
176	1	0	1	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0

Appendix Table 2 continued.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31	sp32
202	1	0	0	1	0	1	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0
211	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
234	1	0	0	1	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	0	0
242	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	1
275	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
288	0	0	0	1	1	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
297	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
312	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0
325	1	0	0	1	1	1	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	1	1	0	1	0	0
332	1	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0
337	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
343	1	1	0	0	1	1	1	0	0	0	0	0	1	0	0	1	0	0	1	1	1	0	0	1	1	1	0	1	0	1	1	0
366	1	1	0	1	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0
366B	1	1	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	0	1	0
373	1	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	1	0	0	1	1	0
374	1	0	0	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	1	0	0
376	1	0	0	1	1	1	1	0	0	1	0	0	1	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	1	0	0
397	1	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0
423	1	0	0	1	1	1	1	0	1	1	0	0	1	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0
427	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	1	0	0	0	0
513	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0
552	1	1	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	1	0	1	1	1	0	0	0	0	0	0
AB17	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0
E7	0	1	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0
E9	1	0	0	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
E13	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	1	0
E19	0	1	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	1	0	0
H9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	0	0	1	0	1	0	1
H17	1	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	1	1	0	0
M2	1	1	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	1	0	0
M5	1	0	0	0	0	1	1	0	1	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	1	0
M10	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0
S3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
S6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	1

Appendix Table 2 continued.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31	sp32
S21	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
LiM	1	1	1	0	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0	1	1	0	1	1	1	0	0	1	0	0	1	0
LiF2000	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	1	1	1	0	0	1	0	0	1	0
LiF2001	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	1	0
LiF2002	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0
MoM	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0	0	0
MoF2000	0	0	1	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	1	0
MoF2001	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0
MoF2002	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0
RaBM	1	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0	1	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0
RaBF2000	1	0	1	0	0	1	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0
RaBF2001	1	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0
RaBF2002	1	0	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	1	0	0
ReBM	1	1	0	0	0	1	0	0	1	0	0	1	1	1	0	0	0	0	0	1	1	0	1	0	1	0	0	1	0	0	1	0
ReBF2000	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	0	1	0	0	1	0	0	0	0
ReBF2001	1	1	1	0	0	1	0	0	1	0	0	0	1	1	0	0	0	0	1	1	1	0	1	0	1	0	0	1	0	0	0	0
ReBF2002	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	1	0	0	0	0
Z01	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1

Appendix Table 2 continued.

site	sp33	sp34	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60	sp61	sp62	sp63	sp64
SE01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1
SE03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
SE06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE08	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
SE09	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SE10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
SE11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE12	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1
SE13	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1
SE14	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0	1	1	0	0
SE15	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	1	1	0	0
SE16	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0
SE17	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SE18	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	1	0	0
SE19	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0
SE20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SE21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SE22	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0
SE23	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	1	1	0	0
SE24	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0
SE25	0	0	1	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	1	0	0
SE26	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
SE27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SE28	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0
SE29	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
SE30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
SE32	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
SE34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1

Appendix Table 2 continued.

site	sp33	sp34	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60	sp61	sp62	sp63	sp64
SE35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE36	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
SE37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
SE38	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
SE39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1
SE40	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0
SE41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
SE42	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0
SE43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
SE44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1
4	1	0	0	0	1	1	0	1	1	1	0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	0	0	1	0	1	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	1	1	0	1	0	1	0	0	1	1	0	0	1	0	0	1
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	1	0	1	0	0	0	1	1	1	1	1	0	0
69	1	0	0	1	1	0	0	0	0	1	0	0	1	0	1	1	0	1	0	0	0	0	0	0	1	0	0	1	0	1	0	1
77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	1	0	0	1	0	0	1	0	1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	1	0	0	1	1	1	0	0
92	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	1	1	1	0	0	0	1	0	0	1	1	0	0	0	1	1	0
97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
115	0	0	0	1	1	0	0	0	1	1	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0	1	0	1	1	1	0	0
117	0	0	0	1	1	0	1	0	1	1	0	0	0	0	1	1	0	1	0	0	0	1	1	0	0	1	0	1	1	1	0	0
120	0	0	0	0	1	0	0	0	0	0	1	1	0	0	1	1	1	1	0	0	1	0	0	0	0	1	0	0	1	0	0	1
136	1	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	1
138	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1
147	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
151	0	0	0	0	1	0	1	0	1	0	1	0	0	0	1	0	0	1	0	0	0	1	0	1	1	0	0	1	1	1	0	1
168	1	0	0	0	1	1	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	1	1	1	0	1
171	0	0	0	1	1	1	0	0	1	0	0	0	0	0	1	1	1	0	0	1	0	0	1	0	0	0	0	0	1	1	0	1
176	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1

Appendix Table 2 continued.

site	sp33	sp34	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60	sp61	sp62	sp63	sp64
202	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	1
211	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	1	0	0	1	1
234	1	0	0	0	0	0	0	1	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	1	1	0	1	0	0	0	1
242	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1	1	1	0	1	0	1	1	1
275	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1
288	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	1
297	1	0	0	0	1	0	0	1	0	1	0	0	0	0	0	1	1	1	0	1	0	0	1	1	0	0	0	1	0	0	0	1
312	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
325	0	0	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	0	0	1	0	1	0	0	1	1	1	1	1
332	1	0	0	0	0	1	0	1	1	1	0	0	0	0	1	1	1	1	0	0	0	1	0	1	1	1	0	1	0	1	1	1
337	1	0	0	0	1	1	0	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	1	0	1	1	0
343	0	1	0	1	0	1	0	0	1	1	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1
366	0	0	0	0	0	0	1	0	1	1	1	1	0	0	0	1	1	1	0	1	0	0	0	1	1	0	0	1	0	0	0	1
366B	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
373	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	1	1	0	0	0	1	0	0
374	1	0	0	1	1	1	0	0	1	1	0	0	0	0	1	1	1	1	0	1	0	1	0	1	1	0	0	1	0	0	0	1
376	1	0	0	1	0	1	1	1	1	1	1	0	0	0	1	1	1	1	0	0	0	0	0	1	1	1	0	1	0	0	1	1
397	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	1	1	1	0	1	0	0	0	0	1	1	0	1	1	1	1	1
423	1	0	0	0	1	0	1	1	1	1	0	1	0	0	0	1	1	1	0	0	0	1	0	0	0	1	0	1	0	0	0	0
427	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	1	0	1	1	0	1
513	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0
552	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	0	0	0	0	1	0	0	1	1	0	1
AB17	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
E7	0	1	0	0	0	0	0	0	1	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0
E9	1	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1	0	1	0	0	0	1	0	0	1	0	0	1	1	1	1	1
E13	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	1	0	1	0	1
E19	1	0	0	0	1	1	0	0	1	1	1	0	0	0	1	0	1	1	0	1	0	1	0	1	0	1	0	0	0	1	1	0
H9	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
H17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
M2	1	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1	0	1	0	0	0	1	0	1	1	0	0	0	1	1	0	0
M5	0	0	0	1	0	1	1	0	1	1	1	0	1	0	1	1	1	1	0	0	0	1	1	0	1	1	0	0	1	1	0	0
M10	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	1	1	0	0	1	1	0	0
S3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
S6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0

Appendix Table 2 continued.

site	sp33	sp34	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60	sp61	sp62	sp63	sp64
S21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
LiM	0	1	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0	1	0	1	0	0	0	1	0	1	1	0	0
LiF2000	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	1	1	0	1	0	1	0	1	0	1	1	0	0
LiF2001	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0
LiF2002	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0
MoM	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0
MoF2000	0	1	0	1	0	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	1	0	1	0	0	0	1	0	0	1	0	0
MoF2001	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	1	0	0	0	0	1	0	0
MoF2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	0	0	0
RaBM	0	0	1	0	0	0	1	0	1	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	0	1	1	0	0
RaBF2000	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0
RaBF2001	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0
RaBF2002	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0
ReBM	0	0	0	1	0	0	1	0	1	0	0	0	1	0	1	1	1	1	0	0	1	0	1	0	1	0	1	0	1	1	0	0
ReBF2000	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	0	1	0	0	0	1	1	0	0
ReBF2001	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	1	1	0	1
ReBF2002	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	1	0	1	0	1	0	0	0	1	1	0	0
Z01	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Appendix Table 2 continued.

site	sp65	sp66	sp67	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75
SE01	0	0	0	0	0	0	1	0	1	0	0
SE02	0	0	0	1	0	1	1	1	0	0	0
SE03	0	0	0	0	0	1	0	0	0	0	0
SE04	0	0	0	0	0	0	0	0	0	0	0
SE05	0	0	0	0	0	1	0	0	0	0	0
SE06	0	0	0	0	0	0	0	0	0	0	0
SE07	0	0	0	0	0	0	0	0	0	0	0
SE08	0	0	0	0	1	0	1	0	0	0	0
SE09	0	0	0	0	0	0	0	0	1	1	0
SE10	0	0	0	0	0	0	1	0	0	0	0
SE11	0	0	0	0	0	0	0	0	0	0	0
SE12	0	0	0	0	1	0	0	0	1	1	0
SE13	0	0	0	0	0	0	0	0	0	0	1
SE14	0	0	0	0	0	0	0	0	1	0	0
SE15	0	0	0	0	1	0	0	0	1	0	1
SE16	0	0	0	0	0	0	0	0	1	0	0
SE17	0	0	0	0	0	0	0	0	1	0	0
SE18	0	0	0	0	1	1	0	0	1	0	0
SE19	1	0	0	0	0	1	0	0	1	0	1
SE20	1	0	0	0	0	0	1	0	1	0	0
SE21	0	0	0	0	0	0	0	0	1	0	0
SE22	1	0	1	0	0	1	1	0	1	0	1
SE23	1	0	0	0	1	0	0	0	1	0	1
SE24	0	0	0	0	0	0	0	0	1	0	1
SE25	0	0	1	0	0	0	0	0	0	0	1
SE26	0	0	0	0	0	0	0	1	1	0	1
SE27	0	0	0	0	0	0	0	0	0	0	1
SE28	0	0	0	0	0	0	0	0	0	0	0
SE29	0	0	0	0	0	0	1	0	0	0	0
SE30	0	0	0	0	0	0	0	0	0	0	0
SE31	0	0	0	0	0	0	1	0	0	0	0
SE32	0	0	0	0	0	0	1	0	0	0	0
SE33	1	0	0	0	0	0	0	0	0	0	0
SE34	0	0	0	1	0	0	0	0	0	0	0

Appendix Table 2 continued.

site	sp65	sp66	sp67	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75
SE35	0	0	0	0	0	0	0	0	0	0	0
SE36	0	0	1	0	1	0	0	0	1	1	0
SE37	0	0	0	0	0	1	0	0	0	0	0
SE38	0	0	1	0	0	0	0	0	1	1	0
SE39	0	0	0	0	0	0	0	0	0	0	0
SE40	0	0	0	0	1	0	0	0	1	0	0
SE41	0	0	0	0	1	0	0	0	0	0	0
SE42	0	0	0	1	1	0	0	0	0	0	0
SE43	0	0	0	0	0	0	0	1	0	0	0
SE44	0	0	0	0	0	0	0	0	0	0	0
3	0	0	1	0	0	0	0	1	0	0	0
4	0	0	1	0	1	0	0	1	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0
47	0	1	1	1	0	0	1	1	1	0	0
51	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0
56	1	0	1	0	1	0	1	0	1	0	0
69	0	0	1	0	1	0	0	1	0	0	1
77	0	0	0	0	0	0	0	0	0	0	0
91	1	0	1	1	1	1	1	0	1	0	0
92	0	0	1	0	1	0	0	0	0	0	0
97	0	0	0	1	0	0	0	0	0	0	0
115	0	0	1	0	0	0	0	0	1	0	1
117	0	0	1	0	1	0	0	1	0	0	1
120	0	0	1	0	1	1	1	0	0	0	0
136	0	0	1	1	1	0	1	1	0	0	0
138	0	0	1	0	0	1	1	0	0	0	0
147	0	0	0	0	0	0	0	0	0	0	0
151	0	0	0	0	1	0	0	1	0	0	1
168	0	1	1	0	1	0	0	1	1	0	1
171	0	0	1	1	1	0	0	0	0	0	0
176	0	0	1	1	1	0	0	0	0	0	0

Appendix Table 2 continued.

site	sp65	sp66	sp67	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75
202	1	1	0	0	1	0	1	0	0	0	0
211	0	0	0	0	1	0	0	1	0	0	0
234	0	0	1	1	1	1	1	0	1	1	0
242	0	0	1	0	0	0	0	0	0	0	0
275	0	0	1	0	0	0	0	1	0	0	0
288	0	0	1	1	0	0	1	0	1	0	0
297	0	1	1	1	0	0	1	0	0	0	0
312	0	0	0	0	0	0	1	0	0	1	0
325	0	1	1	1	1	1	1	1	0	0	0
332	0	1	1	0	1	0	0	1	1	0	0
337	0	0	1	0	0	0	0	1	1	0	0
343	0	1	1	0	1	0	1	0	1	0	1
366	0	0	1	0	1	0	1	0	1	0	0
366B	0	0	0	0	0	1	0	1	1	0	0
373	1	0	0	0	1	1	0	0	1	0	0
374	0	0	1	0	1	0	0	1	0	0	1
376	0	1	1	1	1	0	1	1	1	0	0
397	0	0	1	1	1	1	1	1	1	0	0
423	0	0	1	1	1	0	1	1	1	1	0
427	0	0	0	0	0	0	1	0	0	0	0
513	1	0	0	0	0	0	0	0	1	0	1
552	0	0	0	0	0	0	1	0	1	1	0
AB17	0	0	0	0	0	0	0	0	0	0	0
E7	0	0	0	0	0	1	1	1	0	1	1
E9	1	1	1	0	0	1	1	0	0	0	0
E13	0	0	1	1	0	0	0	1	0	0	0
E19	0	0	1	1	1	0	0	1	0	0	1
H9	0	0	0	0	0	1	0	0	0	0	1
H17	0	0	0	0	0	0	0	0	0	0	0
M2	0	0	1	0	1	0	0	1	1	0	1
M5	0	0	1	1	1	0	0	0	1	0	1
M10	0	0	0	0	1	0	0	0	1	0	0
S3	0	0	0	0	0	0	0	0	0	0	0
S6	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 2 continued.

site	sp65	sp66	sp67	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75
S21	0	0	0	0	0	0	0	0	0	0	0
LiM	1	0	0	0	1	0	0	0	0	0	0
LiF2000	1	0	0	0	1	1	1	0	0	0	0
LiF2001	1	0	0	0	1	0	1	0	0	0	0
LiF2002	1	0	0	0	0	1	1	0	1	1	0
MoM	1	0	0	0	0	0	0	0	1	0	0
MoF2000	1	0	0	0	0	0	0	0	0	0	0
MoF2001	0	0	0	0	0	0	0	0	1	0	0
MoF2002	1	0	0	0	0	1	0	0	0	0	0
RaBM	1	0	0	0	0	0	0	1	1	0	1
RaBF2000	1	0	0	0	1	0	0	0	0	0	1
RaBF2001	1	0	0	0	0	0	0	0	0	0	0
RaBF2002	1	1	0	0	0	1	0	0	1	0	0
ReBM	0	0	0	0	1	0	0	0	1	0	1
ReBF2000	0	0	0	0	1	0	0	0	0	0	1
ReBF2001	1	0	0	0	0	0	0	0	0	0	1
ReBF2002	1	0	0	0	0	0	0	0	1	0	0
Z01	0	0	0	0	1	0	0	1	0	0	1

Appendix Table 3: Hassberge: Site x environmental parameters matrix. (P=plant available phosphorus, K=plant available potassium, CaCO3=calcium carbonate, N=total nitrogen content, C=total carbon content, C/N=relation between C and N, PAW=plant available water, kf=soil water permeability in saturated soil, AC=air capacity,CECeff=cation exchange capacity, biomass=biomass destruction, dist_ag=above-ground disturbance 1997, dist_bg=below-ground disturbance 1997, freq=disturbance frequency, week=disturbance week, expos=exposition) For explanation on frequency and exposition see Chapter 3.

site	P [kg*ha^{-1}]	K [kg*ha^{-1}]	$CaCO_3$ [kg*ha^{-1}]	N [kg*ha^{-1}]	C [kg*ha^{-1}]	C/N	pH	PAW [mm]	kf [cm*d^{-1}]	AC [mm]	CEC_{eff} [cmol$_c$* kg^{-1}]	biomass [%]	dist_ag [0=no, 1=yes]	dist_bg [0=no, 1=yes]	freq	week [number]	slope [°]	expos
SE01	277	1018	258444	3423	45739	13.4	7.3	30.08	17.00	16.92	28	100	0	1	5	53	12	1
SE02	419	1958	546813	4666	49	0.0	7.3	34.65	7.00	9.90	39	100	0	1	5	53	13	1
SE03	1159	3519	1200375	12052	10460	0.9	7.3	84.00	7.00	24.00	39	100	0	1	5	53	15	1
SE04	1154	13018	1958375	1110	0	0.0	7.3	63.69	1.00	8.69	39	100	0	1	5	53	17	1
SE05	3043	5583	128716	12869	89801	7.0	7.1	84.00	7.00	24.00	39	100	0	1	5	53	12	1
SE06	4424	13746	1516015	4719	5467	1.2	7.4	92.00	2.00	14.38	39	100	0	1	5	53	12	1
SE07	226	3445	0	7349	121668	16.6	6.6	87.00	5.00	18.00	29	50	0	1	1	27	2	1
SE08	321	1249	333557	6267	18746	3.0	7.2	26.32	7.00	7.52	39	100	0	1	0.27	38	10	1
SE09	330	3533	413639	8808	79460	9.0	6.7	89.50	6.72	21.75	26	50	0	1	1	33	5	0
SE10	1156	4389	783298	10657	59645	5.6	7.3	79.92	2.00	12.49	39	50	0	1	1	29	2	1
SE11	584	2998	1374379	8942	52442	5.9	7.2	68.31	4.20	18.42	39	50	0	1	1	37	4	0
SE12	970	2626	61960	9770	133054	13.6	7.2	84.00	7.00	24.00	39	100	0	1	0.27	38	7	1
SE13	125	854	254085	4234	35244	8.3	7.0	13.23	7.00	3.78	39	50	0	0	0.13	53	20	1
SE14	274	2873	910550	16873	113116	6.7	7.4	66.56	2.00	10.40	39	50	1	0	0.27	53	13	1
SE15	295	1636	1855178	8274	0	0.0	7.4	75.22	3.73	18.75	39	50	1	0	1	26	25	1
SE16	657	1344	530239	256	0	0.0	7.3	16.13	2.00	2.52	39	100	0	0	0.13	53	15	1
SE17	123	583	727335	240	0	0.0	7.3	15.12	2.00	2.36	39	100	0	0	0.01	53	28	1
SE18	381	2704	1653701	960	0	0.0	7.3	60.48	2.00	9.45	39	100	0	0	0.01	53	10	1
SE19	260	715	451634	1879	0	0.0	7.2	11.09	2.00	1.73	39	100	0	0	0.01	53	17	1
SE20	931	5137	2477375	960	0	0.0	7.3	42.08	2.00	6.58	39	100	0	0	0.13	53	28	1
SE21	621	4011	1246654	960	0	0.0	7.2	60.48	2.00	9.45	39	100	0	0	0.13	53	12	1
SE22	488	2376	1253543	15211	48738	3.2	7.4	54.68	3.17	11.97	39	50	0	0	0.01	53	2	0
SE23	54	1899	982630	8665	44599	5.1	7.3	106.50	10.37	24.00	34	50	0	0	0.13	53	30	0
SE24	1183	2118	0	10676	76599	7.2	6.7	96.00	2.00	15.00	39	50	0	0	0.01	53	20	1
SE25	525	1930	903002	4924	28512	5.8	7.1	72.32	4.86	27.68	32	50	0	0	0.01	53	12	1
SE26	350	1417	791988	8958	19245	2.1	7.3	74.00	3.50	17.00	39	50	0	0	0.01	53	10	0
SE27	1070	3117	525298	9970	76679	7.7	7.3	96.00	2.00	15.00	39	50	0	0	0.01	53	10	0
SE28	96	753	509794	4842	8549	1.8	7.3	23.90	2.00	3.74	39	50	0	0	0.01	53	14	1

Appendix Table 3 continued.

site	P [kg*ha^{-1}]	K [kg*ha^{-1}]	CaCO$_3$ [kg*ha^{-1}]	N [kg*ha^{-1}]	C [kg*ha^{-1}]	C/N	pH	PAW [mm]	kf [cm*d^{-1}]	AC [mm]	CEC$_{eff}$ [cmol$_c$* kg^{-1}]	biomass [%]	dist_ag [0=no, 1=yes]	dist_bg [0=no, 1=yes]	freq	week [number]	slope [°]	expos
SE29	776	3564	76659	11121	131994	11.9	6.9	84.00	7.00	24.00	39	100	0	1	0.27	53	0	1
SE30	639	3429	1669668	14461	6371	0.4	7.3	90.00	3.11	19.50	39	50	0	1	1	24	2	1
SE31	532	3095	1164302	7267	50825	7.0	7.4	90.00	3.11	19.50	39	50	0	1	1	36	0	1
SE32	570	2363	606814	9152	59700	6.5	7.3	82.82	7.21	24.50	38	50	0	1	1	34	5	0
SE33	522	2225	1767600	8248	14590	1.8	7.4	77.06	2.00	12.04	39	50	0	1	1	34	0	1
SE34	1825	4942	119985	11425	101396	8.9	7.3	85.94	2.00	13.43	39	50	0	1	1	29	6	1
SE35	1238	6650	1066846	23422	203638	8.7	7.3	84.00	7.00	24.00	39	50	0	1	1	36	0	1
SE36	404	4213	1561668	8609	0	0.0	7.3	82.63	3.91	20.34	39	100	0	1	0.27	53	0	1
SE37	926	1711	215641	8723	89985	10.3	7.3	84.00	7.00	24.00	39	100	0	1	0.27	53	5	0
SE38	537	3273	1018328	7388	24572	3.3	7.3	96.00	2.00	15.00	39	100	0	1	0.27	53	0	1
SE39	771	4159	81439	7337	68643	9.4	7.1	78.24	2.00	12.23	39	100	0	1	0.27	53	0	1
SE40	718	1635	1837865	5315	0	0.0	7.3	84.68	2.60	16.68	39	50	1	0	0.27	53	0	1
SE41	45	2248	335906	1628	0	0.0	7.3	12.70	25.00	8.22	28	100	0	0	0.01	53	0	1
SE42	124	949	82546	6947	65070	9.4	7.3	34.40	20.00	6.40	29	100	0	0	0.01	53	0	1
SE43	301	1679	0	6965	92468	13.3	7.3	91.35	23.09	81.90	5	100	0	0	0.01	53	0	1
SE44	561	4204	1160750	16328	92231	5.6	7.3	75.67	7.00	21.62	39	100	0	0	0.01	53	0	1
3	60	1826	0	6969	68147	9.8	5.6	81.66	7.22	20.12	25	50	1	0	4	19	12	0
4	135	2950	0	12785	136320	10.7	5.7	104.63	30.11	46.69	14	50	1	0	4	19	16	0
21	361	2239	0	7593	110142	14.5	6.1	84.00	7.00	24.00	39	100	0	1	5	53	3	1
29	623	4561	0	13112	100770	7.7	6.2	109.50	17.55	31.50	21	100	0	1	5	53	0	1
30	358	2782	0	6023	64401	10.7	6.3	70.97	5.83	17.43	34	100	0	1	5	53	6	1
47	369	1836	1223495	9177	44503	4.8	7.1	87.95	2.71	17.73	39	50	1	0	2	24	6	0
51	482	4219	832682	8022	57860	7.2	6.9	90.00	3.11	19.50	39	100	0	1	5	53	3	1
53	224	1528	751800	6217	0	0.0	6.8	46.50	13.00	13.50	21	100	0	1	5	53	8	1
56	311	780	110717	8882	93093	10.5	6.5	56.98	10.00	22.79	22	50	1	0	1	38	18	1
69	543	1062	0	5988	91549	15.3	6.3	88.83	10.00	29.61	22	50	1	0	3	24	11	1
77	726	2928	1418443	11475	35417	3.1	7.0	113.59	18.85	30.40	21	100	0	1	5	53	2	1
91	233	2205	0	9424	95155	10.1	6.2	84.60	3.11	18.33	39	50	1	0	4	27	15	1
92	171	1099	0	7190	82489	11.5	5.1	117.80	15.98	35.20	23	50	1	0	1	28	14	0
97	452	1234	0	8144	83016	10.2	5.4	87.42	3.27	21.15	28	50	1	0	2	26	12	1
115	404	2494	408398	16764	180568	10.8	7.0	85.88	14.70	36.82	14	50	1	0	1	35	14	1
117	187	2012	301860	14976	136899	9.1	7.4	126.00	26.00	45.00	15	50	1	0	1	33	8	0

Appendix Table 3 continued.

site	P [kg*ha^{-1}]	K [kg*ha^{-1}]	$CaCO_3$ [kg*ha^{-1}]	N [kg*ha^{-1}]	C [kg*ha^{-1}]	C/N	pH	PAW [mm]	kf [cm*d^{-1}]	AC [mm]	CEC_{eff} [$cmol_c$* kg^{-1}]	biomass [%]	dist_ag [0=no, 1=yes]	dist_bg [0=no, 1=yes]	freq	week [number]	slope [°]	expos
120	104	1139	797657	7117	15681	2.2	6.8	77.00	4.18	32.50	21	50	1	0	3	25	4	0
136	13	1180	0	4375	76672	17.5	4.4	94.15	10.00	31.15	22	50	1	0	3	26	12	0
138	571	2523	227358	13267	97807	7.4	6.8	105.00	10.00	42.00	22	50	1	0	2	26	8	1
147	991	5163	633700	12665	113632	9.0	7.2	83.16	7.00	23.76	39	50	0	0	0.01	53	22	1
151	230	1703	0	10799	194019	18.0	7.3	126.00	26.00	45.00	15	50	1	0	1	31	6	0
168	373	1124	0	8786	117417	13.4	5.7	90.00	3.11	19.50	39	50	1	0	2	26	11	1
171	829	2836	237617	5942	79481	13.4	6.6	45.63	2.47	10.03	39	50	1	0	2	26	13	0
176	218	1664	0	4161	73184	17.6	5.2	87.40	4.10	21.45	39	50	1	0	3	27	14	1
202	263	1607	288538	11036	50609	4.6	6.8	80.89	10.00	32.35	22	50	1	0	1	28	14	1
211	35	1069	0	6366	81130	12.7	5.5	119.12	11.81	32.01	25	50	1	0	3	27	3	0
234	21	1293	0	7318	90395	12.4	5.4	96.00	2.00	15.00	39	50	1	0	3	27	12	1
242	869	2436	1645417	8720	0	0.0	6.5	89.10	3.11	19.31	39	50	1	0	1	26	14	1
275	196	1038	0	1002	52253	52.1	6.3	84.00	10.00	21.00	22	50	1	0	2	19	10	0
288	84	1723	0	7928	81260	10.3	4.8	71.82	21.27	25.52	15	50	1	0	1	33	11	0
297	979	2536	0	7476	92355	12.4	6.2	113.60	21.14	40.35	15	50	1	0	3	24	6	0
312	3255	3196	0	5930	70973	12.0	5.9	115.50	10.48	40.50	16	100	0	1	0.27	53	2	0
325	164	1690	0	5829	69544	11.9	6.1	93.56	10.00	31.19	22	50	1	0	3	24	14	1
332	182	879	0	8871	85366	9.6	5.6	73.84	8.87	37.73	28	50	1	0	1	28	8	1
337	30	352	0	5364	62684	11.7	4.7	165.00	41.00	51.00	9	50	1	0	3	27	17	0
343	910	2123	0	8954	105752	11.8	6.8	105.20	8.02	30.60	22	50	1	0	1	34	8	0
366	907	1922	42900	6998	83050	11.9	6.8	103.95	10.00	41.58	22	50	1	0	2	24	4	1
366B	483	1861	0	14181	113837	8.0	6.3	103.75	12.54	46.50	17	50	0	0	0.13	53	3	1
373	818	2557	1264596	6455	42131	6.5	6.9	78.54	10.00	23.57	22	50	1	0	1	29	8	1
374	0	1329	0	12770	98265	7.7	5.6	120.65	26.00	43.09	15	50	1	0	3	29	10	0
376	83	502	0	3556	46423	13.1	5.3	39.94	22.23	16.05	14	50	1	0	3	34	3	0
397	52	572	0	3370	34562	10.3	5.8	24.69	10.00	9.88	22	50	1	0	1	29	11	1
423	306	1510	0	7849	97761	12.5	5.9	97.05	21.94	39.27	14	50	1	0	3	30	12	1
427	142	2358	1791619	5870	16977	2.9	7.1	46.56	15.38	15.62	17	50	1	0	4	27	22	1
513	197	1530	1238075	4699	24437	5.2	7.0	58.68	10.00	23.47	22	50	0	0	0.01	53	20	1
552	326	956	395326	6400	31093	4.9	6.7	26.32	10.00	6.58	22	50	1	0	1	26	12	1
AB17	1057	3215	818100	6713	24431	3.6	6.9	94.50	10.00	31.50	22	100	0	0	0.01	53	4	1
E13	0	1838	0	17751	190972	10.8	5.6	98.70	10.00	39.48	22	50	1	0	3	29	5	0

Appendix Table 3 continued.

site	P [kg*ha^{-1}]	K [kg*ha^{-1}]	$CaCO_3$ [kg*ha^{-1}]	N [kg*ha^{-1}]	C [kg*ha^{-1}]	C/N	pH	PAW [mm]	kf [cm*d^{-1}]	AC [mm]	CEC_{eff} [$cmol_c$* kg^{-1}]	biomass [%]	dist_ag [0=no, 1=yes]	dist_bg [0=no, 1=yes]	freq	week [number]	slope [°]	expos
E19	302	1401	0	5221	85786	16.4	6.5	100.61	8.00	19.47	29	50	1	0	3	27	12	1
E7	335	1176	0	8546	88442	10.3	6.8	52.50	10.00	21.00	22	50	1	0	0.27	53	14	1
E9	25	889	0	3284	70286	21.4	6.0	46.75	10.00	12.64	29	50	1	0	3	26	14	1
H17	771	1671	374523	6903	63908	9.3	7.1	86.24	10.00	31.54	22	50	0	0	0.01	53	17	1
H9	687	1675	149385	4869	98157	20.2	7.3	126.00	41.00	57.00	13	50	0	0	0.01	53	11	1
LiF2000	309	1077	227139	7211	64618	9.0	7.3	37.94	3.09	6.51	35	100	1	0	0.33	33	20	1
LiF2001	309	1097	270264	7415	53700	7.2	7.3	44.61	20.00	8.30	29	100	1	0	0.5	33	20	1
LiF2002	207	1176	134561	5824	56860	9.8	7.4	23.24	7.00	6.64	39	100	1	0	1	33	20	1
LiM	237	1086	197989	6597	53459	8.1	7.3	23.24	7.00	6.64	39	50	1	0	1	36	20	1
M10	136	1283	785523	11839	32624	2.8	7.2	77.00	10.00	30.80	22	50	1	0	0.27	53	22	1
M2	379	1799	382124	9484	83749	8.8	6.8	105.00	10.00	42.00	22	50	1	0	0.27	53	20	1
M5	25	1755	925330	11652	39614	3.4	7.3	123.20	22.94	45.40	15	50	1	0	1	32	12	0
MoF2000	84	1376	403685	17444	39207	2.2	7.4	34.86	7.00	9.96	39	100	1	0	0.33	33	20	1
MoF2001	102	1421	317848	5963	43169	7.2	7.2	30.21	7.00	8.63	39	100	1	0	0.5	33	20	1
MoF2002	246	1781	274155	4159	35020	8.4	7.3	48.63	28.91	33.00	24	100	1	0	1	33	20	1
MoM	27	457	721678	210	0	0.0	7.4	16.27	7.00	4.65	39	50	1	0	1	36	20	1
RaBF2000	327	2231	959723	6921	77465	11.2	7.4	71.35	2.53	11.89	37	100	1	0	0.33	33	28	1
RaBF2001	221	2186	1297572	5821	63520	10.9	7.3	62.17	2.30	11.37	39	100	1	0	0.5	33	28	1
RaBF2002	340	1965	523306	13953	100343	7.2	7.2	54.78	8.71	21.17	35	100	1	0	1	33	28	1
RaBM	206	1363	697108	12824	73163	5.7	7.4	58.06	2.57	11.63	39	50	1	0	1	40	23	1
ReBF2000	260	3085	897028	13074	89621	6.9	7.0	64.50	6.14	16.92	36	100	1	0	0.33	33	21	1
ReBF2001	109	3215	2602908	13105	66048	5.0	7.4	66.18	9.04	25.33	35	100	1	0	0.5	33	21	1
ReBF2002	111	1688	2837783	4104	0	0.0	7.0	63.56	2.63	12.94	39	100	1	0	1	33	17	1
ReBM	122	1708	1359102	7032	26671	3.8	7.3	46.12	2.85	9.91	39	50	1	0	1	40	14	1
S21	213	607	0	7125	78138	11.0	7.0	25.14	41.00	11.37	13	50	0	0	0.01	53	25	1
S3	495	3320	688279	3594	35616	9.9	6.7	88.19	10.00	23.84	29	50	0	0	0.01	53	22	1
S6	1358	2724	535935	21309	45112	2.1	6.8	94.50	10.00	31.50	22	50	0	0	0.01	53	11	1
Z01	66	3966	455228	8460	74499	8.8	7.5	126.00	26.00	45.00	15	50	0	0	0.01	53	22	1

Appendix Table 4: Hassberge: Species x trait matrix. Bold marked species indicate the responsive species. For index explanation see Chapter 3.

species name	SLA [mm^2* mg^{-1}]	canopy height [mm]	seed mass [mg]	woodi-ness [Index]	spacers [Index]	plant life span [Index]	clonality [Index]	start seed shedding [month]	SLI [Index]	seed number per ramet
Achillea millefolium	29.0	463	0.12	0	0.833	1	1	8	0.26	343
Agrimonia eupatoria	20.9	453	3.61	0	1	1	1	7	0.13	66
Agropyron repens	25.6	517	1.92	0	1	1	1	8	0.34	16
Alopecurus pratensis	25.8	466	0.67	0	1	1	1	8	0.39	414
Anthoxanthum odoratum	39.8	207	0.48	0	0.75	1	1	6	0.38	169
Arrhenatherum elatius	32.0	818	2.68	0	1	1	1	7	0.20	-
Avenula pubescens	27.6	333	1.28	0	0.75	1	1	6	0.21	16
Brachypodium pinnatum	28.1	440	2.77	0	1	1	1	7	0.10	83
Bromus erectus	20.6	297	3.69	0	0.5	1	0.5	6	0.20	83
Bromus hordeaceus	30.4	284	2.68	0	0	0.25	0	5	0.44	48
Bromus sterilis	32.4	281	8.16	0	0	0	0	6	0.00	138
Bupleurum falcatum	19.3	565	1.85	0	0.5	1	1	9	0.00	988
Centaurea jacea	25.9	579	1.62	0	1	1	1	8	0.19	183
Centaurea scabiosa	18.3	231	6.74	0	0.75	1	0.75	7	0.25	1000
Cerastium brachypetalum	21.8	91	0.05	0	0	0	0	5	0.00	1418
Cirsium arvense	15.5	742	0.86	0	1	1	1	7	0.53	957
Convolvulus arvensis	25.7	10	14.02	0	1	1	1	8	0.37	31
Cornus sanguinea	17.6	1366	35.16	1	1	1	1	9	0.20	1750
Crataegus monogyna	15.1	848	64.87	1	0	1	0	9	0.00	-
Dactylis glomerata	27.7	588	0.68	0	0.75	1	1	6	0.39	771
Daucus carota	25.9	557	0.93	0	0	1	0	8	0.70	816
Dianthus carthusianorum	19.8	341	1.03	0	0.75	1	1	9	0.20	-
Euphorbia cyparissias	34.1	335	2.21	0	1	1	1	5	0.71	435
Falcaria vulgaris	11.8	344	1.78	0	0.75	0.75	1		0.00	4432
Festuca ovina agg.	13.2	211	0.38	0	0.5	1	0.5	6	0.16	469
Festuca pratensis	25.9	562	1.67	0	0.5	1	0.5	7	0.21	85
Festuca rubra	15.1	384	0.83	0	0.833	1	0.75	7	0.32	273
Fragaria viridis	18.4	190	0.47	0	0.5	1	1	6	0.60	-
Galium aparine	33.8	437	7.79	0	0	0	0	8	0.35	190
Galium mollugo	33.1	491	0.48	0	1	1	1	8	0.19	609
Galium verum	25.6	495	0.46	0	1	1	1	8	0.15	1622
Geum urbanum	25.9	344	0.73	0	0.5	1	1	8	0.20	-
Holcus lanatus	40.3	393	0.32	0	0.5	1	0.5	7	0.61	122
Hypericum perforatum	33.2	665	0.08	0.25	0.833	1	1	9	0.83	3036
Inula conyza	20.0	293	0.23	0	1	1	1	9	1.00	-
Knautia arvensis	20.2	409	3.34	0	0.5	1	1	7	0.08	192
Lathyrus pratensis	32.4	420	12.82	0	1	1	1	7	0.14	103
Leontodon hispidus	31.3	208	0.75	0	0.5	1	0.833	7	0.37	84
Leucanthemum vulgare	29.6	385	0.38	0	0.5	1	1	7	0.47	69
Lolium perenne	30.9	268	1.60	0	1	1	1	8	0.46	58
Lotus corniculatus	28.8	355	1.20	0	0.75	1	0.5	7	0.46	426
Luzula campestris	29.7	104	0.64	0	1	1	1	6	0.46	44
Medicago lupulina	32.8	321	1.60	0	1	1	0.25	6	0.70	154
Myosotis ramosissima	45.7	207	0.20	0	0	0.1	0	6	0.56	379
Ononis repens	33.0	430	4.84	0.5	0.5	1	1	9	0.17	-
Origanum vulgare	23.7	514	0.10	0	1	1	1	10	0.75	316
Pimpinella saxifraga	21.5	274	1.10	0	0.75	1	1	9	0.08	268
Plantago lanceolata	19.8	300	1.64	0	0.75	1	1	7	0.54	384
Plantago media	21.3	191	0.30	0	0.75	1	1	8	0.42	282
Poa pratensis agg.	22.7	244	0.25	0	0.833	1	0.75	6	0.62	281
Poa trivialis	49.5	495	0.15	0	0.75	1	1	6	0.83	201

Appendix Table 4 continued.

species name	SLA [mm^2* mg^{-1}]	canopy height [mm]	seed mass [mg]	woodi-ness [Index]	spacers [Index]	plant life span [Index]	clonality [Index]	start seed shedding [month]	SLI [Index]	seed number per ramet
Potentilla neumanniana	16.8	58	0.48	0	0.5	1	1	5	0.60	203
Potentilla reptans	19.6	196	0.30	0	0.5	1	1	8	0.50	93
Primula veris	20.7	158	0.86	0	0.5	1	1	7	0.18	271
Prunus spinosa	18.8	1221	427	1	1	1	1	9	0.50	96
Ranunculus acris	19.3	251	1.54	0	0.5	1	0.5	7	0.39	294
Ranunculus bulbosus	19.7	144	3.51	0	1	1	1	6	0.50	124
Rhinanthus minor	26.6	244	2.54	0	0	0	0	7	0.60	187
Rosa canina agg.	13.0	928	22.63	1	1	1	1	9	0.00	3623
Rumex acetosa	25.3	229	0.44	0	0.5	1	1	6	0.48	763
Salvia pratensis	18.9	271	2.56	0	0.5	1	1	6	0.22	528
Sanguisorba minor	21.2	293	2.84	0	0.5	1	1	6	0.33	106
Saxifraga granulata	27.4	138	0.02	0	0.75	1	1	5	0.57	554
Taraxacum officinale agg.	27.3	252	0.56	0	0.75	1	0.75	5	0.47	543
Thlaspi perfoliatum	22.7	80	0.27	0	0	0	0	6	0.75	131
Tragopopgon pratensis	25.7	362	7.64	0	0	1	0		1.00	-
Trifolium pratense	23.2	366	1.39	0	0.75	1	0.75	8	0.49	348
Trifolium repens	23.6	204	0.43	0	0.5	1	1	6	0.60	47
Trisetum flavenscens	32.1	493	0.19	0	0.5	1	0.5	7	0.00	258
Valerianella locusta	38.4	86	0.65	0	0	0	0	5	1.00	-
Veronica arvensis	25.0	49	0.10	0	0	0	0	5	0.50	383
Veronica chamaedrys	32.9	206	0.19	0	0.833	1	1	7	0.40	153
Vicia angustifolia	34.6	190	13.60	0	0	0	0	7		76
Vicia tetrasperma	43.2	360	4.52	0	0	0	0	6	0.43	-
Viola hirta	19.5	199	2.27	0	0.5	1	1	6	0.29	-

Appendix Table 5: Hassberge: Species codes.

species	**code**
Achillea millefolium	sp1
Agrimonia eupatoria	sp2
Agropyron repens	sp3
Alopecurus pratensis	sp4
Anthoxanthum odoratum	sp5
Arrhenatherum elatius	sp6
Avena pubescens	sp7
Brachypodium pinnatum	sp8
Bromus erectus	sp9
Bromus hordeaceus	sp10
Bromus sterilis	sp11
Bupleurum falcatum	sp12
Centaurea jacea	sp13
Centaurea scabiosa	sp14
Cerastium brachypetalum	sp15
Cirsium arvense	sp16
Convolvulus arvensis	sp17
Cornus sanguinea	sp18
Crataegus monogyna	sp19
Dactylis glomerata	sp20
Daucus carota	sp21
Dianthus carthusianorum	sp22
Euphorbia cyparissias	sp23
Falcaria vulgaris	sp24
Festuca ovina agg.	sp25
Festuca pratensis	sp26
Festuca rubra	sp27
Fragaria viridis	sp28
Galium aparine	sp29
Galium mollugo	sp30
Galium verum	sp31
Geum urbanum	sp32
Holcus lanatus	sp33
Hypericum perforatum	sp34
Inula conyza	sp35
Knautia arvensis	sp36
Lathyrus pratensis	sp37
Leontodon hispidus	sp38
Leucanthemum vulgare	sp39
Lolium perenne	sp40
Lotus corniculatus	sp41
Luzula campestris	sp42
Medicago lupulina	sp43
Myosotis ramosissima	sp44
Ononis repens	sp45
Origanum vulgare	sp46
Pimpinella saxifraga	sp47
Plantago lanceolata	sp48
Plantago media	sp49
Poa pratensis agg.	sp50
Poa trivialis	sp51
Potentilla reptans	sp52
Potentilla neumanniana	sp53
Primula veris	sp54
Prunus spinosa	sp55
Ranunculus acris	sp56
Ranunculus bulbosus	sp57
Rhinanthus minor	sp58
Rosa canina agg.	sp59
Rumex acetosa	sp60
Salvia pratensis	sp61
Sanguisorba minor	sp62
Saxifraga granulata	sp63
Taraxacum officinale agg.	sp64
Thlaspi perfoliatum	sp65
Tragopopgon pratensis	sp66
Trifolium pratense	sp67
Trifolium repens	sp68
Trisetum flavenscens	sp69
Valerianella locusta	sp70
Veronica arvensis	sp71
Veronica chamaedrys	sp72
Vicia angustifolia	sp73
Vicia tetrasperma	sp74
Viola hirta	sp75

Appendix Table 6: Müritz: Site x species matrix. For species codes see Appendix Table 9.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31
1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0
2	1	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0
3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
4	1	1	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
7	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	1	0	0	0	1	0
10	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
11	1	1	1	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
12	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
14	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
15	1	1	1	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0
16	1	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
17	1	1	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
18	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
19	1	0	1	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0
20	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
21	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
22	1	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
23	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
25	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	1	0	1	0	0
26	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
27	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	1	0	0
28	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0
29	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1	0	0	0	1	0	0	0	1	0
30	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0
31	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
32	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1
33	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
34	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	1	1	1	0	0	1	0	1	0	0	1	0	0	0	1	1

Appendix Table 6 continued.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31
35	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	1	0	1	0	0	1	0	1	0	0	0
36	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	1	0
37	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	1	0	0	0	1	0
38	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
41	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
45	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	1	1	0	1	0	0
46	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	1	0
47	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
50	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1
51	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1
52	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0
57	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0
58	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0	0	1	0	0	0	1	0
59	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0
60	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0
61	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	1	1	0	0	1	0	1	0	1	1
62	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	1	0	1	1
63	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
64	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1
65	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0
66	1	0	1	0	1	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1	0	1	0	1	0
67	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	1	0	1	0	0	0
68	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0

Appendix Table 6 continued.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31
69	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0
70	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0
71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0
72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0
73	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0
74	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	1
75	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	1	1	0
76	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	1	1	0	1
77	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0
78	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	1	0	0	1	1	1
79	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	0	0	1	0
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0
81	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1
82	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	1	0
83	1	0	0	1	1	0	1	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0
84	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
85	1	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0
86	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1	1	0	0	0	1	0	0	0	0	1	0	1	1
87	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
88	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
89	0	0	1	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	1	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
91	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	1	1
92	1	0	0	0	1	1	1	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
93	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
94	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	1	0	1	0
95	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	1	0	1	0
96	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	1	0	0	0
97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
98	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0
99	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0
101	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 6 continued.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31
103	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	1	0	1	1
104	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0	0	1	0	1	0	0	0
105	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0
106	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	1	0	1	0	1	1
108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
109	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
110	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	1	0	1	0	0	0
111	1	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
112	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	1	1	0	0	1	0	0	0	0	0	1	0	1	0
113	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
114	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
115	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	1
116	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
117	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1
118	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
119	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0
120	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0

Appendix Table 6 continued.

site	sp32	sp33	sp34	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60
1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
5	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
7	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0
10	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
12	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
13	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
14	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
16	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
17	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
18	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
19	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
24	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
25	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0
28	0	0	1	1	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0
29	0	0	1	1	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0
30	0	1	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0
31	0	0	1	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
32	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
33	0	0	1	1	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
34	0	1	1	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0

Appendix Table 6 continued.

site	sp32	sp33	sp34	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60
35	0	1	0	0	0	1	1	0	0	1	1	0	0	1	0	0	0	1	0	1	0	0	0	1	1	0	1	1	0
36	0	0	1	1	0	1	1	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	1	0
37	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	1	1	0	1	0	0	0	1	1	0	0	0	0	0
38	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
40	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0
41	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0
42	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
44	0	1	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	1	0
45	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	0
46	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0
47	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	1	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0
50	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
51	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
57	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
58	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0
60	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	0	0	0
61	0	0	1	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0
62	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0
63	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	0	0	1	0	0	1	1	0	1	1	1
64	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	0
65	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0
66	0	1	0	0	0	0	0	1	1	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	1	0
67	0	1	0	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1	0	1	0	1	0	1	1	0	0	1	0
68	0	0	0	1	1	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Appendix Table 6 continued.

site	sp32	sp33	sp34	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60
69	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
70	0	1	0	0	1	0	0	0	1	1	1	0	0	1	0	0	1	1	0	1	0	0	0	1	1	0	1	1	1
71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	0	1	0	0	1	1	0	0	0	1	1	0	1	1	0	0	1	1	0	1	0	0	1	1	1	0	1	1	0
74	0	1	0	0	0	1	1	0	1	1	0	0	1	0	0	0	0	1	0	0	1	0	0	1	1	0	1	1	0
75	0	0	1	1	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0
76	0	1	1	0	0	1	0	0	1	1	1	1	1	0	1	0	0	1	0	1	0	0	0	0	1	0	1	1	0
77	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0
78	0	1	1	1	0	0	1	0	0	1	1	0	1	0	0	0	1	1	0	1	0	0	0	0	1	1	0	0	0
79	0	0	0	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	0
80	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	0
81	0	1	0	0	1	1	0	0	0	1	1	0	0	1	0	0	1	1	0	1	0	0	1	0	1	0	0	1	0
82	0	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
83	0	0	0	1	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
84	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0
85	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0
86	0	0	1	1	0	1	1	0	1	0	0	1	1	0	0	0	0	1	0	1	1	0	0	1	1	1	1	1	1
87	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
88	0	0	1	1	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0
89	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
90	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	0	0	0	1	0	1	0	0	0	0	1	1	1	0	1	0	0	0	0	0	1	0	0	1	1	0	0	1	0
92	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
93	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
94	0	0	1	1	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0
95	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
96	0	1	0	1	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0	1	0
97	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
98	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
99	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
100	0	1	0	0	0	0	1	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	1	1
101	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
102	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 6 continued.

site	sp32	sp33	sp34	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60
103	0	0	0	0	0	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
104	0	1	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0
105	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	1	0
106	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
107	0	1	1	1	0	1	1	0	1	1	1	1	0	1	0	0	1	1	0	1	0	0	1	1	1	0	1	1	0
108	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
109	0	0	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
110	0	1	0	1	1	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	1	0
111	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
112	0	0	0	0	0	1	1	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0
113	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
114	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0
116	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
117	0	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	1	0
118	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0
119	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	0
120	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0

Appendix Table 6 continued.

site	sp61	sp62	sp63	sp64	sp65	sp66	sp67	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75	sp76	sp77	sp78	sp79	sp80	sp81	sp82	sp83	sp84	sp85	sp86	sp87	sp88
1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	1	0
2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
4	1	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0
5	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
6	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
7	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
8	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
9	1	0	1	1	0	0	0	1	0	1	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
10	1	0	1	1	0	0	0	1	0	1	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0
11	1	1	1	0	0	0	0	1	0	0	0	1	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0
12	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
13	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
14	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
15	1	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0
16	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0
17	1	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	1	0	1	0	0	0
18	1	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	1	1	0	0	1	0	0
19	1	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0
20	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
21	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
22	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
23	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
24	1	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
25	1	1	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0
26	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0
27	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
28	1	1	1	1	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0	0	0	1	1	0	0	0	0	0
29	0	0	1	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0
30	0	0	1	0	0	1	1	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
31	0	0	1	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
32	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
33	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0
34	0	0	1	1	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Appendix Table 6 continued.

site	sp61	sp62	sp63	sp64	sp65	sp66	sp67	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75	sp76	sp77	sp78	sp79	sp80	sp81	sp82	sp83	sp84	sp85	sp86	sp87	sp88
35	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	1	0	1	1	1	0	0	0	0
36	0	0	1	1	0	1	0	1	0	1	1	1	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0
37	1	0	1	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
45	1	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0
46	1	1	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	1	0	1	1	1	0	0	0	1	0
47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
50	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
51	1	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
52	1	0	1	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0	0	1	1	0	1	1	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	1	0	0	0	1	0	1	0	0	0
57	1	0	1	1	0	1	0	1	0	0	0	1	0	1	0	0	1	0	1	0	0	1	1	0	0	0	0	0
58	1	0	1	1	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
59	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
60	1	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	1	1	1
61	0	0	0	1	0	1	1	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	1	1	0	1	1	0
62	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0
63	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
64	0	0	1	0	0	1	1	0	0	1	1	0	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0
65	1	0	0	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	1	1
66	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0
67	1	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0
68	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Appendix Table 6 continued.

site	sp61	sp62	sp63	sp64	sp65	sp66	sp67	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75	sp76	sp77	sp78	sp79	sp80	sp81	sp82	sp83	sp84	sp85	sp86	sp87	sp88
69	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
70	1	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0
71	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
72	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
73	1	0	1	0	1	0	1	0	1	1	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0
74	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
75	1	0	0	1	0	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	1	0
76	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	1	0
77	1	0	0	1	0	0	0	1	0	1	0	0	0	1	0	0	1	0	1	0	0	1	1	0	1	1	0	0
78	1	0	0	0	0	1	1	1	1	1	0	0	0	0	0	1	0	1	0	0	0	1	1	0	1	0	1	1
79	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0
80	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
81	1	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0
82	1	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0
83	1	0	0	0	1	1	1	0	0	1	0	0	1	1	0	1	0	1	0	0	0	1	0	0	0	0	1	1
84	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
85	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
86	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0
87	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
88	1	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
89	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
90	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
91	0	0	1	0	0	1	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
92	1	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0
93	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0
94	0	0	0	0	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
95	1	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0
96	1	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0
97	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
98	1	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0
99	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0	1	0	0	0	0	1	1	0	0	1	1	1
100	0	0	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0
101	1	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	0
102	1	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1	1	0

Appendix Table 6 continued.

site	sp61	sp62	sp63	sp64	sp65	sp66	sp67	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75	sp76	sp77	sp78	sp79	sp80	sp81	sp82	sp83	sp84	sp85	sp86	sp87	sp88
103	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
104	1	0	1	1	0	0	1	1	1	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	1	0
105	1	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	1
106	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
109	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0
110	1	0	1	0	1	0	1	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	1	1	1
111	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
112	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
113	0	1	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
114	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
115	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
117	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
118	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
119	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
120	0	0	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0

Appendix Table 7: Müritz: Site x environmental parameters matrix. (P=plant available phosphorus, K=plant available potassium, CaCO3=calcium carbonate, N=total nitrogen content, C=total carbon content, C/N=relation between C and N, PAW=plant available water, kf=soil water permeability of the soil, AC=air capacity,CECeff=cation exchange capacity, GIwint=grazing intensity in winter, GIsumm=grazing intensity in summer, SWLwint=soil water logging in winter)

site	P [kg*ha^{-1}]	K [kg*ha^{-1}]	$CaCO_3$ [kg*ha^{-1}]	C [kg*ha^{-1}]	N [kg*ha^{-1}]	C/N	pH	kf [cm*d^{-1}]	PAW [mm]	AC [mm]	CEC_{eff} [$cmol_c$* kg^{-1}]	GI_{summ} [%]	GI_{wint} [%]	SWL_{wint} [0=no, 1=yes]
1	523	503	0	74730	5422	13.8	6.2	653.00	54.00	168.00	2.00	0	96	0
2	590	676	0	64717	3192	20.3	4.9	564.34	54.15	161.10	2.03	96	98	0
3	290	605	0	12655	804	15.7	4.6	172.00	129.00	105.00	2.00	0	81	0
4	512	408	0	33407	2401	13.9	3.8	178.58	125.25	108.15	2.09	92	99	0
5	751	722	0	45824	2296	20.0	4.4	235.64	101.50	128.10	2.12	90	98	0
6	38	511	0	96287	7801	12.3	5.9	51.23	129.00	94.50	4.98	60	98	0
7	727	391	0	36831	1941	19.0	4.0	172.00	129.00	105.00	2.04	91	99	0
8	637	483	0	38220	5306	7.2	3.9	355.09	76.50	149.10	2.42	94	86	0
9	12	338	481312	73598	4585	16.1	7.0	24.07	128.20	49.85	9.77	71	99	0
10	62	331	0	104089	11242	9.3	5.4	567.85	51.45	162.90	3.69	63	99	0
11	409	416	0	68657	4967	13.8	5.0	653.00	54.00	168.00	2.70	100	99	0
12	64	1309	0	246933	16756	14.7	3.9	653.00	54.00	168.00	4.13	34	99	0
13	1137	275	0	44128	2198	20.1	4.2	172.00	129.00	105.00	2.04	78	99	0
14	710	216	0	60271	4394	13.7	3.8	172.00	129.00	105.00	2.14	96	99	0
15	107	296	0	108769	5713	19.0	4.5	172.00	129.00	105.00	5.63	96	99	0
16	797	289	0	108156	8692	12.4	4.2	172.00	129.00	105.00	2.73	74	99	0
17	888	430	0	114779	10043	11.4	4.2	172.00	129.00	105.00	2.18	89	99	0
18	579	966	0	93303	6498	14.4	5.5	172.00	129.00	105.00	2.23	98	99	0
19	613	215	0	102730	7230	14.2	5.7	172.00	129.00	105.00	2.46	80	99	0
20	1362	789	0	58582	896	65.4	5.1	172.00	129.00	105.00	2.98	98	99	0
21	662	597	0	81558	4875	16.7	3.9	172.00	129.00	105.00	2.19	97	99	0
22	289	279	0	128803	12075	10.7	5.6	172.00	129.00	105.00	2.00	91	99	0
23	2952	297	0	1431210	96478	14.8	5.9	300.00	192.00	96.00	25.00	39	77	1
24	64	125	668043	86061	10401	8.3	7.1	614.90	60.00	162.00	3.20	96	99	0
25	73	712	734081	77034	10864	7.1	7.3	172.00	129.00	105.00	3.44	92	99	0
26	95	171	695201	56048	9833	5.7	6.4	172.00	129.00	105.00	2.20	61	99	0
27	11	550	870955	147450	17045	8.7	7.4	75.50	127.80	85.80	6.40	76	99	0
28	18	434	363109	107373	18216	5.9	6.9	28.98	61.00	134.40	11.05	77	99	0
29	0	241	1566845	44793	6949	6.4	7.5	172.00	129.00	105.00	2.80	84	100	1
30	473	224	168237	80250	6963	11.5	7.0	172.00	129.00	105.00	3.05	22	47	1
31	0	213	1747466	158999	14495	11.0	7.2	122.44	123.15	75.75	3.96	71	43	1
32	34	99	19067	227204	20206	11.2	7.0	232.05	92.60	124.50	5.17	77	58	1
33	295	141	322766	50037	4896	10.2	6.9	183.82	158.30	66.10	2.98	77	89	1
34	0	84	0	138250	10340	13.4	6.2	653.00	54.00	168.00	6.20	67	60	1
35	5	273	1352516	37289	4212	8.9	7.5	10.18	122.15	57.55	9.57	73	78	1
36	62	215	13871	97778	7431	13.2	6.6	458.75	46.80	153.60	4.40	37	87	1
37	24	109	638829	40675	4436	9.2	7.5	172.00	129.00	105.00	2.44	76	99	0
38	20	69	138461	31867	2699	11.8	7.4	172.00	129.00	105.00	2.00	0	15	1
39	64	50	225622	27908	2390	11.7	7.4	172.00	129.00	105.00	2.93	15	49	1
40	222	80	17386	72373	3853	18.8	6.9	117.25	130.25	63.25	3.05	0	63	1
41	132	63	87489	44699	3799	11.8	7.4	269.10	81.40	137.10	2.56	16	7	0
42	75	54	101387	63185	4582	13.8	6.7	172.00	207.75	26.25	4.25	13	10	1
43	7	143	110565	96012	3489	27.5	6.9	119.33	185.60	0.00	2.75	0	35	1
44	49	91	522857	67024	6319	10.6	7.3	172.00	157.00	77.00	2.60	33	74	1
45	37	624	769650	174025	18395	9.5	7.6	23.61	117.00	83.40	13.63	84	98	0
46	32	647	905150	78505	6980	11.2	7.7	67.30	124.40	80.85	8.13	69	99	0
47	439	96	6763	101928	2015	50.6	6.8	114.02	170.65	19.25	3.91	24	31	1
48	1050	173	0	107639	3463	31.1	3.5	172.00	129.00	105.00	2.34	0	0	0
49	58	115	0	253859	15631	16.2	5.4	459.15	213.50	27.20	7.10	59	83	1
50	188	181	7299	129208	6479	19.9	6.4	172.00	214.75	19.25	2.44	47	80	1
51	209	144	222305	220915	18611	11.9	7.0	615.02	52.95	165.90	5.02	26	44	1

Appendix Table 7 continued.

site	P [kg*ha^{-1}]	K [kg*ha^{-1}]	$CaCO_3$ [kg*ha^{-1}]	C [kg*ha^{-1}]	N [kg*ha^{-1}]	C/N	pH	kf [cm*d^{-1}]	PAW [mm]	AC [mm]	CEC_{eff} [$cmol_c$* kg^{-1}]	GI_{summ} [%]	GI_{wint} [%]	SWL_{wint} [0=no, 1=yes]
52	143	168	0	252724	19292	13.1	6.6	572.23	51.60	163.20	3.32	0	99	0
53	0	98	0	143936	6467	22.3	4.9	172.00	129.00	105.00	2.23	0	0	0
54	484	170	0	183897	5465	33.6	3.3	172.00	129.00	105.00	2.15	0	0	0
55	792	225	0	212770	7819	27.2	3.3	172.00	129.00	105.00	2.15	0	0	0
56	303	211	0	48805	4726	10.3	5.0	308.22	84.00	142.80	2.00	26	99	0
57	395	159	47552	133084	13618	9.8	6.9	131.17	124.50	82.50	4.80	38	99	1
58	21	156	136174	46161	892	51.8	6.5	131.17	124.50	82.50	2.00	26	47	0
59	31	470	807664	131294	6942	18.9	5.5	65.28	124.80	69.15	7.36	50	64	0
60	518	279	64923	55841	3837	14.6	6.4	155.83	127.50	97.50	2.20	39	82	0
61	68	88	881542	96350	11052	8.7	7.5	172.00	129.00	105.00	2.40	47	77	1
62	22	141	1143365	34138	2586	13.2	7.5	54.95	127.00	73.00	10.13	41	33	1
63	0	200	2157723	9588	3793	2.5	7.0	172.00	129.00	105.00	2.00	20	20	1
64	109	168	1213283	43432	4535	9.6	7.1	63.80	121.10	83.85	8.45	36	36	1
65	8	124	0	106393	11285	9.4	5.7	233.54	98.55	127.95	3.32	33	92	0
66	106	112	197049	60637	8238	7.4	6.2	262.09	94.00	134.40	2.00	11	38	0
67	19	209	1167712	41671	932	44.7	7.0	133.27	124.80	84.00	2.00	39	69	0
68	209	187	0	82151	5104	16.1	5.5	172.00	129.00	105.00	2.00	9	84	0
69	31	122	177526	82886	3214	25.8	5.9	289.14	87.75	139.65	2.23	56	48	0
70	58	92	418462	35973	850	42.3	7.7	172.00	129.00	105.00	2.00	0	58	0
71	84	231	512507	105734	14305	7.4	7.4	272.28	91.50	136.50	2.00	39	61	0
72	232	216	0	71667	6082	11.8	4.4	308.22	84.00	142.80	2.05	57	69	0
73	1	148	1304319	33045	4708	7.0	7.3	172.00	129.00	105.00	2.00	49	62	0
74	30	138	1450853	39626	3826	10.4	7.3	30.94	107.40	67.20	8.60	37	41	1
75	37	97	969714	115215	12265	9.4	7.7	172.00	129.00	105.00	2.00	33	18	1
76	148	142	427084	75092	7879	9.5	7.0	186.88	137.80	91.00	2.76	30	59	1
77	249	138	0	160169	11618	13.8	6.1	178.58	125.25	108.15	2.00	31	100	1
78	270	116	252677	59721	5662	10.5	7.3	172.00	129.00	105.00	3.16	46	100	1
79	220	146	301424	78709	8171	9.6	7.6	308.22	84.00	142.80	3.20	36	32	0
80	0	136	1547203	226897	22945	9.9	6.6	172.00	143.00	91.00	2.72	0	46	1
81	205	120	639815	28088	4632	6.1	7.0	300.69	68.80	137.25	2.68	26	0	0
82	60	124	1303500	179518	20102	8.9	7.6	81.59	137.75	83.75	4.87	32	99	0
83	176	85	0	56518	4165	13.6	5.2	268.04	78.60	132.00	2.48	27	80	1
84	136	148	0	120251	6999	17.2	6.0	281.13	171.90	36.75	2.63	16	37	1
85	70	148	223941	31531	2858	11.0	6.1	172.00	129.00	105.00	2.13	62	68	0
86	0	60	1067280	39214	4838	8.1	7.5	172.00	185.00	49.00	2.52	76	78	1
87	303	181	69806	169483	12268	13.8	6.6	172.00	204.25	29.75	2.00	12	30	1
88	67	1075	151822	45485	4912	9.3	5.9	172.00	129.00	105.00	2.47	42	67	0
89	176	86	0	7920	1445	5.5	3.8	172.00	129.00	105.00	2.00	1	82	0
90	187	302	0	29241	1983	14.7	5.2	172.00	129.00	105.00	2.00	45	40	0
91	32	46	0	367751	20856	17.6	6.6	374.16	141.40	122.40	51.79	20	70	1
92	10	74	0	43792	2018	21.7	4.5	550.39	59.00	163.80	2.00	46	94	0
93	204	76	0	53430	4687	11.4	6.8	122.55	128.85	71.85	6.57	17	2	0
94	14	48	0	266878	20229	13.2	6.3	297.78	146.85	113.65	34.23	29	59	1
95	80	89	0	60708	2890	21.0	6.8	172.00	129.00	105.00	2.30	2	71	0
96	87	123	94407	35053	3966	8.8	6.0	172.00	129.00	105.00	2.26	5	90	0
97	105	104	0	1494100	82858	18.0	6.4	300.00	192.00	96.00	30.00	50	10	1
98	157	92	0	19680	2897	6.8	5.2	371.87	53.40	145.50	2.08	59	81	0
99	47	364	55328	37275	3446	10.8	6.0	172.00	129.00	105.00	2.13	14	87	0
100	192	76	16010	562366	25379	22.2	6.0	389.99	115.95	122.15	8.43	45	15	1
101	104	64	108450	28108	2615	10.7	5.2	492.36	62.75	160.65	2.09	27	95	0
102	102	410	83364	39425	4322	9.1	5.6	172.00	129.00	105.00	2.10	40	86	0
103	56	73	248670	23672	3049	7.8	7.4	342.40	59.00	142.50	2.93	30	35	1
104	20	151	149414	112546	5152	21.8	6.1	335.74	60.40	141.75	3.65	64	35	0
105	170	112	0	40028	3909	10.2	5.3	172.00	129.00	105.00	2.00	43	58	0
106	227	144	91575	1035758	47154	22.0	6.7	224.74	216.45	47.25	19.20	10	4	1

Appendix Table 7 continued.

site	P [$kg*ha^{-1}$]	K [$kg*ha^{-1}$]	$CaCO_3$ [$kg*ha^{-1}$]	C [$kg*ha^{-1}$]	N [$kg*ha^{-1}$]	C/N	pH	kf [$cm*d^{-1}$]	PAW [mm]	AC [mm]	CEC_{eff} [$cmol_c$* kg^{-1}]	GI_{summ} [%]	GI_{wint} [%]	SWL_{wint} [0=no, 1=yes]
107	174	91	0	42925	3881	11.1	6.9	172.00	129.00	105.00	2.63	14	53	0
108	236	88	0	1273775	67308	18.9	6.3	332.14	198.00	63.70	18.51	29	62	1
109	185	81	142531	58654	4953	11.8	6.0	445.40	144.90	79.10	2.20	0	62	0
110	342	130	0	11705	2853	4.1	5.7	172.00	129.00	105.00	2.18	14	88	0
111	4	33	0	16430	1596	10.3	5.3	460.11	52.10	159.45	2.00	48	87	0
112	168	212	135184	142693	13366	10.7	6.8	427.00	45.00	150.00	4.80	47	65	1
113	35	60	9264	18970	1458	13.0	6.3	610.15	60.80	161.20	2.00	56	94	0
114	57	88	0	30463	1999	15.2	4.0	587.48	64.80	157.20	2.00	28	97	0
115	269	110	53302	566553	35774	15.8	6.4	296.29	132.05	97.75	11.15	58	38	1
116	12	95	2546	34800	2717	12.8	4.9	404.29	65.80	155.20	2.37	64	98	0
117	228	145	29048	705515	33095	21.3	6.7	311.14	144.20	100.80	13.60	13	41	1
118	45	76	0	56247	3958	14.2	4.6	361.22	77.20	143.60	3.35	69	62	0
119	23	143	0	87621	2604	33.6	5.3	581.00	66.00	156.00	2.63	55	6	0
120	88	418	350019	68714	7368	9.3	7.2	157.31	127.65	98.25	6.29	79	99	1

Appendix Table 8: Müritz: Species x trait matrix. Species in bold letters are the responsive species.

species name	SLA [mm^{2}* mg^{-1}]	canopy height [mm]	seed number per ramet	spacers [Index]	clonality [Index]	aeren-chyma [no=0; yes=1]	thorny physical defense [no=0; yes=1]	other physical defense [no=0; yes=1]	seed mass [mg]	plant life span [Index]	SLI [Index]
Achillea millefolium	33.7	141	496	0.833	1	0	0	0	0.13	1	0.26
Agropyron repens	33.8	214.5	16	1	1	0	0	0	1.73	1	0.34
Agrostis capillaris	39.9	149	110	0.833	1	0	0	0	0.04	1	0.67
Agrostis stolonifera	59.2	199.5	544	0.667	1	1	0	0	0.06	1	0.50
Anthoxanthum odoratum	33.5	312	34	0.75	1	0	0	0	0.21	1	0.38
Armeria maritima ssp. *elongata*	25.9	62.5	72	0.5	1	0	0	0	1.03	1	0.00
Avenula pubescens	23.0	223.5	16	0.75	1	0	0	0	0.59	1	0.21
Briza media	25.5	259	18	0.833	1	0	0	0	0.26	1	0.00
Bromus hordeaceus	40.7	305.5	48	0	0	0	0	0	1.71	0.25	0.44
Calamagrostis epigejos	19.6	739	3217	1	1	1	0	1	0.12	1	0.33
Calamagrostis stricta	18.0	552	521	1	1	1	0	1	0.19	1	-
Capsella bursa-pastoris	30.7	91	1838	0	0	0	0	0	0.10	0.25	0.91
Carex arenaria	13.5	163	67	1	1	1	0	1	0.53	1	-
Carex disticha	19.5	306	219	1	1	1	0	1	0.50	1	0.44
Carex flacca	20.8	326	195	0.833	0.75	1	0	1	0.73	1	0.53
Carex hirta	22.8	221	35	1	1	1	0	1	2.23	1	0.25
Carex nigra	22.2	287	146	1	1	1	0	1	0.68	1	0.42
Carex panicea	23.0	267	27	1	1	1	0	1	1.61	1	0.36
Centaurea jacea	23.6	188	316	1	1	0	0	1	1.80	1	0.19
Cerastium arvense	46.4	121	240	1	1	0	0	0	0.15	1	0.57
Cerastium glomeratum	41.0	105	761	0	0	0	0	0	0.09	0	0.50
Cirsium arvense	14.7	388.6	957	1	1	0	1	0	0.72	1	0.53
Cirsium palustre	25.4	190	814	0	0	1	1	0	0.84	0.5	0.41
Cladium mariscus	6.3	1372	1603	1	1	1	0	1	2.36	1	0.00
Convolvulus arvensis	24.7	10	31	1	1	0	0	0	11.27	1	0.37
Cynosurus cristatus	23.2	338	139	0.5	0.5	0	0	0	0.41	1	0.06
Dactylis glomerata	27.7	588	771	0.75	1	0	0	0	0.68	1	0.39
Danthonia decumbens	22.6	129	22	0.5	0.5	1	0	0	0.70	1	0.46
Daucus carota	31.5	174.5	816	0	0	0	0	0	0.82	1	0.70
Deschampsia cespitosa	16.2	256	486	0.5	0.5	1	0	1	0.24	1	0.34
Eleocharis uniglumis	14.3	327	24	1	1	1	0	0	0.68	1	0.00
Erodium cicutarium	45.0	88	70	0	0	0	0	0	0.50	0.75	0.33
Festuca ovina agg.	21.3	179	90	0.5	0.5	0	0	0	0.71	1	0.16
Festuca pratensis	27.4	233	85	0.5	0.5	0	0	0	1.44	1	0.21
Festuca rubra	27.1	176	81	0.833	0.75	0	0	0	0.58	1	0.32
Galium mollugo	39.8	180	609	1	1	0	0	0	0.43	1	0.19
Galium palustre	59.7	228	645	1	1	1	0	1	1.23	1	0.39
Galium uliginosum	48.1	187	547	0.5	1	1	0	1	0.17	1	0.17
Galium verum	29.8	202	1622	1	1	0	0	0	0.49	1	0.15
Genista tinctoria	19.7	132.5	32	0	0	0	0	0	2.44	1	0.00
Gentianella uliginosa	30.9	130	448	0	0	1	0	0	0.12	0	-
Holcus lanatus	36.7	208	122	0.5	0.5	0	0	0	0.17	1	0.61
Hydrocotyle vulgaris	35.9	125	24	0.75	1	1	0	0	0.24	1	0.30
Juncus articulatus	19.5	294	3176	1	1	1	0	0	0.02	1	0.79
Juniperus communis	10.5	875	223	0	0	0	1	0	13.13	1	0.00
Lathyrus pratensis	37.1	202	168	1	1	0	0	0	13.41	1	0.14
Leontodon autumnalis	32.8	139	205	0.5	0.833	0	0	0	0.28	1	0.28
Leontodon hispidus	33.6	76	122	0.5	0.833	0	0	0	0.37	1	0.37
Linum catharticum	35.5	151	84	0	0	0	0	0	0.11	0.25	0.68
Lolium perenne	35.3	167	58	1	1	0	0	0	1.18	1	0.46

Appendix Table 8 continued.

species name	SLA [mm^2* mg^{-1}]	canopy height [mm]	seed number per ramet	spacers [Index]	clonality [Index]	aeren-chyma [no=0; yes=1]	thorny physical defense [no=0; yes=1]	other physical defense [no=0; yes=1]	seed mass [mg]	plant life span [Index]	SLI [Index]
Lotus corniculatus	42.7	155	210	0.75	0.5	0	0	0	0.72	1	0.46
Lotus uliginosus	40.0	175.5	181	0.75	0.5	1	0	0	0.49	1	0.38
Luzula campestris	31.9	118	37	1	1	0	0	0	0.50	1	0.46
Medicago lupulina	35.5	206.5	154	1	0.25	0	0	0	1.22	-	0.70
Mentha aquatica	33.9	219	475	0.75	1	1	0	0	0.10	1	0.43
Molinia caerulea	25.4	297	413	0.5	1	1	0	0	0.27	1	0.50
Odontites vulgaris	25.4	228	3044	0	0	0	0	0	0.18	0	-
Parnassia palustris	36.6	49.5	1972	0.5	0.833	1	0	0	0.03	1	0.14
Phragmitis australis	12.1	1224	4085	0.75	1	1	0	1	0.12	1	0.10
Pinguicula vulgaris	42.6	10.1	208	1	0.5	1	0	1	0.02	1	-
Plantago lanceolata	23.7	152.5	183	0.75	1	0	0	0	0.95	1	0.54
Poa annua	40.6	88	69	0	0	0	0	0	0.26	0	0.89
Poa pratensis agg.	29.6	199	354	0.833	0.75	0	0	0	0.23	1	0.62
Poa trivialis	49.5	495	201	0.75	1	1	0	0	0.16	1	0.83
Polygala vulgaris	22.3	115.5	48	1	0.5	0	0	0	2.21	1	0.13
Potentilla anserina	26.0	201	14	0.75	1	1	0	0	0.70	1	0.44
Potentilla erecta	35.7	144.5	461	0.5	1	1	0	0	0.29	1	0.58
Potentilla reptans	26.5	121	93	0.5	1	1	0	0	0.32	1	0.50
Prunella vulgaris	25.1	142	626	0.5	0.833	0	0	0	0.82	1	0.30
Ranunculus acris	24.2	141.5	176	0.5	0.5	1	0	0	1.16	1	0.39
Ranunculus flammula	20.0	196	1406	0.5	0.833	1	0	0	0.10	1	0.77
Ranunculus repens	26.7	186.5	60	0.5	0.833	1	0	0	1.81	1	0.73
Rhinanthus serotinus	23.0	204	536	0	0	0	0	0	1.74	0	0.00
Rumex acetosa	37.8	158.5	1194	0.5	1	0	0	0	0.44	1	0.48
Rumex acetosella	41.1	117.5	391	0.75	1	0	0	0	0.27	1	0.75
Salix repens	18.1	163.5	1532	0.5	1	1	0	0	-	1	0.00
Stellaria graminea	43.8	182.5	329	0.75	1	0	0	0	0.19	1	0.45
Succisa pratensis	17.8	54	124	0.5	0.5	1	0	1	0.66	1	0.20
Taraxacum officinale agg.	34.8	211	543	0.75	0.75	0	0	0	0.47	1	0.47
Taraxacum palustre	19.1	99	90	1	0.5	1	0	0	0.58	1	-
Trifolium fragiferum	31.5	189	41	0.5	1	1	0	0	1.07	1	0.00
Trifolium pratense	26.0	171	165	0.75	0.75	0	0	0	1.09	1	0.49
Trifolium repens	35.5	136	29	0.5	1	0	0	0	0.34	1	0.60
Valeriana dioica	33.9	83	102	0.75	0.833	1	0	0	0.53	1	0.00
Veronica arvensis	35.7	100	383	0	0	0	0	0	0.10	0	0.50
Veronica chamaedrys	40.5	144.5	223	0.833	1	0	0	0	0.17	1	0.40
Vicia cracca	42.4	240.5	280	1	1	0	0	0	12.28	1	0.10
Viola canina	35.2	119	96	0.75	0.75	0	0	0	0.85	1	0.56

Appendix Table 9: Müritz: Species codes.

species	code
Achillea millefolium	sp1
Agropyron repens	sp2
Agrostis capillaris	sp3
Agrostis stolonifera	sp4
Anthoxanthum odoratum	sp5
Armeria maritima spp. elongata	sp6
Avenula pubescens	sp7
Briza media	sp8
Bromus hordeaceus	sp9
Calamagrostis epigejos	sp10
Calamagrostis stricta	sp11
Capsella bursa-pastoris	sp12
Carex arenaria	sp13
Carex disticha	sp14
Carex flacca	sp15
Carex hirta	sp16
Carex nigra	sp17
Carex panicea	sp18
Centaurea jacea	sp19
Cerastium arvense	sp20
Cerastium glomeratum	sp21
Cirsium arvense	sp22
Cirsium palustre	sp23
Cladium mariscus	sp24
Convolvulus arvensis	sp25
Cynosurus cristatus	sp26
Dactylis glomerata	sp27
Danthonia decumbens	sp28
Daucus carota	sp29
Deschampsia cespitosa	sp30
Eleocharis uniglumis	sp31
Erodium cicutarium	sp32
Festuca ovina agg.	sp33
Festuca pratensis	sp34
Festuca rubra	sp35
Galium mollugo	sp36
Galium palustre	sp37
Galium uliginosum	sp38
Galium verum	sp39
Genista tinctoria	sp40
Gentianella uliginosa	sp41
Holcus lanatus	sp42
Hydrocotyle vulgaris	sp43
Juncus articulatus	sp44
Juniperus communis	sp45
Lathyrus pratensis	sp46
Leontodon autumnalis	sp47
Leontodon hispidus	sp48
Linum carthaticum	sp49
Lolium perenne	sp50
Lotus corniculatus	sp51
Lotus uliginosus	sp52
Luzula campestris	sp53
Medicago lupulina	sp54
Mentha aquatica	sp55
Molinia caerulea	sp56
Odontites vulgaris	sp57
Parnassia palustris	sp58
Phragmitis australis	sp59
Pinguicula vulgaris	sp60
Plantago lanceolata	sp61
Poa annua	sp62
Poa pratensis agg.	sp63
Poa trivialis	sp64
Polygala vulgaris	sp65
Potentilla anserina	sp66
Potentilla erecta	sp67
Potentilla reptans	sp68
Prunella vulgaris	sp69
Ranunculus acris	sp70
Ranunculus flammula	sp71
Ranunculus repens	sp72
Rhinanthus serotinus	sp73
Rumex acetosa	sp74
Rumex acetosella	sp75
Salix repens	sp76
Stellaria graminea	sp77
Succisa pratensis	sp78
Taraxacum officinale agg.	sp79
Taraxacum palustre	sp80
Trifolium fragiferum	sp81
Trifolium pratense	sp82
Trifolium repens	sp83
Valeriana dioica	sp84
Veronica arvensis	sp85
Veronica chamaedrys	sp86
Vicia cracca	sp87
Viola canina	sp88

Appendix Table 10: Hassberge: Sensitivity of responsive species to environmental factors. The appendix '2' labels the square of the variable. (AUC = area under ROC-curve, R²N = coefficient of determination for linear regression models, PAW = plant available water, freq 0 disturbance frequency, week = siturbance week, dist_ag =above-ground disturbance 1997, CECeff = effective cation exchanfe capacity, N = total nitrogen, K = plant available potassium, dist_bg = below-ground disturbance 1997, magn = disturbance magnitude, expos = exposition)

species	AUC	R^2_N	pH2	pH	PAW	PAW2	freq2	freq	week	week2	slope2	slope	dist_ag	$CEC_{eff}2$	CEC_{eff}	N2	N	K2	K	dist_bg	magn	expos
Trifolium pratense	0.909	0.6219	-0.104	-	-	-	-	-	-	-	-0.006	-	3.2174	-	-	-	-	-	-	-	-	-
Plantago lanceolata	0.955	0.7592	-0.166	-	-	-	-	-	-	-	-	-	5.0953	-	-	-	-	-	-	-	-	-
Knautia arvensis	0.861	0.4074	0.0862	-	-	-	-	-	-	-	-	-	3.9899	-	-	-	-	-	-	-	-	-
Prunus spinosa	0.806	0.3495	0.1218	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-2.678	-	-
Lolium perenne	0.923	0.4855	-1.692	17.573	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Saxifraga granulata	0.919	0.5284	-	-2.38	-	-	-	-	-	-	-	-	-	-	-	-	-3E-04	-	-	-	-	-
Fragaria viridis	0.846	0.4907	-	1.4392	-	-	-	-	-	-	-	-	-	-	-	-	-	-1E-07	-	-9.567	-0.02	-
Potentilla neumanniana	0.868	0.4444	0.1711	-	-	-2E-04	-	-	-	-	-	-	2.4864	-	-	-	-	-	-	-	-	-
Festuca ovina	0.873	0.5459	0.1783	-	-	0.0002	-	-	-	-	-	-	-	-	0.055	-	-	-	-0.001	-2.998	-	-
Viola hirta	0.851	0.4457	0.1495	-	-	0.0002	-	-	-	-	-	-	-	-	-	-	-	-	-	-9.68	-0.028	-
Luzula campestris	0.977	0.8047	-2.432	26.995	-0.195	0.0017	-	-	0.1714	-	-	-	17.893	-	-	-	-	-	-	-	-	-
Bromus hordeaceus	0.916	0.4780	-0.18	-	-0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.4316	-0.192	-
Anthoxanthum odoratum	0.989	0.8370	-0.308	-	0.0549	-	-	-	-	-	-	-	11.437	-	-	-	-	-	-	-	-	-
Leontodon hispidus	0.931	0.5769	13.141	-1.168	-	0.0002	-	-	-	-	-	-	9.4513	-	-	-	-	-	-	-	-	-
Ranunculus acris	0.918	0.5235	-0.091	-	-	0.0003	-	-	-	-	-	-	2.5493	-	-	-	-	-	-	-	-	-
Veronica chamaedrys	0.875	0.4651	-	-	0.0337	-	-	0.3356	-	-	-	-	-	-	-0.055	-	-	-	-0.002	-	-	-
Lathyrus pratensis	0.883	0.4516	-	-	0.0264	-	-	-	-0.112	-	-	-	-	-	-0.081	-	-	-	-	-	-	-
Primula veris	0.839	0.3955	-	-	0.0178	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-9.089	-0.182	-
Inula conyza	0.910	0.4100	-	-	-0.027	-	-	-	-	-	-	-	-	0.0029	-	-	-	-	-	-8.228	-	-
Centaurea jacea	0.794	0.3095	-	-	0.0169	-	-0.134	-	-	-	-	-	2.4609	-	-	-	-	-	-	-	-	-
Rhinanthus minor	0.911	0.5273	-	-	-	-	-0.156	-	-	-	-	-	10.949	-	-0.066	-	-	-	-	-	-0.198	-
Holcus lanatus	0.983	0.8228	-	-3.04	-	-	0.3619	-	-	0.0016	-	-	10.595	-	-	-	-	-	-	-8.792	-	-
Galium verum	0.850	0.3834	-	-	-	-	-	-1.286	0.831	-0.011	-	-	-	-	-	-	-	-	-7E-04	-2.009	-	-1.467
Brachypodium pinnatum	0.851	0.3301	-	-	-	-	-	-0.916	-	-	0.0039	-	-	-	-	-	-	-	-6E-04	-	-	-1.653
Sanguisorba minor	0.942	0.6943	-	1.081	-	-	-	-0.514	-	-	-0.016	0.6351	3.5737	-	-	-	-	-	-6E-04	-	-	-
Cirsium arvense	0.934	0.6559	-	-	-	-	-	-0.448	-	-	-	-0.201	-	-	-	-	-	-	-	2.9968	-	-
Origanum vulgare	0.842	0.3211	-	-	-	-	-	-1.696	-	-	-	-	-	-	-	-	-	-	-	-	-0.045	-
Poa trivialis	0.963	0.7404	-	-	-	-	-	-59.43	-	-	-	-	-	-	-	-	-	-	-	296.89	4.7391	-
Euphorbia cyparissias	0.957	0.7005	-	-	-	-	-	-2.039	6.3351	-0.096	-	-	-34.35	-	0.2524	9E-09	-	-	-	-48.96	-0.079	-
Thlaspi perfoliatum	0.901	0.5200	-	-	-	-2E-04	-	-	0.7807	-0.01	0.0052	-	-	-	-	-	-	-	-	-	-	-
Bromus erectus	0.803	0.3237	-	-	-	-	-	-	0.0984	-	-	-	4.2922	-	-	-	-	-	-	-	-	-
Taraxacum officinale	0.871	0.5051	-	-	-	-	-	-	-0.117	-	-	-0.183	-	-	-	-8E-09	-	-	-	-	-	-
Alopecurus pratensis	0.968	0.7717	-0.228	-	-	-	-	-	-0.139	-	-	-0.435	-	-	-	-	-	-	-	-4.355	-	2.4118
Cornus sanguinea	0.829	0.3049	-	-	-	-	-	-	-	0.0018	-	-	-	-	-	-	-	-	-	-	-0.038	-
Dactylis glomerata	0.773	0.3310	-	-	-	-	-	-	-	-9E-04	-	-	-	-0.001	-	-	-	-	-	-	-	-
Trifolium repens	0.815	0.3100	-	-1.075	-	-	-	-	-	-8E-04	-	-	-	-	-	-	-	-	-	-	-	-
Rumex acetosa	0.980	0.8314	-1.833	19.795	-	-	-	-	-	-	-	-0.23	11.553	0.0289	-1.713	-	-	-	-	-	-	-
Plantago media	0.813	0.3324	-	-	-	-	-	-	-	-	-	-0.114	2.9988	-	-	-	-	-	-	-	-	-
Cerastium brachypetalum	0.804	0.3140	-	-	-0.016	-	-	-	-	-	-	-0.165	2.9857	-	-	-	-	-	-	-	-	-
Centaurea scabiosa	0.906	0.4185	-	-	-	-	-	-	-	-	0.0033	-	1.9038	0.0043	-	-	-	-	-	-	-	-
Avena pubescens	0.905	0.5635	-	-	-	-	-	-	-	-	-0.006	-	11.033	-	-0.057	-	-	-	-	-	-	-
Salvia pratensis	0.919	0.6112	-	1.6175	-	-	-	-	-	-	0.006	-	4.3072	-	-	-	-	-	-	-	-0.051	-
Convolvulus arvensis	0.809	0.4013	-	-	-	-	-	-	-	-	-0.005	-	-	-	-	-	-	-	-	1.287	-	1.3004
Rosa canina agg.	0.830	0.3492	-	-	-0.016	-	-	-	-	-	0.0035	-	-	-	-	-	-	-	-	-	-	8.2743

Appendix Table 10 continued.

species	AUC	R^2_N	pH2	pH	PAW	PAW2	freq2	freq	week	week2	slope2	slope	dist_ag	$CEC_{eff}2$	CEC_{eff}	N2	N	K2	K	dist_bg	bio_de	expos
Galium aparine	0.799	0.4196	-	-	-	-	-	-	-	-	-	-	-3.068	-	-	7E-09	-	-	-	-	-	-
Trisetum flavenscens	0.802	0.3546	-	-	-	-	-	-	-	-	-	-	2.2025	-	-	-3E-08	0.0005	-	-	-	-	-
Ranunculus bulbosus	0.792	0.4128	-	-	-	-	-	-	-	-	-	-	3.7833	-	-	-	-	-	-	-	-	-
Poa pratensis agg.	0.850	0.4891	-	-	-	-	-	-	-	-	-	-	2.494	-	-	-	-	-	-5E-04	-	-	-
Lotus corniculatus	0.854	0.5205	-	-	-	-	-	-	-	-	-	-	2.5594	-	-	-	-	-	-	-	-0.051	-
Achillea millefolium	0.761	0.3016	-	-	-	-	-	-	-	-	-	-	1.5198	-	-	-	-	-	-	-1.099	-	-
Bromus sterilis	0.843	0.3483	-	-	-	-	-	-	-	-	-	-	-	0.0041	-	-	-	-	-	1.2985	-	-

Appendix Table 11: Hassberge: Plant functional groups with statistical values and their species with traits. For index explanation see Chapter 3.

PFG	species name	SLA $[mm^{2}*mg^{-1}]$	canopy height [mm]	plant life span [Index]	seed number per ramet	seed mass [mg]	woodiness [Index]	spacers [Index]	clonality [Index]	start seed shedding [month]	SLI [Index]
1	*Bromus erectus*	20.6	297	1	83	3.69	0	0.5	0.5	6	0.20
	Centaurea scabiosa	18.3	231	1	210	6.74	0	0.75	0.75	7	0.25
	Festuca ovina agg.	13.2	211	1	469	0.38	0	0.5	0.5	6	0.16
	Knautia arvensis	20.2	409	1	192	3.34	0	0.5	1	7	0.08
	Plantago lanceolata	19.8	300	1	384	1.64	0	0.75	1	7	0.54
	Plantago media	21.3	191	1	282	0.30	0	0.75	1	8	0.42
	Poa pratensis agg.	22.7	244	1	281	0.25	0	0.833	0.75	6	0.62
	Potentilla neumanniana	16.8	58	1	203	0.48	0	0.5	1	5	0.60
	Primula veris	20.7	158	1	271	0.86	0	0.5	1	7	0.18
	Ranunculus acris	19.3	251	1	294	1.54	0	0.5	0.5	7	0.39
	Ranunculus bulbosus	19.7	144	1	124	3.51	0	1	1	6	0.50
	Salvia pratensis	18.9	271	1	528	2.56	0	0.5	1	6	0.22
	Sanguisorba minor	21.2	293	1	106	2.84	0	0.5	1	6	0.33
	Trifolium pratense	23.2	366	1	348	1.39	0	0.75	0.75	8	0.49
	Trifolium repens	23.6	204	1	47	0.43	0	0.5	1	6	0.60
	median	20.2	244	1	271	1.54	0	0.50	1.00	6	0.39
	mean	20.0	242	1	255	2.00	0	0.62	0.85	7	0.37
	standard deviation	2.61	88.28	0.00	138.76	1.81	0.00	0.17	0.21	0.83	0.18
	coefficient of variation	0.13	0.37	0.00	0.54	0.91	0.00	0.27	0.24	0.13	0.49
2	*Convolvulus arvensis*	25.7	10	1	31	14.02	0	1	1	8	0.37
	Leontodon hispidus	31.3	208	1	84	0.75	0	0.5	0.833	7	0.37
	Lolium perenne	30.9	268	1	58	1.60	0	1	1	8	0.46
	Luzula campestris	29.7	104	1	44	0.64	0	1	1	6	0.46
	Rumex acetosa	25.3	229	1	763	0.44	0	0.5	1	6	0.48
	Saxifraga granulata	27.4	138	1	554	0.02	0	0.75	1	5	0.57
	Taraxacum officinale agg.	27.3	252	1	543	0.56	0	0.75	0.75	5	0.47
	Veronica chamaedrys	32.9	206	1	153	0.19	0	0.833	1	7	0.40
	median	28.6	207	1	119	0.60	0	0.79	1.00	7	0.46
	mean	28.8	177	1	279	2.28	0	0.79	0.95	7	0.45
	standard deviation	2.79	87.20	0.00	292.54	4.77	0.00	0.21	0.10	1.20	0.07
	coefficient of variation	0.10	0.49	0.00	1.05	2.09	0.00	0.26	0.10	0.18	0.15

Appendix Table 11 continued.

PFG	species name	SLA [mm^{2}*mg^{-1}]	canopy height [mm]	plant life span [Index]	seed number per ramet	seed mass [mg]	woodiness [Index]	spacers [Index]	clonality [Index]	start seed shedding [month]	SLI [Index]
3	*Achillea millefolium*	29.0	463	1	343	0.12	0	0.833	1	8	0.26
	Alopecurus pratensis	25.8	466	1	414	0.67	0	1	1	8	0.39
	Avenula pubescens	27.6	333	1	16	1.28	0	0.75	1	6	0.21
	Brachypodium pinnatum	28.1	440	1	83	2.77	0	1	1	7	0.10
	Centaurea jacea	25.9	579	1	183	1.62	0	1	1	8	0.19
	Dactylis glomerata	27.7	588	1	771	0.68	0	0.75	1	6	0.39
	Euphorbia cyparissias	34.1	335	1	435	2.21	0	1	1	5	0.71
	Lathyrus pratensis	32.4	420	1	103	12.82	0	1	1	7	0.14
	Lotus corniculatus	28.8	355	1	426	1.20	0	0.75	0.5	7	0.46
	Origanum vulgare	23.7	514	1	316	0.10	0	1	1	10	0.75
	Trisetum flavenscens	32.1	493	1	258	0.19	0	0.5	0.5	7	0.00
	median	28.1	463	1	316	1.20	0	1.00	1.00	7	0.26
	mean	28.7	453	1	304	2.15	0	0.87	0.91	7	0.33
	standard deviation	3.13	88.81	0.00	212.77	3.64	0.00	0.17	0.20	1.33	0.24
	coefficient of variation	0.11	0.20	0.00	0.70	1.69	0.00	0.19	0.22	0.18	0.74
4	*Bromus hordeaceus*	30.4	284	0.25	48	2.68	0	0	0	5	0.44
	Bromus sterilis	32.4	281	0	138	8.16	0	0	0	6	0.00
	Cerastium brachypetalum	21.8	91	0	1418	0.05	0	0	0	5	0.00
	Galium aparine	33.8	437	0	190	7.79	0	0	0	8	0.35
	Rhinanthus minor	26.6	244	0	187	2.54	0	0	0	7	0.60
	Thlaspi perfoliatum	22.7	80	0	131	0.27	0	0	0	6	0.75
	median	28.5	263	0	163	2.61	0	0.00	0.00	6	0.40
	mean	27.9	236	0	352	3.58	0	0.00	0.00	6	0.36
	standard deviation	5.06	134.35	0.10	524.78	3.58	0.00	0.00	0.00	1.17	0.31
	coefficient of variation	0.18	0.57	2.45	1.49	1.00	0.00	0.00	0.00	0.19	0.86

Appendix Table 11 continued.

PFG	species name	SLA [mm²*mg^{-1}]	canopy height [mm]	plant life span [Index]	seed number per ramet	seed mass [mg]	woodiness [Index]	spacers [Index]	clonality [Index]	start seed shedding [month]	SLI [Index]
5	*Anthoxanthum odoratum*	39.8	207	1	169	0.48	0	0.75	1	6	0.38
	Holcus lanatus	40.3	393	1	122	0.32	0	0.5	0.5	7	0.61
	Poa trivialis	49.5	495	1	201	0.15	0	0.75	1	6	0.83
	median	40.3	393	1	169	0.32	0	0.75	1.00	6	0.61
	mean	43.2	365	1	164	0.31	0	0.67	0.83	6	0.60
	standard deviation	5.46	146.03	0.00	39.74	0.17	0.00	0.14	0.29	0.58	0.23
	coefficient of variation	0.13	0.40	0.00	0.24	0.53	0.00	0.22	0.35	0.09	0.37
6	*Cirsium arvense*	15.5	742	1	957	0.86	0	1	1	7	0.53
	Galium verum	25.6	495	1	1622	0.46	0	1	1	8	0.15
	median	20.6	619	1	1290	0.66	0	1.00	1.00	8	0.34
	mean	20.6	619	1	1290	0.66	0	1.00	1.00	8	0.34
	standard deviation	7.13	174.66	0.00	470.23	0.28	0.00	0.00	0.00	0.71	0.27
	coefficient of variation	0.35	0.28	0.00	0.36	0.42	0.00	0.00	0.00	0.09	0.79
7	*Cornus sanguinea*	17.6	1366	1	1750	35.16	1	1	1	9	0.20
	Prunus spinosa	18.8	1221	1	96	427.13	1	1	1	9	0.50
	median	18.2	1294	1	923	231.15	1	1.00	1.00	9.00	0.35
	mean	18.2	1294	1	923	231.15	1	1.00	1.00	9.00	0.35
	standard deviation	0.80	102.53	0.00	1169.55	277.17	0.00	0.00	0.00	0.00	0.21
	coefficient of variation	0.04	0.08	0.00	1.27	1.20	0.00	0.00	0.00	0.00	0.61
8	*Rosa canina* agg.	13.0	928	1	3623	22.63	1	1	1	9	0.00
	median	-	-	-	-	-	-	-	-	-	-
	mean	-	-	-	-	-	-	-	-	-	-
	standard deviation	-	-	-	-	-	-	-	-	-	-
	coefficient of variation	-	-	-	-	-	-	-	-	-	-

Appendix Table 12: Müritz: Sensitivity of responsive species to environmental factors. The appendix '2' labels the square of the variable. (AUC = area under ROC-curve, R²N = coefficient of determination for linear regression models, kf = water permeability in saturated soil, PAW = plant available water, P = plant available phosphorus, K = plant available potassium, SWLwint = soil water logging in winter, GIsumm/GIwint = grazing intensity in summer/winter)

species	AUC	R^2_N	kf2	kf	PAW2	PAW	P2	P	K2	K	SWL_{wint}	$GI_{summ}2$	GI_{summ}	pH2	pH	$GI_{wint}2$	GI_{wint}
Taraxacum palustre	0.931	0.5584	-	-0.0348702	-	-	-	-	-	-	-	-	-	-	-	-0.0005202	-
Ranunculus repens	0.817	0.3498	-	0.0031528	-	-	-	-	-	-	-	-	0.0271057	-0.6239888	8.4965903	-	0.0209408
Potentilla anserina	0.883	0.5131	-	0.003941	-	-	-	-	-	-	2.7667884	-	0.0288393	-	0.9959561	-	-
Carex nigra	0.820	0.3062	-	0.003728	-	-	-	-	-	-	2.766711	-	-	-	-	-	-
Calamagrostis stricta	0.906	0.4567	-	-	5.31E-05	-	-	-	-	-	9.6631259	-	-	-	-	-	-
Mentha aquatica	0.937	0.7014	-	-	7.051E-05	-	-	-	-	-	2.023656	-	-	0.1163348	-	-0.0012716	0.1244674
Carex hirta	0.829	0.3974	-	-	-6.337E-05	-	-	-	-	-	-	-	-	-0.7170717	9.0916992	0.0003247	-
Cirsium arvense	0.819	0.3784	-	-	-6.768E-05	-	-	-	-	-	-	-	-	0.1053505	-	0.0002542	-
Cladium mariscus	0.958	0.4746	-	-	0.0001209	-	-	-	-	-	-	-	-0.0507259	0.1478725	-	-	-
Deschampsia cespitosa	0.799	0.3234	-	-	-4.485E-05	-	-	-	-	-	-	-	-	0.0988687	-	-	-
Potentilla reptans	0.830	0.4154	-	-	-8.575E-05	-	-	-	-	-	-	-	-	-0.6612889	9.0424577	-	0.0317279
Danthonia decumbens	0.851	0.3964	-	-0.0060647	-0.0001001	-	-	-	-	-0.0073632	-	-	-	-	-	-0.0010571	0.1067416
Briza media	0.865	0.4601	-	-0.0065789	-0.0001116	-	-	-	-	-0.0072544	-	-	-	0.0818287	-	-	-
Cerastium glomeratum	0.845	0.4378	-	-	-	-0.0255869	-	-	-	-	-	-	-	-	0.9158655	0.0003883	-
Carex panicea	0.835	0.3986	-	-	-	-0.0111629	-	-	-	-0.0081117	1.2689227	-	-	-	0.7058331	-	-
Anthoxanthum odoratum	0.841	0.4191	-1.048E-05	-	-	-0.0327125	-	-0.0039571	-	-	-1.8560874	-0.0001999	-	-	-	-	-
Centaurea jacea	0.828	0.4306	-1.14E-05	-	-8.58E-05	-	-	-0.0070537	-	-0.0036941	-	-	-	-	-	-	-
Luzula campestris	0.833	0.3473	-	-	-	-	-	-0.0049021	-	-	-2.6761454	-0.0002224	-	-	-	-	-
Capsella bursa-pastoris	0.973	0.6839	-	-	-	-	-	0.002279	-	-	-	0.0009521	-	-	-	-	-
Erodium cicutarium	0.953	0.6071	-	-	-	-	-	0.0024228	-	-	-	0.0006491	-	-	-	-	-
Carex arenaria	0.946	0.5566	-	-	-	-	-	-0.014069	-	-	-	-	-	-0.1985231	-	-	-
Bromus hordeaceus	0.886	0.4401	-	-	-	-	-	0.0017499	-	-	-	-	-	-	-	0.0004336	-
Veronica arvensis	0.920	0.4870	-	-	-	-	-	0.0018737	-	-	-	-	-	-	-	0.000718	-
Leontodon autumnalis	0.814	0.3748	-	-	-	-	-	-0.0058104	-7.791E-06	0.0107379	-	-	-	-	-	0.0001814	-
Ranunculus acris	0.837	0.4196	-	-	-	-	-	-	-5.039E-05	0.0218717	-	-	-	0.08186	-	0.0002675	-
Dactylis glomerata	0.894	0.3771	-	-	-	-	-	-	-1.496E-05	0.0194659	-	-	-	-	-	-	-
Agropyron repens	0.893	0.4495	4.397E-06	-	-	-	-	-	-7.378E-06	0.0115761	-	-	-	-	-0.8581676	-	-
Phragmitis australis	0.883	0.5366	-	-	-	-	-	-	9.19E-06	-0.0138702	0.9058004	-	-	-	-	-0.0008543	0.0757
Hydrocotyle vulgaris	0.852	0.4020	-	-	-	-	-	-	-	-0.0098421	2.2640605	-	-	-	-	-	-
Poa annua	0.952	0.6456	-	-	-	-	-	-	-8.48E-06	0.0121701	-8.3649864	0.0003678	-	-	-	-	-
Rumex acetosella	0.959	0.7480	-	-	-	-	-	-	-2.296E-06	-	-8.7338139	0.0003609	-	-0.1395146	-	-	0.0404724

Appendix Table 12 continued.

species	AUC	R^2_N	kf2	kf	PAW2	PAW	P2	P	K2	K	SWL_{wint}	$GI_{summ}2$	GI_{summ}	pH2	pH	$GI_{wint}2$	GI_{wint}
Carex disticha	0.954	0.6436	-	-	-	-	-	-	-	-	17.95072	0.0024604	-0.1522596	-3.0159663	35.52263	-	-
Juncus articulatus	0.873	0.4298	-	-	-	-	-	-	-	-	1.9508841	-0.0012461	0.1411948	-	0.755244	-	-
Galium palustre	0.916	0.5807	-	-	-	-	-	-	-	-	3.2826996	-0.0009872	0.1103769	-	-	-0.0002881	-
Poa pratensis agg.	0.811	0.3721	-	-	-	-	-	-	-	-	-1.1647236	0.0002496	-	-	-	-	0.0169454
Trifolium fragiferum	0.856	0.3780	-	-	-	-	-	-	-	-	3.6453467	-	0.0309927	-	-	-	-
Galium uliginosum	0.839	0.4415	-	-	-	-	-	-	-	-	3.552858	-	-	-	-	-	-
Achillea millefolium	0.870	0.4790	-	-	-	-	-	-	-	-	-2.6739603	-	-	-	-	0.0002844	-
Eleocharis uniglumis	0.839	0.4415	-	-	-	-	-	-	-	-	3.552858	-	-	-	-	-	-
Valeriana dioica	0.849	0.3351	-	-	-	-	-	-	-	-	1.5593046	-	-	0.1186776	-	-	-
Agrostis capillaris	0.882	0.5411	-5.892E-06	-	-	-	-	-	-	-	-2.4710948	-	-	-0.5811387	6.2907744	-	0.0245498
Cerastium arvense	0.876	0.4502	-	-	-	-	-	-	-	-	-1.9062038	-	-	-0.6042861	6.3487908	0.0003095	-
Plantago lanceolata	0.840	0.4346	-	-	-	-	-	-	-	-	-3.0286402	-	-	-	1.0284927	0.0001682	-
Potentilla erecta	0.804	0.3673	-	-	-	-	-	-	-	-	-	-0.001243	0.0747047	-	0.7099349	-	-
Convolvulus arvensis	0.895	0.3652	-	-	-	-	-	-	-	-	-	0.0002566	-	-1.0867657	10.748597	-	-
Trifolium repens	0.837	0.4202	-	-	-	-	-	-	-	-	-	-	-	-0.3427663	4.6263256	0.0004436	-
Molinia caerulea	0.866	0.4759	-	-	-	-	-	-	-	-	-	-	-	0.1031655	-	-0.0008396	0.0671166
Odontites vulgaris	0.907	0.3933	-	-	-	-	-	-	-	-	-	-	-	0.1620682	-	0.0002885	-
Parnassia palustris	0.896	0.4035	-	-	-	-	-	-	-	-	-	-	-	0.174263	-	-0.0002531	-
Carex flacca	0.813	0.3227	-	-	-	-	-	-	-	-	-	-	-	0.0931707	-	-0.0001617	-
Gentianella uliginosa	0.873	0.3551	-	-	-	-	-	-	-	-	-	-	-	0.1509165	-	-0.0002114	-
Trifolium pratense	0.844	0.4147	-	-	-	-	-	-	-	-	-	-	-	0.1009775	-	0.0003951	-
Lolium perenne	0.922	0.5952	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0007792	-

Appendix Table 13: Müritz: Plant functional groups with statistical values and their species with traits. Grey marked groups indicate low quality measures. For trait index explanation see Chapter 4.

PFG	***species name***	**aeren-chyma [0=no, 1=yes]**	**thorny physical defence [0=no, 1=yes]**	**spacers [Index]**	**SLI [Index]**	**canopy height [mm]**	**plant life span [Index]**	**clonality [Index]**	**SLA $[\mathrm{mm}^2*\mathrm{mg}^{-1}]$**	**other physical defense [0=no, 1=yes]**	**seed number per ramet**	**seed mass [mg]**
1	*Bromus hordeaceus*	0	0	0	0.44	306	0.25	0	40.7	0	48	1.71
	Cerastium glomeratum	0	0	0	0.5	105	0	0	41.0	0	761	0.09
	Erodium cicutarium	0	0	0	0.33	88	0.75	0	45.0	0	70	0.50
	Veronica arvensis	0	0	0	0.5	100	0	0	35.7	0	383	0.10
	median	0.00	0.00	0.00	0.47	103	0.13	0.00	40.85	0.00	226	0.30
	mean	0.00	0.00	0.00	0.44	150	0.25	0.00	40.60	0.00	315	0.60
	standard deviation	0.00	0.00	0.00	0.08	104.16	0.35	0.00	3.83	0.00	334.05	0.77
	coefficient of variation	0.00	0.00	0.00	0.18	0.70	1.41	0.00	0.09	0.00	1.06	1.27
2	*Carex disticha*	1	0	1	0.44	306	1	1	19.5	1	219	0.50
	Carex flacca	1	0	0.83	0.53	326	1	0.75	20.8	1	195	0.73
	Carex hirta	1	0	1	0.25	221	1	1	22.8	1	35	2.23
	Carex nigra	1	0	1	0.42	287	1	1	22.2	1	146	0.68
	Carex panicea	1	0	1	0.36	267	1	1	23.0	1	27	1.61
	Galium palustre	1	0	1	0.39	228	1	1	59.7	1	645	1.23
	Hydrocotyle vulgaris	1	0	0.75	0.3	125	1	1	35.9	0	24	0.24
	Juncus articulatus	1	0	1	0.79	294	1	1	19.5	0	3176	0.02
	Mentha aquatica	1	0	0.75	0.43	219	1	1	33.9	0	475	0.10
	Potentilla anserina	1	0	0.75	0.44	201	1	1	26.0	0	14	0.70
	median	1.00	0.00	1.00	0.42	248	1.00	1.00	22.94	1.00	170	0.69
	mean	1.00	0.00	0.91	0.44	247	1.00	0.98	28.33	0.60	496	0.80
	standard deviation	0.00	0.00	0.12	0.15	60.32	0.00	0.08	12.40	0.52	965.07	0.70
	coefficient of variation	0.00	0.00	0.13	0.34	0.24	0.00	0.08	0.44	0.86	1.95	0.87

Appendix Table 13 continued.

PFG	*species name*	**aeren-chyma [0=no, 1=yes]**	**thorny physical defence [0=no, 1=yes]**	**spacers [Index]**	**SLI [Index]**	**canopy height [mm]**	**plant life span [Index]**	**clonality [Index]**	**SLA [mm^2*mg^{-1}]**	**other physical defense [0=no, 1=yes]**	**seed number per ramet**	**seed mass [mg]**
3	*Danthonia decumbens*	1	0	0.5	0.46	129	1	0.5	22.6	0	22	0.70
	Deschampsia cespitosa	1	0	0.5	0.34	256	1	0.5	16.2	1	486	0.24
	Molinia caerulea	1	0	0.5	0.5	297	1	1	25.4	0	413	0.27
	Potentilla erecta	1	0	0.5	0.58	145	1	1	35.7	0	461	0.29
	Potentilla reptans	1	0	0.5	0.5	121	1	1	26.5	0	93	0.32
	Ranunculus acris	1	0	0.5	0.39	142	1	0.5	24.2	0	176	1.16
	Ranunculus repens	1	0	0.5	0.73	187	1	0.83	26.7	0	60	1.81
	median	1.00	0.00	0.50	0.50	145	1.00	0.83	25.40	0.00	176	0.32
	mean	1.00	0.00	0.50	0.50	182	1.00	0.76	25.32	0.14	245	0.68
	standard deviation	0.00	0.00	0.00	0.13	68.67	0.00	0.25	5.82	0.38	202.03	0.60
	coefficient of variation	0.00	0.00	0.00	0.26	0.38	0.00	0.33	0.23	2.65	0.83	0.88
4	*Agrostis capillaris*	0	0	0.83	0.67	149	1	1	39.9	0	110	0.04
	Anthoxanthum odoratum	0	0	0.75	0.38	312	1	1	33.5	0	34	0.21
	Cerastium arvense	0	0	1	0.57	121	1	1	46.4	0	240	0.15
	Convolvulus arvensis	0	0	1	0.37	10	1	1	24.7	0	31	11.27
	Dactylis glomerata	0	0	0.75	0.39	588	1	1	27.7	0	771	0.68
	Leontodon autumnalis	0	0	0.5	0.28	139	1	0.83	32.8	0	205	0.28
	Lolium perenne	0	0	1	0.46	167	1	1	35.3	0	58	1.18
	Luzula campestris	0	0	1	0.46	118	1	1	31.9	0	37	0.50
	Plantago lanceolata	0	0	0.75	0.54	153	1	1	23.7	0	183	0.95
	Poa pratensis agg.	0	0	0.83	0.62	199	1	0.75	29.6	0	354	0.23
	Rumex acetosella	0	0	0.75	0.75	118	1	1	41.1	0	391	0.27
	Trifolium pratense	0	0	0.75	0.49	171	1	0.75	26.0	0	165	1.09
	Trifolium repens	0	0	0.5	0.6	136	1	1	35.5	0	29	0.34
	median	0.00	0.00	0.75	0.49	149	1.00	1.00	32.78	0.00	165	0.34
	mean	0.00	0.00	0.80	0.51	183	1.00	0.95	32.93	0.00	201	1.32
	standard deviation	0.00	0.00	0.17	0.13	138.40	0.00	0.10	6.76	0.00	210.07	3.01
	coefficient of variation	0.00	0.00	0.21	0.27	0.76	0.00	0.10	0.21	0.00	1.05	2.28

Appendix Table 13 continued.

PFG	*species name*	aeren-chyma [0=no, 1=yes]	thorny physical defence [0=no, 1=yes]	spacers [Index]	SLI [Index]	canopy height [mm]	plant life span [Index]	clonality [Index]	SLA $[mm^2*mg^{-1}]$	other physical defense [0=no, 1=yes]	seed number per ramet	seed mass [mg]
5	*Eleocharis uniglumis*	1	0	1	0	327	1	1	14.3	0	24	0.68
	Galium uliginosum	1	0	0.5	0.17	187	1	1	48.1	1	547	0.17
	Parnassia palustris	1	0	0.5	0.14	50	1	0.83	36.6	0	1972	0.03
	Trifolium fragiferum	1	0	0.5	0	189	1	1	31.5	0	41	1.07
	Valeriana dioica	1	0	0.75	0	83	1	0.83	33.9	0	102	0.53
	median	1.00	0.00	0.50	0.00	187	1.00	1.00	33.89	0.00	102	0.53
	mean	1.00	0.00	0.65	0.06	167	1.00	0.93	32.87	0.20	537	0.50
	standard deviation	0.00	0.00	0.22	0.09	108.80	0.00	0.09	12.20	0.45	830.06	0.42
	coefficient of variation	0.00	0.00	0.34	1.38*	0.65	0.00	0.10	0.37	2.24	1.55	0.84
6	*Achillea millefolium*	0	0	0.83	0.26	141	1	1	33.7	0	496	0.13
	Agropyron repens	0	0	1	0.34	215	1	1	33.8	0	16	1.73
	Briza media	0	0	0.83	0	259	1	1	25.5	0	18	0.26
	Centaurea jacea	0	0	1	0.19	188	1	1	23.6	1	316	1.80
	median	0.00	0.00	0.92	0.22	201.25	1.00	1.00	29.60	0.00	167	1.00
	mean	0.00	0.00	0.92	0.20	200.63	1.00	1.00	29.15	0.25	212	0.98
	standard deviation	0.00	0.00	0.10	0.15	49.38	0.00	0.00	5.41	0.50	236.29	0.91
	coefficient of variation	0.00	0.00	0.10	0.74	0.25	0.00	0.00	0.19	2.00	1.12	0.92
7	*Cladium mariscus*	1	0	1	0	1372	1	1	6.3	1	1603	2.36
	Phragmitis australis	1	0	0.75	0.1	1224	1	1	12.1	1	4085	0.12
	median	1.00	0.00	0.88	0.05	1298	1.00	1.00	9.22	1.00	2844	1.24
	mean	1.00	0.00	0.88	0.05	1298	1.00	1.00	9.22	1.00	2844	1.24
	standard deviation	0.00	0.00	0.18	0.07	104.65	0.00	0.00	4.12	0.00	1754.80	1.58
	coefficient of variation	0.00	0.00	0.20	1.41*	0.08	0.00	0.00	0.45	0.00	0.62	1.28
8	*Capsella bursa-pastoris*	0	0	0	0.91	91	0.25	0	30.7	0	1838	0.10
	Poa annua	0	0	0	0.89	88	0	0	40.6	0	69	0.26
	median	0.00	0.00	0.00	0.90	90	0.13	0.00	35.67	0.00	954	0.18
	mean	0.00	0.00	0.00	0.90	90	0.13	0.00	35.67	0.00	954	0.18
	standard deviation	0.00	0.00	0.00	0.01	2.12	0.18	0.00	7.00	0.00	1250.76	0.11
	coefficient of variation	0.00	0.00	0.00	0.01	0.02	1.41	0.00	0.20	0.00	1.31	0.62

Appendix Table 13 continued.

PFG	***species name***	**aeren-chyma [0=no, 1=yes]**	**thorny physical defence [0=no, 1=yes]**	**spacers [Index]**	**SLI [Index]**	**canopy height [mm]**	**plant life span [Index]**	**clonality [Index]**	**SLA [mm^2*mg^{-1}]**	**other physical defense [0=no, 1=yes]**	**seed number per ramet**	**seed mass [mg]**
9	*Cirsium arvense*	0	1	1	0.53	389	1	1	14.7	0	957	0.72
	median	-	-	-	-	-	-	-	-	-	-	-
	mean	-	-	-	-	-	-	-	-	-	-	-
	standard deviation	-	-	-	-	-	-	-	-	-	-	-
	coefficient of variation	-	-	-	-	-	-	-	-	-	-	-

Appendix Table 14: Hassberge (H) and Müritz (M): Species x trait matrix. Two species are labelled H/M indicating they were found in both but measured only in the bold lettered area. Species in bold letters are the responsive species for Chapter 5. (1 - traits considered only for the Müritz species, but added to Hassberge species for Chapter 5 and Box 1; 2 - traits considered only for the Hassberge species, but added to Müritz species for Chapter 5 and Box 1)

species	invest-igation area	SLA [mm^2* mg^{-1}]	canopy height [mm]	spacers [Index]	clonality [Index]	thorny physical defense[1] [no=0; yes=1]	other physical defense[1] [no=0; yes=1]	aeren-chyma[1] [no=0; yes=1]	woodi-ness[2] [Index]	plant life span [Index]	seed mass per seed [mg]	seed number per ramet	seed longevity in soil (SLI)	start seed shedding[2] [month]
Achillea millefolium	H/M	31.4	302	0.83	1	0	0	0	0	1	0.1	420	0.26	8
Agrimonia eupatoria	H	20.9	453	1	1	0	0	0	0	1	3.6	66	0.13	7
Agropyron repens	H/M	29.7	366	1	1	0	0	0	0	1	1.8	16	0.34	8
Agrostis capillaris	M	39.9	149	0.83	1	0	0	0	0	1	0.0	110	0.67	8
Agrostis stolonifera	M	59.2	200	0.67	1	0	0	1	0	1	0.1	544	0.50	8
Alopecurus pratensis	H	25.8	466	1	1	0	0	0	0	1	0.7	414	0.39	8
Anthoxanthum odoratum	H/M	36.6	260	0.75	1	0	0	0	0	1	0.3	102	0.38	6
Armeria maritima ssp. elongata	M	25.9	63	0.5	1	0	0	0	0.5	1	1.0	72	0.00	-
Arrhenatherum elatius	H	32.0	818	1	1	0	0	0	0	1	2.7	-	0.20	7
Avenula pubescens	H/M	25.3	278	0.75	1	0	0	0	0	1	0.9	16	0.21	6
Brachypodium pinnatum	H	28.1	440	1	1	0	0	0	0	1	2.8	83	0.10	7
Briza media	M	25.5	259	0.83	1	0	0	0	0	1	0.3	18	0.00	6
Bromus erectus	H	20.6	297	0.5	0.5	0	0	0	0	1	3.7	83	0.20	6
Bromus hordeaceus	H/M	35.5	295	0	0	0	0	0	0	0.25	2.2	48	0.44	5
Bromus sterilis	H	32.4	281	0	0	0	0	0	0	0	8.2	138	0.00	6
Bupleurum falcatum	H	19.3	565	0.5	1	0	0	0	0	1	1.9	988	0.00	9
Calamagrostis epigejos	M	19.6	739	1	1	0	1	1	0	1	0.1	3217	0.33	8
Calamagrostis stricta	M	18.0	552	1	1	0	1	1	0	1	0.2	521	-	-
Capsella bursa-pastoris	M	30.7	91	0	0	0	0	0	0	0.25	0.1	1838	0.91	-
Carex arenaria	M	13.5	163	1	1	0	1	1	0	1	0.5	67	-	-
Carex disticha	M	19.5	306	1	1	0	1	1	0	1	0.5	219	0.44	-
Carex flacca	M	20.8	326	0.83	0.75	0	1	1	0	1	0.7	195	0.53	5
Carex hirta	M	22.8	221	1	1	0	1	1	0	1	2.2	35	0.25	7
Carex nigra	M	22.2	287	1	1	0	1	1	0	1	0.7	146	0.42	8
Carex panicea	M	23.0	267	1	1	0	1	1	0	1	1.6	27	0.36	8
Centaurea jacea	H/M	24.7	384	1	1	0	1	0	0	1	1.7	250	0.19	8
Centaurea scabiosa	H	18.3	231	0.75	0.75	0	1	0	0	1	6.7	210	0.25	7
Cerastium arvense	M	46.4	121	1	1	0	0	0	0	1	0.2	240	0.57	-

Appendix Table 14 continued.

species	investigation area	SLA [mm^{2}* mg^{-1}]	canopy height [mm]	spacers [Index]	clonality [Index]	thorny physical defense[1] [no=0; yes=1]	other physical defense[1] [no=0; yes=1]	aerenchyma[1] [no=0; yes=1]	woodiness[2] [Index]	plant life span [Index]	seed mass per seed [mg]	seed number per ramet	seed longevity in soil (SLI)	start seed shedding[2] [month]
Cerastium brachypetalum	H	21.8	91	0	0	0	0	0	0	0	0.1	1418	0.00	5
Cerastium glomeratum	M	41.0	105	0	0	0	0	0	0	0	0.1	761	0.50	-
Cirsium arvense	H/M	15.1	565	1	1	1	0	0	0	1	0.8	957	0.53	7
Cirsium palustre	M	25.4	190	0	0	1	0	1	0	0.5	0.8	814	0.41	7
Cladium mariscus	M	6.3	1372	1	1	0	1	1	0	1	2.4	1603	0.00	8
Convolvulus arvensis	H/M	25.2	10	1	1	0	0	0	0	1	12.6	31	0.37	8
Cornus sanguinea	H	17.6	1366	1	1	0	0	0	1	1	35.2	1750	0.20	9
Crataegus monogyna	H	15.1	848	0	0	1	0	0	1	1	64.9	-	0.00	9
Cynosurus cristatus	M	23.2	338	0.5	0.5	0	0	0	0	1	0.4	139	0.06	7
Dactylis glomerata	**H**/M	27.7	588	0.75	1	0	0	0	0	1	0.7	771	0.39	6
Danthonia decumbens	M	22.6	129	0.5	0.5	0	0	1	0	1	0.7	22	0.46	7
Daucus carota	H/M	28.7	366	0	0	0	0	0	0	1	0.9	816	0.70	8
Deschampsia cespitosa	M	16.2	256	0.5	0.5	0	1	1	0	1	0.2	486	0.34	8
Dianthus carthusianorum	H	19.8	341	0.75	1	0	0	0	0	1	1.0	-	0.20	9
Eleocharis uniglumis	M	14.3	327	1	1	0	0	1	0	1	0.7	24	0.00	-
Erodium cicutarium	M	45.0	88	0	0	0	0	0	0	0.75	0.5	70	0.33	5
Euphorbia cyparissias	H	34.1	335	1	1	0	0	0	0	1	2.2	435	0.71	5
Falcaria vulgaris	H	11.8	344	0.75	1	0	0	0	0	0.75	1.8	4432	0.00	-
Festuca ovina agg.	H/M	17.3	195	0.5	0.5	0	0	0	0	1	0.5	279	0.16	6
Festuca pratensis	H/M	26.7	398	0.5	0.5	0	0	0	0	1	1.6	85	0.21	7
Festuca rubra	H/M	21.1	280	0.83	0.75	0	0	0	0	1	0.7	177	0.32	7
Fragaria viridis	H	18.4	190	0.5	1	0	0	0	0	1	0.5	-	0.60	6
Galium aparine	H	33.8	437	0	0	0	1	0	0	0	7.8	190	0.35	8
Galium mollugo	H/M	36.5	336	1	1	0	0	0	0	1	0.5	609	0.19	8
Galium palustre	M	59.7	228	1	1	0	1	1	0	1	1.2	645	0.39	7
Galium uliginosum	M	48.1	187	0.5	1	0	1	1	0	1	0.2	547	0.17	9
Galium verum	H/M	27.7	349	1	1	0	0	0	0	1	0.5	1622	0.15	8
Genista tinctoria	M	19.7	133	0	0	0	0	0	1	1	2.4	32	0.00	8
Gentianella uliginosa	M	30.9	130	0	0	0	0	1	0	0	0.1	448	-	-
Geum urbanum	H	25.9	344	0.5	1	0	0	0	0	1	0.7	-	0.20	8
Holcus lanatus	H/M	38.5	301	0.5	0.5	0	0	0	0	1	0.2	122	0.61	7

Appendix Table 14 continued.

species	invest-igation area	SLA [mm²* mg^{-1}]	canopy height [mm]	spacers [Index]	clonality [Index]	thorny physical defense[1] [no=0; yes=1]	other physical defense[1] [no=0; yes=1]	aeren-chyma[1] [no=0; yes=1]	woodi-ness[2] [Index]	plant life span [Index]	seed mass per seed [mg]	seed number per ramet	seed longevity in soil (SLI)	start seed shedding[2] [month]
Hydrocotyle vulgaris	M	35.9	125	0.75	1	0	0	1	0	1	0.2	24	0.30	-
Hypericum perforatum	H	33.2	665	0.83	1	0	0	0	0.25	1	0.1	3036	0.83	9
Inula conyza	H	20.0	293	1	1	0	0	0	0	1	0.2	-	1.00	9
Juncus articulatus	M	19.5	294	1	1	0	0	1	0	1	0.0	3176	0.79	8
Juniperus communis	M	10.5	875	0	0	1	0	0	1	1	13.1	223	0.00	7
Knautia arvensis	H	20.2	409	0.5	1	0	0	0	0	1	3.3	192	0.08	7
Lathyrus pratensis	H/M	34.8	311	1	1	0	0	0	0	1	13.1	136	0.14	7
Leontodon autumnalis	M	32.8	139	0.5	0.83	0	0	0	0	1	0.3	205	0.28	8
Leontodon hispidus	H/M	32.4	142	0.5	0.83	0	0	0	0	1	0.6	103	0.37	7
Leucanthemum vulgare	H	29.6	385	0.5	1	0	0	0	0	1	0.4	69	0.47	7
Linum catharticum	M	35.5	151	0	0	0	0	0	0	0.25	0.1	84	0.68	7
Lolium perenne	H/M	33.1	218	1	1	0	0	0	0	1	1.4	58	0.46	8
Lotus corniculatus	H/M	35.7	255	0.75	0.5	0	0	0	0	1	1.0	318	0.46	7
Lotus uliginosus	M	40.0	176	0.75	0.5	0	0	1	0	1	0.5	181	0.38	8
Luzula campestris	H/M	30.8	111	1	1	0	0	0	0	1	0.6	41	0.46	6
Medicago lupulina	H/M	34.2	264	1	0.25	0	0	0	0	1	1.4	154	0.70	6
Mentha aquatica	M	33.9	219	0.75	1	0	0	1	0	1	0.1	475	0.43	9
Molinia caerulea	M	25.4	297	0.5	1	0	0	1	0	1	0.3	413	0.50	9
Myosotis ramosissima	H	45.7	207	0	0	0	0	0	0	0.1	0.2	379	0.56	6
Odontites vulgaris	M	25.4	228	0	0	0	0	0	0	0	0.2	3044	-	8
Ononis repens	H	33.0	430	0.5	1	1	0	0	0.5	1	4.8	-	0.17	9
Origanum vulgare	H	23.7	514	1	1	0	0	0	0	1	0.1	316	0.75	10
Parnassia palustris	M	36.6	50	0.5	0.83	0	0	1	0	1	0.0	1972	0.14	8
Phragmitis australis	M	12.1	1224	0.75	1	0	1	1	0	1	0.1	4085	0.10	11
Pimpinella saxifraga	H	21.5	274	0.75	1	0	0	0	0	1	1.1	268	0.08	9
Pinguicula vulgaris	M	42.6	10	1	0.5	0	1	1	0	1	0.0	208	-	6
Plantago lanceolata	H/M	21.8	226	0.75	1	0	0	0	0	1	1.3	283	0.54	7
Plantago media	H	21.3	191	0.75	1	0	0	0	0	1	0.3	282	0.42	8
Poa annua	M	40.6	88	0	0	0	0	0	0	0	0.3	69	0.89	1
Poa pratensis agg.	H/M	26.1	222	0.83	0.75	0	0	0	0	1	0.2	318	0.62	6
Poa trivialis	H/M	49.5	495	0.75	1	0	0	1	0	1	0.2	201	0.83	6

Appendix Table 14 continued.

species	invest-igation area	SLA [mm^{2*} mg^{-1}]	canopy height [mm]	spacers [Index]	clonality [Index]	thorny physical defense[1] [no=0; yes=1]	other physical defense[1] [no=0; yes=1]	aeren-chyma[1] [no=0; yes=1]	woodi-ness[2] [Index]	plant life span [Index]	seed mass per seed [mg]	seed number per ramet	seed longevity in soil (SLI)	start seed shedding[2] [month]
Polygala vulgaris	M	22.3	116	1	0.5	0	0	0	0	1	2.2	48	0.13	7
Potentilla anserina	M	26.0	201	0.75	1	0	0	1	0	1	0.7	14	0.44	-
Potentilla erecta	M	35.7	145	0.5	1	0	0	1	0	1	0.3	461	0.58	7
Potentilla neumanniana	H	16.8	58	0.5	1	0	0	0	0	1	0.5	203	0.60	5
Potentilla reptans	H/M	23.0	159	0.5	1	0	0	1	0	1	0.3	93	0.50	8
Primula veris	H	20.7	158	0.5	1	0	0	0	0	1	0.9	271	0.18	7
Prunella vulgaris	M	25.1	142	0.5	0.83	0	0	0	0	1	0.8	626	0.30	8
Prunus spinosa	H	18.8	1221	1	1	1	0	0	1	1	427.1	96	0.50	9
Ranunculus acris	H/M	21.7	196	0.5	0.5	0	0	1	0	1	1.4	235	0.39	7
Ranunculus bulbosus	H	19.7	144	1	1	0	0	0	0	1	3.5	124	0.50	6
Ranunculus flammula	M	20.0	196	0.5	0.83	0	0	1	0	1	0.1	1406	0.77	8
Ranunculus repens	M	26.7	187	0.5	0.83	0	0	1	0	1	1.8	60	0.73	7
Rhinanthus minor	H	26.6	244	0	0	0	0	0	0	0	2.5	187	0.60	7
Rhinanthus serotinus	M	23.0	204	0	0	0	0	0	0	0	1.7	536	0.00	7
Rosa canina agg.	H	13.0	928	1	1	1	0	0	1	1	22.6	3623	0.00	9
Rumex acetosa	H/M	31.5	194	0.5	1	0	0	0	0	1	0.4	978	0.48	6
Rumex acetosella	M	41.1	118	0.75	1	0	0	0	0	1	0.3	391	0.75	6
Salix repens	M	18.1	164	0.5	1	0	0	1	1	1	-	1532	0.00	6
Salvia pratensis	H	18.9	271	0.5	1	0	0	0	0	1	2.6	528	0.22	6
Sanguisorba minor	H	21.2	293	0.5	1	0	0	0	0	1	2.8	106	0.33	6
Saxifraga granulata	H	27.4	138	0.75	1	0	0	0	0	1	0.0	554	0.57	5
Stellaria graminea	M	43.8	183	0.75	1	0	0	0	0	1	0.2	329	0.45	7
Succisa pratensis	M	17.8	54	0.5	0.5	0	1	1	0	1	0.7	124	0.20	9
Taraxacum officinale agg.	H/M	31.1	232	0.75	0.75	0	0	0	0	1	0.5	543	0.47	5
Taraxacum palustre	M	19.1	99	1	0.5	0	0	1	0	1	0.6	90	-	5
Thlaspi perfoliatum	H	22.7	80	0	0	0	0	0	0	0	0.3	131	0.75	6
Tragopopgon pratensis	H	25.7	362	0	0	0	0	0	0	1	7.6	-	1.00	-
Trifolium fragiferum	M	31.5	189	0.5	1	0	0	1	0	1	1.1	41	0.00	8
Trifolium pratense	H/M	24.6	269	0.75	0.75	0	0	0	0	1	1.2	256	0.49	8
Trifolium repens	H/M	29.6	170	0.5	1	0	0	0	0	1	0.4	38	0.60	6
Trisetum flavenscens	H	32.1	493	0.5	0.5	0	0	0	0	1	0.2	258	0.00	7

Appendix Table 14 continued.

species	invest-igation area	SLA [mm^{2}* mg^{-1}]	canopy height [mm]	spacers [Index]	clonality [Index]	thorny physical defense[1] [no=0; yes=1]	other physical defense[1] [no=0; yes=1]	aeren-chyma[1] [no=0; yes=1]	woodi-ness[2] [Index]	plant life span [Index]	seed mass per seed [mg]	seed number per ramet	seed longevity in soil (SLI)	start seed shedding[2] [month]
Valeriana dioica	M	33.9	83	0.75	0.83	0	0	1	0	1	0.5	102	0.00	6
Valerianella locusta	H	38.4	86	0	0	0	0	0	0	0	0.6	-	1.00	5
Veronica arvensis	H/M	30.3	75	0	0	0	0	0	0	0	0.1	383	0.50	5
Veronica chamaedrys	H/M	36.7	175	0.83	1	0	0	0	0	1	0.2	188	0.40	7
Vicia angustifolia	H	34.6	190	0	0	0	0	0	0	0	13.6	76	-	7
Vicia cracca	M	42.4	241	1	1	0	0	0	0	1	12.3	280	0.10	7
Vicia tetrasperma	H	43.2	360	0	0	0	0	0	0	0	4.5	-	0.43	6
Viola canina	M	35.2	119	0.75	0.75	0	0	0	0	1	0.9	96	0.56	7
Viola hirta	H	19.5	199	0.5	1	0	0	0	0	1	2.3	-	0.29	6

Appendix Table 15: Hassberge and Müritz: Site x species matrix. For species codes see Appendix Table 18.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31	sp32	sp33	sp34
SE01	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE07	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
SE08	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
SE09	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
SE11	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
SE12	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
SE13	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE14	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE15	1	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
SE16	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
SE17	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE18	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
SE19	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
SE22	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SE23	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE24	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
SE25	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE26	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE27	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE28	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE29	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SE30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
SE31	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
SE32	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
SE33	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1

Appendix Table 15 continued.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31	sp32	sp33	sp34
SE34	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE35	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE36	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1
SE37	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE38	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	1
SE39	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
SE40	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SE41	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE42	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
SE43	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE44	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	1	0	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
47	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	1	0	0	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
69	0	1	0	0	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
77	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
91	1	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
92	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
97	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
115	1	1	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
117	1	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
120	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
136	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
138	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1
168	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Appendix Table 15 continued.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31	sp32	sp33	sp34
171	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
176	1	0	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
202	1	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
211	1	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
234	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
242	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
275	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
288	0	0	0	0	1	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
297	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
312	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
325	1	0	0	0	0	1	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
332	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
337	1	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
343	1	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
366	1	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
366B	1	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
373	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
374	1	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
376	1	0	0	1	0	1	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
397	1	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
423	1	0	0	0	0	1	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1
427	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
513	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
552	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
AB17	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
E13	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
E19	0	1	0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E7	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
E9	1	0	0	0	0	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H17	1	0	1	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
LiF2000	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LiF2001	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0

Appendix Table 15 continued.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31	sp32	sp33	sp34
LiF2002	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
LiM	1	1	1	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
M10	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
M2	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
M5	1	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0
MoF2000	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
MoF2001	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MoF2002	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MoM	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RaBF2000	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
RaBF2001	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
RaBF2002	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
RaBM	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	1
ReBF2000	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ReBF2001	1	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
ReBF2002	1	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ReBM	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
S21	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
S3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S6	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Z01	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 1	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1
MÜR 2	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1
MÜR 3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 4	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 5	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MÜR 6	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 7	0	0	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MÜR 8	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MÜR 9	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0
MÜR 10	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0
MÜR 11	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	1	0	0	0
MÜR 12	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 15 continued.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31	sp32	sp33	sp34
MÜR 13	1	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
MÜR 14	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
MÜR 15	1	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	1
MÜR 16	1	0	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
MÜR 17	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
MÜR 18	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0
MÜR 19	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1
MÜR 20	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 21	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 22	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
MÜR 23	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
MÜR 24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0
MÜR 25	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0	0	0
MÜR 26	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0
MÜR 27	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0
MÜR 28	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0
MÜR 29	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	1	1	0	0	0
MÜR 30	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0
MÜR 31	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 32	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 33	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0
MÜR 34	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	1	0	1	0	0
MÜR 35	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	1	0	0
MÜR 36	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	0
MÜR 37	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0
MÜR 38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
MÜR 39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
MÜR 40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 41	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0
MÜR 42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
MÜR 43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
MÜR 44	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0
MÜR 45	1	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0

Appendix Table 15 continued.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31	sp32	sp33	sp34
MÜR 46	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0
MÜR 47	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 49	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0
MÜR 51	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
MÜR 52	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
MÜR 53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 56	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0
MÜR 57	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0
MÜR 58	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	1	0	0	0
MÜR 59	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
MÜR 60	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
MÜR 61	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	1	0	0
MÜR 62	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0
MÜR 63	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 64	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
MÜR 65	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0
MÜR 66	1	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0
MÜR 67	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0
MÜR 68	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0
MÜR 69	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0
MÜR 70	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0
MÜR 71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
MÜR 72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
MÜR 73	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 74	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0
MÜR 75	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
MÜR 76	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0
MÜR 77	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0
MÜR 78	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0

Appendix Table 15 continued.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31	sp32	sp33	sp34
MÜR 79	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	1	0	0
MÜR 80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0
MÜR 81	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0
MÜR 82	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0
MÜR 83	1	0	0	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0
MÜR 84	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0
MÜR 85	1	0	0	1	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
MÜR 86	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	1	0	0
MÜR 87	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 88	1	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 89	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MÜR 90	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1
MÜR 91	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0
MÜR 92	1	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
MÜR 93	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 94	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
MÜR 95	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0
MÜR 96	1	0	0	1	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0
MÜR 97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
MÜR 98	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
MÜR 99	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
MÜR 100	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	1	0	0
MÜR 101	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 102	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
MÜR 103	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1	0	0
MÜR 104	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0
MÜR 105	1	0	0	1	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0
MÜR 106	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 107	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0
MÜR 108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
MÜR 109	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 110	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0
MÜR 111	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	1	0	0	0	0	0

Appendix Table 15 continued.

site	sp1	sp2	sp3	sp4	sp5	sp6	sp7	sp8	sp9	sp10	sp11	sp12	sp13	sp14	sp15	sp16	sp17	sp18	sp19	sp20	sp21	sp22	sp23	sp24	sp25	sp26	sp27	sp28	sp29	sp30	sp31	sp32	sp33	sp34
MÜR 112	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0
MÜR 113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
MÜR 114	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 115	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0
MÜR 116	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
MÜR 117	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
MÜR 118	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
MÜR 119	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0
MÜR 120	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0

Appendix Table 15 continued.

site	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60	sp61	sp62	sp63	sp64	sp65	sp66	sp67
SE01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE03	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE07	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE08	0	0	0	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SE09	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SE10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SE11	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE12	0	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE13	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
SE14	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
SE15	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
SE16	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SE17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SE18	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0
SE19	0	0	0	0	0	1	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SE20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE21	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE22	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SE23	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SE24	0	1	0	1	0	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
SE25	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
SE26	1	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE28	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE29	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
SE30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE32	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 15 continued.

site	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60	sp61	sp62	sp63	sp64	sp65	sp66	sp67
SE34	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE36	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SE37	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SE38	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE39	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE40	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
SE41	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SE42	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SE43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
4	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
69	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0
77	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
92	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
97	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
117	0	0	0	1	0	0	0	0	0	0	1	0	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
120	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
136	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
138	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
147	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151	0	0	0	1	0	1	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
168	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0

Appendix Table 15 continued.

site	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60	sp61	sp62	sp63	sp64	sp65	sp66	sp67
171	0	0	0	1	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
176	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
202	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
211	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
234	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
242	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
275	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
288	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
297	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1
312	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
325	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
332	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
337	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
343	0	1	0	1	0	1	0	0	0	0	0	1	1	1	0	1	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0
366	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
366B	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
373	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
374	0	0	1	1	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0
376	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
397	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
423	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
427	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
513	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
552	0	0	0	1	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AB17	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E13	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0
E19	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
E7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
E9	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
H17	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H9	1	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
LiF2000	1	0	0	1	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0
LiF2001	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0

Appendix Table 15 continued.

site	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60	sp61	sp62	sp63	sp64	sp65	sp66	sp67
LiF2002	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
LiM	0	0	0	1	0	1	0	0	0	0	1	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0
M10	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M2	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
M5	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
MoF2000	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	0	0
MoF2001	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
MoF2002	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MoM	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
RaBF2000	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
RaBF2001	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
RaBF2002	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RaBM	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
ReBF2000	0	0	0	1	0	1	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
ReBF2001	0	1	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
ReBF2002	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
ReBM	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
S21	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S6	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Z01	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
MÜR 1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
MÜR 4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 6	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
MÜR 7	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 8	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 9	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1
MÜR 10	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1
MÜR 11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MÜR 12	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Appendix Table 15 continued.

site	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60	sp61	sp62	sp63	sp64	sp65	sp66	sp67
MÜR 13	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 15	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 16	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 17	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 18	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 19	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 20	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 21	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
MÜR 24	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 25	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MÜR 26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 27	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
MÜR 28	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1
MÜR 29	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	1
MÜR 30	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
MÜR 31	0	0	0	0	0	0	1	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0
MÜR 32	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 33	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	1
MÜR 34	0	0	1	0	0	0	1	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1	0	0	0	0
MÜR 35	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	1	0	1	0	0	0	0	1	0	0	0
MÜR 36	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	1
MÜR 37	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1
MÜR 38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 40	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0
MÜR 41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 44	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 45	0	1	1	1	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1

Appendix Table 15 continued.

site	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60	sp61	sp62	sp63	sp64	sp65	sp66	sp67
MÜR 46	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
MÜR 48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 49	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0	1	0	0	0	0
MÜR 50	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0
MÜR 51	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0
MÜR 52	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 56	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 57	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
MÜR 58	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
MÜR 59	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
MÜR 60	0	0	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 61	0	0	1	0	1	0	1	0	1	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0
MÜR 62	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 63	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
MÜR 64	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0
MÜR 65	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0
MÜR 66	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	1
MÜR 67	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	0	0	0
MÜR 68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0
MÜR 69	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1
MÜR 70	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	0	1	0	0	0
MÜR 71	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
MÜR 72	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 73	0	0	1	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	1	0	0	0	1	1	0	0	0
MÜR 74	0	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	1	0	0	0	0
MÜR 75	0	0	1	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0
MÜR 76	0	0	0	0	1	1	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0	1	1	0	1	1	0	0	1	0	0	1	0
MÜR 77	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
MÜR 78	0	0	1	0	0	1	1	0	1	0	0	0	1	1	1	0	0	0	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0

Appendix Table 15 continued.

site	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60	sp61	sp62	sp63	sp64	sp65	sp66	sp67
MÜR 79	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0
MÜR 80	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0
MÜR 81	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0	1	0	0	0
MÜR 82	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
MÜR 83	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	1	1	0	0	0	0	0	0	0
MÜR 84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
MÜR 85	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 86	0	0	0	0	1	0	1	0	1	0	0	0	0	1	1	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0	0	0	0
MÜR 87	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 88	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1
MÜR 89	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 90	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 91	0	0	0	0	1	0	1	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	1	0	0	1	0	0	1	0
MÜR 92	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 93	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 94	0	0	1	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	1	1	0	0	1	0	0	0	0
MÜR 95	0	0	0	0	1	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MÜR 96	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1
MÜR 97	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0
MÜR 98	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 99	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 100	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0
MÜR 101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
MÜR 102	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
MÜR 103	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	1	0	0	0	0
MÜR 104	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0
MÜR 105	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
MÜR 106	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 107	0	0	1	0	1	0	1	0	1	0	0	0	1	1	1	0	0	0	1	1	0	1	1	0	1	1	0	0	0	1	0	0	0
MÜR 108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
MÜR 109	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
MÜR 110	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0	1
MÜR 111	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 15 continued.

site	sp35	sp36	sp37	sp38	sp39	sp40	sp41	sp42	sp43	sp44	sp45	sp46	sp47	sp48	sp49	sp50	sp51	sp52	sp53	sp54	sp55	sp56	sp57	sp58	sp59	sp60	sp61	sp62	sp63	sp64	sp65	sp66	sp67
MÜR 112	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	1	0	0	0	0	0	1	0
MÜR 113	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 114	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 115	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0
MÜR 116	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 117	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0
MÜR 118	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 119	0	0	1	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
MÜR 120	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1

Appendix Table 15 continued.

site	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75	sp76	sp77	sp78	sp79	sp80	sp81	sp82	sp83	sp84	sp85	sp86	sp87	sp88	sp89	sp90	sp91	sp92	sp93	sp94	sp95	sp96	sp97	sp98	sp99	sp100	sp101
SE01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SE02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0
SE03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SE04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SE06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE07	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE08	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
SE09	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
SE10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SE11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SE12	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SE13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
SE14	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	1	0	0	0
SE15	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
SE16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SE17	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SE18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	1	0
SE19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
SE20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
SE22	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0
SE23	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0
SE24	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0
SE25	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	1	0	0	0
SE26	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
SE27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
SE28	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
SE29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SE30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SE32	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
SE33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 15 continued.

site	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75	sp76	sp77	sp78	sp79	sp80	sp81	sp82	sp83	sp84	sp85	sp86	sp87	sp88	sp89	sp90	sp91	sp92	sp93	sp94	sp95	sp96	sp97	sp98	sp99	sp100	sp101
SE34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
SE35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE36	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SE37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SE38	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SE39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0
SE40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
SE41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SE42	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
SE43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
4	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	1	0	1	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	1	1	0	0	1	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0
69	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	0	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0
92	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0	1	0
97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
115	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
117	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0
120	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0
136	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
138	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
147	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
151	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0
168	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	1	0	0

Appendix Table 15 continued.

site	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75	sp76	sp77	sp78	sp79	sp80	sp81	sp82	sp83	sp84	sp85	sp86	sp87	sp88	sp89	sp90	sp91	sp92	sp93	sp94	sp95	sp96	sp97	sp98	sp99	sp100	sp101
171	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0
176	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
202	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
211	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0
234	0	0	0	1	1	0	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0
242	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0
275	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
288	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
297	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	0	1	1	0	0
312	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
325	1	1	0	1	1	0	1	1	0	0	1	0	1	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	1	0	1	0
332	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	1	0	0	1	1	0
337	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
343	1	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
366	0	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0	1	1	0
366B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
373	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0
374	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	1	1	0	0	1	1	0
376	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0
397	0	1	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	1	0
423	0	1	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0
427	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0
513	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
552	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
AB17	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
E13	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	1	1	0	0
E19	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	1	1	0	0	1	0	0
E7	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0
E9	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0
H17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
H9	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
LiF2000	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	1	0	0	1	0	1	0
LiF2001	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0

Appendix Table 15 continued.

site	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75	sp76	sp77	sp78	sp79	sp80	sp81	sp82	sp83	sp84	sp85	sp86	sp87	sp88	sp89	sp90	sp91	sp92	sp93	sp94	sp95	sp96	sp97	sp98	sp99	sp100	sp101
LiF2002	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0
LiM	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0
M10	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0
M2	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0
M5	1	1	1	0	1	0	1	1	0	0	0	0	1	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	1	0	1	0	1	0
MoF2000	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0
MoF2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	1	0	1	0
MoF2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
MoM	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0
RaBF2000	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0
RaBF2001	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
RaBF2002	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
RaBM	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0
ReBF2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	1	0
ReBF2001	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0
ReBF2002	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	1	0	1	0
ReBM	0	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	1	0	0	0	0	1	0	0	0	1	0	1	0
S21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
S3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Z01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
MÜR 4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	0
MÜR 7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 9	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	1	0	0
MÜR 10	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	1	0	0
MÜR 11	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 12	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 15 continued.

site	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75	sp76	sp77	sp78	sp79	sp80	sp81	sp82	sp83	sp84	sp85	sp86	sp87	sp88	sp89	sp90	sp91	sp92	sp93	sp94	sp95	sp96	sp97	sp98	sp99	sp100	sp101
MÜR 13	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
MÜR 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 15	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0
MÜR 16	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0
MÜR 17	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 18	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 19	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0
MÜR 20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 21	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 22	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 23	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
MÜR 24	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0
MÜR 25	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0
MÜR 26	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 27	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0
MÜR 28	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	1	0	0	0	0	1	0
MÜR 29	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	1	0	0
MÜR 30	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	1	0	0	1	1	0	1	0	0	0	0	0	1
MÜR 31	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0	0	1	0	0
MÜR 32	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
MÜR 33	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
MÜR 34	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0	0	0	1	0	1	0	0
MÜR 35	0	0	1	0	1	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
MÜR 36	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0	1	0	0	0	1	0	1
MÜR 37	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0
MÜR 38	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 39	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 40	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MÜR 41	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
MÜR 42	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 44	0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	1	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	1	0	0
MÜR 45	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	1	0	1	0	0	1	0

Appendix Table 15 continued.

site	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75	sp76	sp77	sp78	sp79	sp80	sp81	sp82	sp83	sp84	sp85	sp86	sp87	sp88	sp89	sp90	sp91	sp92	sp93	sp94	sp95	sp96	sp97	sp98	sp99	sp100	sp101
MÜR 46	0	0	0	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	1	1	0	0	1	0	0	1	0	1	0	0	0	0
MÜR 47	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 49	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
MÜR 50	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
MÜR 51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0
MÜR 52	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
MÜR 53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 56	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
MÜR 57	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0
MÜR 58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	0	1	0	1	0	0
MÜR 59	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 60	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	1	1	0	0
MÜR 61	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0
MÜR 62	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	0	0
MÜR 63	1	0	1	0	0	1	0	0	1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0
MÜR 64	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1	0	1
MÜR 65	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0
MÜR 66	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
MÜR 67	1	0	1	0	1	0	1	0	1	1	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0
MÜR 68	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	1	0	0
MÜR 69	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 70	1	0	1	0	1	0	0	0	1	1	0	0	0	0	1	1	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0
MÜR 71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0
MÜR 72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
MÜR 73	1	0	1	0	1	0	0	1	1	1	0	0	0	0	1	1	0	0	1	0	0	1	0	1	0	1	0	0	0	1	0	1	0	0
MÜR 74	0	0	1	0	0	1	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0
MÜR 75	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	1	0	0
MÜR 76	0	0	1	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0
MÜR 77	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0
MÜR 78	1	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	1	0	1	0	1	0	0

Appendix Table 15 continued.

site	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75	sp76	sp77	sp78	sp79	sp80	sp81	sp82	sp83	sp84	sp85	sp86	sp87	sp88	sp89	sp90	sp91	sp92	sp93	sp94	sp95	sp96	sp97	sp98	sp99	sp100	sp101
MÜR 79	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	1	0	1	0	1	0	1	0	0
MÜR 80	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0
MÜR 81	1	0	1	0	1	0	0	1	0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0
MÜR 82	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	1	0	0	0	1	0	0
MÜR 83	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0
MÜR 84	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MÜR 85	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
MÜR 86	0	0	1	0	1	1	0	0	1	1	0	1	0	0	1	1	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	1	0	0
MÜR 87	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
MÜR 88	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 89	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 91	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	1
MÜR 92	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 93	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 94	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	0	1	0	1	0	1	0	0
MÜR 95	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	1	0	0
MÜR 96	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0
MÜR 97	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
MÜR 98	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 99	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0
MÜR 100	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	1	0	0
MÜR 101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0
MÜR 102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	1	0	0	0	1	0	0
MÜR 103	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0
MÜR 104	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	1	0	1	0	1	0	0	0	0
MÜR 105	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 106	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 107	1	0	1	0	1	0	0	1	1	1	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0
MÜR 108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	0
MÜR 110	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	0	1	0	1	0	0	0	1	0	1	0	0
MÜR 111	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Appendix Table 15 continued.

site	sp68	sp69	sp70	sp71	sp72	sp73	sp74	sp75	sp76	sp77	sp78	sp79	sp80	sp81	sp82	sp83	sp84	sp85	sp86	sp87	sp88	sp89	sp90	sp91	sp92	sp93	sp94	sp95	sp96	sp97	sp98	sp99	sp100	sp101
MÜR 112	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0
MÜR 113	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 115	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
MÜR 116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 117	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
MÜR 118	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 119	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 120	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0	0

Appendix Table 15 continued.

site	sp102	sp103	sp104	sp105	sp106	sp107	sp108	sp109	sp110	sp111	sp112	sp113	sp114	sp115	sp116	sp117	sp118	sp119	sp120	sp121	sp122	sp123	sp124	sp125	sp126	sp127	sp128	sp129	sp130
SE01	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0
SE02	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	1	1	0	0	0	0	0
SE03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
SE04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
SE06	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE07	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE08	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
SE09	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
SE10	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SE11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE12	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0
SE13	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE14	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
SE15	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1
SE16	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
SE17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
SE18	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0
SE19	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	1
SE20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0
SE21	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
SE22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	0	0	1
SE23	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	0	0	1
SE24	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
SE25	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
SE26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1
SE27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SE28	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE29	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SE30	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE31	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SE32	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
SE33	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 15 continued.

site	sp102	sp103	sp104	sp105	sp106	sp107	sp108	sp109	sp110	sp111	sp112	sp113	sp114	sp115	sp116	sp117	sp118	sp119	sp120	sp121	sp122	sp123	sp124	sp125	sp126	sp127	sp128	sp129	sp130
SE34	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
SE35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE36	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0	1	0	0
SE37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
SE38	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0
SE39	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SE40	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
SE41	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SE42	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
SE43	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
SE44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
4	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
47	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	1	1	0	0	0	1	1	1	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	1	0	1	1	0	0	1	1	0	0	0	0	0	1	0	0	1	0	1	0	0	1	0	1	0	0	0	0
69	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1
77	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	0	0	0	0	1	0	0	1	1	0	0	0	0	0	1	0	0	1	1	1	0	1	1	0	1	0	0	0	0
92	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
97	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
115	0	1	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1
117	0	1	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1
120	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	0	1	1	0	0	1	0	0	0
136	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	0	1	1	1	0	0	1	1	0	0	0	0	0
138	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0
147	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
151	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1
168	0	0	0	0	1	0	0	1	1	0	1	0	1	0	0	1	0	1	0	1	0	0	0	1	1	0	0	0	1

Appendix Table 15 continued.

site	sp102	sp103	sp104	sp105	sp106	sp107	sp108	sp109	sp110	sp111	sp112	sp113	sp114	sp115	sp116	sp117	sp118	sp119	sp120	sp121	sp122	sp123	sp124	sp125	sp126	sp127	sp128	sp129	sp130
171	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
176	1	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
202	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0
211	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
234	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	0	1	1	0	1	0	1	0	0
242	0	1	0	0	1	0	0	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
275	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
288	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0
297	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0
312	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0
325	0	0	0	0	1	0	0	1	1	1	0	0	1	0	0	1	0	1	1	1	0	1	1	1	0	0	0	0	0
332	0	1	0	0	1	0	0	0	1	1	0	0	1	0	0	1	0	1	0	1	0	0	0	1	1	0	0	0	0
337	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0
343	0	0	0	0	1	0	0	0	1	1	0	0	1	0	0	1	0	1	0	1	0	0	1	0	1	0	0	0	1
366	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	0
366B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0
373	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0	0	0
374	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1
376	0	1	0	0	1	0	0	0	0	1	1	0	1	0	0	1	0	1	1	1	0	0	1	1	1	0	0	0	0
397	0	1	0	0	1	0	0	1	1	1	0	0	1	0	0	0	0	1	1	1	0	1	1	1	1	0	0	0	0
423	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1	0	1	0	0
427	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
513	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	1
552	0	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0
AB17	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
E13	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0
E19	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	1	0	0	0	1	0	0	0	0	1
E7	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	1
E9	0	0	0	0	1	0	0	1	1	1	1	0	1	0	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0
H17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
LiF2000	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0
LiF2001	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0

Appendix Table 15 continued.

site	sp102	sp103	sp104	sp105	sp106	sp107	sp108	sp109	sp110	sp111	sp112	sp113	sp114	sp115	sp116	sp117	sp118	sp119	sp120	sp121	sp122	sp123	sp124	sp125	sp126	sp127	sp128	sp129	sp130
LiF2002	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	1	0	0
LiM	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
M10	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0
M2	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0	1
M5	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	1
MoF2000	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MoF2001	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
MoF2002	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
MoM	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
RaBF2000	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1
RaBF2001	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RaBF2002	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	0
RaBM	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	1
ReBF2000	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
ReBF2001	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
ReBF2002	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
ReBM	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1
S21	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S6	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Z01	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1
MÜR 1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0
MÜR 2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MÜR 4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
MÜR 5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 7	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 8	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 9	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 10	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 11	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
MÜR 12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0

Appendix Table 15 continued.

site	sp102	sp103	sp104	sp105	sp106	sp107	sp108	sp109	sp110	sp111	sp112	sp113	sp114	sp115	sp116	sp117	sp118	sp119	sp120	sp121	sp122	sp123	sp124	sp125	sp126	sp127	sp128	sp129	sp130
MÜR 13	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 14	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 15	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
MÜR 16	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
MÜR 17	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
MÜR 18	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0
MÜR 19	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
MÜR 20	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 21	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 22	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
MÜR 25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0
MÜR 26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0
MÜR 27	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
MÜR 28	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
MÜR 29	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0
MÜR 30	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 31	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 32	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 33	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 34	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 35	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0
MÜR 36	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
MÜR 37	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 41	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
MÜR 45	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0

Appendix Table 15 continued.

site	sp102	sp103	sp104	sp105	sp106	sp107	sp108	sp109	sp110	sp111	sp112	sp113	sp114	sp115	sp116	sp117	sp118	sp119	sp120	sp121	sp122	sp123	sp124	sp125	sp126	sp127	sp128	sp129	sp130
MÜR 46	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0
MÜR 47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 49	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 51	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 52	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0
MÜR 53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 56	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
MÜR 57	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
MÜR 58	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
MÜR 59	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 60	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	1	0	1	0	1	0
MÜR 61	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0
MÜR 62	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 63	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 64	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 65	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0
MÜR 66	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
MÜR 67	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
MÜR 68	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MÜR 69	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0
MÜR 70	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 71	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 72	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 73	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
MÜR 74	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 75	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
MÜR 76	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
MÜR 77	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0
MÜR 78	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	1	0	0	1	0	1	0

Appendix Table 15 continued.

site	sp102	sp103	sp104	sp105	sp106	sp107	sp108	sp109	sp110	sp111	sp112	sp113	sp114	sp115	sp116	sp117	sp118	sp119	sp120	sp121	sp122	sp123	sp124	sp125	sp126	sp127	sp128	sp129	sp130
MÜR 79	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
MÜR 80	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
MÜR 81	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 82	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0
MÜR 83	0	0	1	0	1	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0
MÜR 84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 85	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 86	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
MÜR 87	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 88	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MÜR 89	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 90	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 91	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 92	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
MÜR 93	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
MÜR 94	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
MÜR 95	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
MÜR 96	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0
MÜR 97	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 98	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MÜR 99	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	1	0
MÜR 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	0	0	0	0	0	0
MÜR 101	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0
MÜR 102	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0
MÜR 103	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MÜR 104	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
MÜR 105	1	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
MÜR 106	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 107	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 108	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 109	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MÜR 110	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0	1	0
MÜR 111	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix Table 15 continued.

site	sp102	sp103	sp104	sp105	sp106	sp107	sp108	sp109	sp110	sp111	sp112	sp113	sp114	sp115	sp116	sp117	sp118	sp119	sp120	sp121	sp122	sp123	sp124	sp125	sp126	sp127	sp128	sp129	sp130
MÜR 112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0
MÜR 113	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 114	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 115	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
MÜR 116	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 117	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
MÜR 118	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MÜR 119	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
MÜR 120	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0

Appendix Table 16: Hassberge and Müritz: Site x environmental parameters matrix. (P=plant available phosphorus, K=plant available potassium, CaCO3=calcium carbonate, N=total nitrogen content, C=total carbon content, C/N=relation between C and N, kf=water permeability in saturated soil, CECeff=effective cation exchange capacity, change=change in magnitude between 1997 and 2002, magnitude=disturbance magnitude, freq=disturbance frequency, AWeff=effectively available water) For explanation on frequency and AWeff see Chapter 5.

site	kf [cm*d^{-1}]	CEC$_{eff}$ [cmol$_c$*kg^{-1}]	P [kg*ha^{-1}]	K [kg*ha^{-1}]	C [kg*ha^{-1}]	N [kg*ha^{-1}]	C/N	CaCO3 [kg*ha^{-1}]	pH	change [0=no, 1=yes]	freq	magnit [%]	AW$_{eff}$ [mm]
SE01	17.0	28	277	1018	45739	3423	13.4	258444	7.3	0	5	100	21.2
SE02	7.0	39	419	1958	49	4666	0.0	546813	7.3	0	5	100	25.2
SE03	7.0	39	1159	3519	10460	12052	0.9	1200375	7.3	0	5	100	63.2
SE04	1.0	39	1154	13018	0	1110	0.0	1958375	7.3	0	5	100	45.5
SE05	7.0	39	3043	5583	89801	12869	7.0	128716	7.1	0	5	100	64.4
SE06	2.0	39	4424	13746	5467	4719	1.2	1516015	7.4	0	5	100	68.9
SE07	5.0	29	226	3445	121668	7349	16.6	0	6.6	1	1	50	67.2
SE08	7.0	39	321	1249	18746	6267	3.0	333557	7.2	0	0.27	100	18.8
SE09	6.7	26	330	3533	79460	8808	9.0	413639	6.7	1	1	50	68.7
SE10	2.0	39	1156	4389	59645	10657	5.6	783298	7.3	1	1	50	62.3
SE11	4.2	39	584	2998	52442	8942	5.9	1374379	7.2	1	1	50	53.6
SE12	7.0	39	970	2626	133054	9770	13.6	61960	7.2	0	0.27	100	65.9
SE13	7.0	39	125	854	35244	4234	8.3	254085	7.0	0	0.13	50	8.6
SE14	2.0	39	274	2873	113116	16873	6.7	910550	7.4	0	0.27	50	49.7
SE15	3.7	39	295	1636	0	8274	0.0	1855178	7.4	0	1	50	54.1
SE16	2.0	39	657	1344	0	256	0.0	530239	7.3	0	0.13	100	10.8
SE17	2.0	39	123	583	0	240	0.0	727335	7.3	0	0.01	100	8.5
SE18	2.0	39	381	2704	0	960	0.0	1653701	7.3	0	0.01	100	45.8
SE19	2.0	39	260	715	0	1879	0.0	451634	7.2	0	0.01	100	7.2
SE20	2.0	39	931	5137	0	960	0.0	2477375	7.3	0	0.13	100	26.6
SE21	2.0	39	621	4011	0	960	0.0	1246654	7.2	0	0.13	100	45.3
SE22	3.2	39	488	2376	48738	15211	3.2	1253543	7.4	0	0.01	50	42.0
SE23	10.4	34	54	1899	44599	8665	5.1	982630	7.3	0	0.13	50	95.6
SE24	2.0	39	1183	2118	76599	10676	7.2	0	6.7	0	0.01	50	70.0
SE25	4.9	32	525	1930	28512	4924	5.8	903002	7.1	0	0.01	50	54.5
SE26	3.5	39	350	1417	19245	8958	2.1	791988	7.3	0	0.01	50	61.9
SE27	2.0	39	1070	3117	76679	9970	7.7	525298	7.3	0	0.01	50	80.0
SE28	2.0	39	96	753	8549	4842	1.8	509794	7.3	0	0.01	50	16.2

Appendix Table 16 continued.

site	kf [cm*d^{-1}]	CEC$_{eff}$ [cmol$_c$*kg^{-1}]	P [kg*ha^{-1}]	K [kg*ha^{-1}]	C [kg*ha^{-1}]	N [kg*ha^{-1}]	C/N	CaCO3 [kg*ha^{-1}]	pH	change [0=no, 1=yes]	freq	magnit [%]	AW$_{eff}$ [mm]
SE29	7.0	39	776	3564	131994	11121	11.9	76659	6.9	0	0.27	100	67.7
SE30	3.1	39	639	3429	6371	14461	0.4	1669668	7.3	1	1	50	72.2
SE31	3.1	39	532	3095	50825	7267	7.0	1164302	7.4	1	1	50	72.7
SE32	7.2	38	570	2363	59700	9152	6.5	606814	7.3	1	1	50	68.8
SE33	2.0	39	522	2225	14590	8248	1.8	1767600	7.4	1	1	50	62.7
SE34	2.0	39	1825	4942	101396	11425	8.9	119985	7.3	1	1	50	66.2
SE35	7.0	39	1238	6650	203638	23422	8.7	1066846	7.3	1	1	50	67.7
SE36	3.9	39	404	4213	0	8609	0.0	1561668	7.3	0	0.27	100	67.7
SE37	7.0	39	926	1711	89985	8723	10.3	215641	7.3	0	0.27	100	68.8
SE38	2.0	39	537	3273	24572	7388	3.3	1018328	7.3	0	0.27	100	77.7
SE39	2.0	39	771	4159	68643	7337	9.4	81439	7.1	0	0.27	100	62.7
SE40	2.6	39	718	1635	0	5315	0.0	1837865	7.3	0	0.27	50	66.5
SE41	25.0	28	45	2248	0	1628	0.0	335906	7.3	0	0.01	100	9.7
SE42	20.0	29	124	949	65070	6947	9.4	82546	7.3	0	0.01	100	25.7
SE43	23.1	5	301	1679	92468	6965	13.3	0	7.3	0	0.01	100	69.2
SE44	7.0	39	561	4204	92231	16328	5.6	1160750	7.3	0	0.01	100	62.7
3	7.2	25	60	1826	68147	6969	9.8	0	5.6	0	4	50	69.6
4	30.1	14	135	2950	136320	12785	10.7	0	5.7	0	4	50	85.2
21	7.0	39	361	2239	110142	7593	14.5	0	6.1	0	5	100	67.0
29	17.6	21	623	4561	100770	13112	7.7	0	6.2	0	5	100	87.0
30	5.8	34	358	2782	64401	6023	10.7	0	6.3	0	5	100	51.5
47	2.7	39	369	1836	44503	9177	4.8	1223495	7.1	0	2	50	74.1
51	3.1	39	482	4219	57860	8022	7.2	832682	6.9	0	5	100	72.0
53	13.0	21	224	1528	0	6217	0.0	751800	6.8	0	5	100	36.0
56	10.0	22	311	780	93093	8882	10.5	110717	6.5	0	1	50	39.3
69	10.0	22	543	1062	91549	5988	15.3	0	6.3	0	3	50	64.3
77	18.8	21	726	2928	35417	11475	3.1	1418443	7.0	0	5	100	92.2
91	3.1	39	233	2205	95155	9424	10.1	0	6.2	0	4	50	63.2
92	16.0	23	171	1099	82489	7190	11.5	0	5.1	0	1	50	96.2
97	3.3	28	452	1234	83016	8144	10.2	0	5.4	0	2	50	64.0
115	14.7	14	404	2494	180568	16764	10.8	408398	7.0	0	1	50	62.9
117	26.0	15	187	2012	136899	14976	9.1	301860	7.4	0	1	50	103.9

Appendix Table 16 continued.

site	kf [cm*d^{-1}]	CEC$_{eff}$ [cmol$_c$*kg^{-1}]	P [kg*ha^{-1}]	K [kg*ha^{-1}]	C [kg*ha^{-1}]	N [kg*ha^{-1}]	C/N	CaCO3 [kg*ha^{-1}]	pH	change [0=no, 1=yes]	freq	magnit [%]	AW$_{eff}$ [mm]
120	4.2	21	104	1139	15681	7117	2.2	797657	6.8	0	3	50	61.9
136	10.0	22	13	1180	76672	4375	17.5	0	4.4	0	3	50	74.9
138	10.0	22	571	2523	97807	13267	7.4	227358	6.8	0	2	50	79.8
147	7.0	39	991	5163	113632	12665	9.0	633700	7.2	0	0.01	50	60.1
151	26.0	15	230	1703	194019	10799	18.0	0	7.3	0	1	50	103.3
168	3.1	39	373	1124	117417	8786	13.4	0	5.7	0	2	50	69.5
171	2.5	39	829	2836	79481	5942	13.4	237617	6.6	0	2	50	39.9
176	4.1	39	218	1664	73184	4161	17.6	0	5.2	0	3	50	68.4
202	10.0	22	263	1607	50609	11036	4.6	288538	6.8	0	1	50	58.6
211	11.8	25	35	1069	81130	6366	12.7	0	5.5	0	3	50	98.0
234	2.0	39	21	1293	90395	7318	12.4	0	5.4	0	3	50	74.0
242	3.1	39	869	2436	0	8720	0.0	1645417	6.5	0	1	50	68.4
275	10.0	22	196	1038	52253	1002	52.1	0	6.3	0	2	50	69.4
288	21.3	15	84	1723	81260	7928	10.3	0	4.8	0	1	50	54.0
297	21.1	15	979	2536	92355	7476	12.4	0	6.2	0	3	50	88.0
312	10.5	16	3255	3196	70973	5930	12.0	0	5.9	0	0.27	100	92.9
325	10.0	22	164	1690	69544	5829	11.9	0	6.1	0	3	50	68.0
332	8.9	28	182	879	85366	8871	9.6	0	5.6	0	1	50	55.3
337	41.0	9	30	352	62684	5364	11.7	0	4.7	0	3	50	138.0
343	8.0	22	910	2123	105752	8954	11.8	0	6.8	0	1	50	83.4
366	10.0	22	907	1922	83050	6998	11.9	42900	6.8	0	2	50	81.2
366B	12.5	17	483	1861	113837	14181	8.0	0	6.3	0	0.13	50	81.0
373	10.0	22	818	2557	42131	6455	6.5	1264596	6.9	0	1	50	60.5
374	26.0	15	0	1329	98265	12770	7.7	0	5.6	0	3	50	99.3
376	22.2	14	83	502	46423	3556	13.1	0	5.3	0	3	50	30.3
397	10.0	22	52	572	34562	3370	10.3	0	5.8	0	1	50	16.9
423	21.9	14	306	1510	97761	7849	12.5	0	5.9	0	3	50	72.4
427	15.4	17	142	2358	16977	5870	2.9	1791619	7.1	0	4	50	28.5
513	10.0	22	197	1530	24437	4699	5.2	1238075	7.0	0	0.01	50	41.1
552	10.0	22	326	956	31093	6400	4.9	395326	6.7	0	1	50	18.4

Appendix Table 16 continued.

site	kf [cm*d^{-1}]	CEC$_{eff}$ [cmol$_c$*kg^{-1}]	P [kg*ha^{-1}]	K [kg*ha^{-1}]	C [kg*ha^{-1}]	N [kg*ha^{-1}]	C/N	CaCO3 [kg*ha^{-1}]	pH	change [0=no, 1=yes]	freq	magnit [%]	AW$_{eff}$ [mm]
AB17	10.0	22	1057	3215	24431	6713	3.6	818100	6.9	0	0.01	100	71.3
E13	10.0	22	0	1838	190972	17751	10.8	0	5.6	0	3	50	78.6
E19	8.0	29	302	1401	85786	5221	16.4	0	6.5	0	3	50	73.9
E7	10.0	22	335	1176	88442	8546	10.3	0	6.8	0	0.27	50	37.0
E9	10.0	29	25	889	70286	3284	21.4	0	6.0	0	3	50	34.2
H17	10.0	22	771	1671	63908	6903	9.3	374523	7.1	0	0.01	50	62.4
H9	41.0	13	687	1675	98157	4869	20.2	149385	7.3	0	0.01	50	95.1
LiF2000	3.1	35	309	1077	64618	7211	9.0	227139	7.3	1	0.33	100	24.9
LiF2001	20.0	29	309	1097	53700	7415	7.2	270264	7.3	1	0.5	100	29.1
LiF2002	7.0	39	207	1176	56860	5824	9.8	134561	7.4	1	1	100	15.7
LiM	7.0	39	237	1086	53459	6597	8.1	197989	7.3	0	1	50	15.7
M10	10.0	22	136	1283	32624	11839	2.8	785523	7.2	0	0.27	50	52.4
M2	10.0	22	379	1799	83749	9484	8.8	382124	6.8	0	0.27	50	73.4
M5	22.9	15	25	1755	39614	11652	3.4	925330	7.3	0	1	50	99.9
MoF2000	7.0	39	84	1376	39207	17444	2.2	403685	7.4	1	0.33	100	24.5
MoF2001	7.0	39	102	1421	43169	5963	7.2	317848	7.2	1	0.5	100	20.9
MoF2002	28.9	24	246	1781	35020	4159	8.4	274155	7.3	1	1	100	33.9
MoM	7.0	39	27	457	0	210	0.0	721678	7.4	0	1	50	10.7
RaBF2000	2.5	37	327	2231	77465	6921	11.2	959723	7.4	1	0.33	100	43.7
RaBF2001	2.3	39	221	2186	63520	5821	10.9	1297572	7.3	1	0.5	100	39.5
RaBF2002	8.7	35	340	1965	100343	13953	7.2	523306	7.2	1	1	100	35.8
RaBM	2.6	39	206	1363	73163	12824	5.7	697108	7.4	0	1	50	42.0
ReBF2000	6.1	36	260	3085	89621	13074	6.9	897028	7.0	1	0.33	100	46.9
ReBF2001	9.0	35	109	3215	66048	13105	5.0	2602908	7.4	1	0.5	100	46.9
ReBF2002	2.6	39	111	1688	0	4104	0.0	2837783	7.0	1	1	100	48.4
ReBM	2.9	39	122	1708	26671	7032	3.8	1359102	7.3	0	1	50	34.7
S21	41.0	13	213	607	78138	7125	11.0	0	7.0	0	0.01	50	14.9
S3	10.0	29	495	3320	35616	3594	9.9	688279	6.7	0	0.01	50	63.8
S6	10.0	22	1358	2724	45112	21309	2.1	535935	6.8	0	0.01	50	69.1
Z01	26.0	15	66	3966	74499	8460	8.8	455228	7.5	0	0.01	50	85.6
MÜR 1	653.0	2.00	523.4	503.1	74730.0	5421.6	13.8	0	6.2	0	2	5	31.8
MÜR 2	564.3	2.03	589.6	675.8	64716.8	3192.3	20.3	0	4.9	0	2	48	33.0

Appendix Table 16 continued.

site	kf [cm*d^{-1}]	CEC$_{eff}$ [cmol$_c$*kg^{-1}]	P [kg*ha^{-1}]	K [kg*ha^{-1}]	C [kg*ha^{-1}]	N [kg*ha^{-1}]	C/N	CaCO3 [kg*ha^{-1}]	pH	change [0=no, 1=yes]	freq	magnit [%]	AW$_{eff}$ [mm]
MÜR 3	172.0	2.00	290.2	605.1	12655.1	803.6	15.7	0	4.6	0	2	0	67.6
MÜR 4	178.6	2.09	511.6	407.9	33407.0	2400.8	13.9	0	3.8	0	2	48	51.6
MÜR 5	235.6	2.12	750.5	722.3	45823.8	2296.4	20.0	0	4.4	0	2	47	60.9
MÜR 6	51.2	4.98	37.6	511.4	96286.7	7801.4	12.3	0	5.9	0	2	35	67.6
MÜR 7	172.0	2.04	726.8	391.3	36830.7	1940.9	19.0	0	4.0	0	2	48	54.9
MÜR 8	355.1	2.42	637.0	483.3	38220.4	5306.4	7.2	0	3.9	0	2	46	46.8
MÜR 9	24.1	9.77	12.1	337.6	73597.5	4585.4	16.1	481312	7.0	0	2	42	75.4
MÜR 10	567.8	3.69	61.8	331.4	104089.1	11242.4	9.3	0	5.4	0	2	38	33.0
MÜR 11	653.0	2.70	409.3	416.1	68657.1	4966.8	13.8	0	5.0	0	2	50	33.0
MÜR 12	653.0	4.13	64.4	1308.9	246933.3	16755.7	14.7	0	3.9	0	2	32	33.0
MÜR 13	172.0	2.04	1137.2	274.5	44128.1	2198.0	20.1	0	4.2	0	2	45	67.6
MÜR 14	172.0	2.14	710.3	215.6	60271.0	4394.3	13.7	0	3.8	0	2	49	67.6
MÜR 15	172.0	5.63	107.2	296.0	108768.8	5713.4	19.0	0	4.5	0	2	49	67.6
MÜR 16	172.0	2.73	796.6	288.7	108156.2	8692.1	12.4	0	4.2	0	2	43	67.6
MÜR 17	172.0	2.18	888.3	430.0	114779.4	10043.3	11.4	0	4.2	0	2	47	67.6
MÜR 18	172.0	2.23	579.3	966.2	93302.9	6498.5	14.4	0	5.5	0	2	49	67.6
MÜR 19	172.0	2.46	613.0	214.9	102729.6	7230.3	14.2	0	5.7	0	2	44	67.6
MÜR 20	172.0	2.98	1362.2	788.9	58582.2	895.6	65.4	0	5.1	0	2	49	67.6
MÜR 21	172.0	2.19	662.2	597.3	81558.5	4874.5	16.7	0	3.9	0	2	49	67.6
MÜR 22	172.0	2.00	288.8	278.5	128803.2	12075.3	10.7	0	5.6	0	2	48	67.6
MÜR 23	300.0	25.00	2951.6	296.8	1431210.3	96477.8	14.8	0	5.9	0	2	21	169.8
MÜR 24	614.9	3.20	64.4	125.1	86060.9	10401.0	8.3	668043	7.1	0	2	49	36.9
MÜR 25	172.0	3.44	72.8	711.7	77034.3	10864.4	7.1	734081	7.3	0	2	47	67.6
MÜR 26	172.0	2.20	95.3	171.0	56048.4	9832.5	5.7	695201	6.4	0	2	36	67.6
MÜR 27	75.5	6.40	10.7	549.8	147450.2	17044.9	8.7	870955	7.4	0	2	42	67.5
MÜR 28	29.0	11.05	18.1	434.0	107373.4	18216.1	5.9	363109	6.9	0	2	44	36.9
MÜR 29	172.0	2.80	0.0	241.1	44792.7	6948.8	6.4	1566845	7.5	0	2	47	143.3
MÜR 30	172.0	3.05	473.4	224.4	80250.2	6963.3	11.5	168237	7.0	0	2	14	127.5
MÜR 31	122.4	3.96	0.0	212.9	158998.9	14494.9	11.0	1747466	7.2	0	2	35	121.5
MÜR 32	232.1	5.17	34.4	99.3	227203.8	20205.8	11.2	19067	7.0	0	2	37	116.7
MÜR 33	183.8	2.98	294.8	140.5	50037.5	4895.9	10.2	322766	6.9	0	2	41	170.5

Appendix Table 16 continued.

site	kf [cm*d^{-1}]	CEC$_{eff}$ [cmol$_c$*kg^{-1}]	P [kg*ha^{-1}]	K [kg*ha^{-1}]	C [kg*ha^{-1}]	N [kg*ha^{-1}]	C/N	CaCO3 [kg*ha^{-1}]	pH	change [0=no, 1=yes]	freq	magnit [%]	AW$_{eff}$ [mm]
MÜR 34	653.0	6.20	0.0	84.0	138249.5	10339.7	13.4	0	6.2	0	2	33	117.2
MÜR 35	10.2	9.57	5.3	272.8	37288.9	4211.9	8.9	1352516	7.5	0	2	38	115.9
MÜR 36	458.8	4.40	62.3	215.3	97778.1	7430.5	13.2	13871	6.6	0	2	30	89.2
MÜR 37	172.0	2.44	24.0	108.8	40675.1	4435.9	9.2	638829	7.5	0	2	44	116.7
MÜR 38	172.0	2.00	19.6	69.3	31867.1	2698.8	11.8	138461	7.4	0	2	0	232.0
MÜR 39	172.0	2.93	64.0	50.1	27908.3	2389.9	11.7	225622	7.4	0	2	10	127.5
MÜR 40	117.2	3.05	221.8	79.7	72372.9	3853.2	18.8	17386	6.9	0	2	0	116.5
MÜR 41	269.1	2.56	131.7	63.2	44699.2	3798.9	11.8	87489	7.4	0	2	7	84.7
MÜR 42	172.0	4.25	74.8	53.9	63185.1	4582.2	13.8	101387	6.7	0	2	7	127.9
MÜR 43	119.3	2.75	7.1	142.9	96011.5	3489.1	27.5	110565	6.9	0	2	0	216.8
MÜR 44	172.0	2.60	49.0	91.4	67024.2	6319.1	10.6	522857	7.3	0	2	24	130.4
MÜR 45	23.6	13.63	37.3	623.9	174024.5	18395.1	9.5	769650	7.6	0	2	43	66.7
MÜR 46	67.3	8.13	31.6	646.7	78505.3	6980.2	11.2	905150	7.7	0	2	40	67.5
MÜR 47	114.0	3.91	439.0	95.9	101927.6	2014.9	50.6	6763	6.8	0	2	13	196.2
MÜR 48	172.0	2.34	1050.2	173.2	107638.7	3463.4	31.1	0	3.5	0	0.001	0	67.6
MÜR 49	459.1	7.10	58.2	115.1	253858.9	15631.1	16.2	0	5.4	0	2	33	204.6
MÜR 50	172.0	2.44	188.5	180.6	129208.2	6478.8	19.9	7299	6.4	0	2	28	232.0
MÜR 51	615.0	5.02	209.2	143.9	220914.7	18611.4	11.9	222305	7.0	0	3	14	115.6
MÜR 52	572.2	3.32	142.9	167.7	252723.6	19292.5	13.1	0	6.6	0	3	7	33.0
MÜR 53	172.0	2.23	0.0	98.4	143936.0	6467.2	22.3	0	4.9	0	0.001	0	67.6
MÜR 54	172.0	2.15	484.5	170.2	183896.8	5465.3	33.6	0	3.3	0	0.001	0	67.6
MÜR 55	172.0	2.15	792.2	225.2	212769.7	7818.6	27.2	0	3.3	0	0.001	0	67.6
MÜR 56	308.2	2.00	302.7	211.2	48805.5	4725.8	10.3	0	5.0	0	3	19	51.4
MÜR 57	131.2	4.80	394.7	158.7	133084.2	13618.0	9.8	47552	6.9	0	3	22	123.6
MÜR 58	131.2	2.00	21.5	156.1	46161.3	891.8	51.8	136174	6.5	0	2	14	67.5
MÜR 59	65.3	7.36	31.5	469.6	131294.2	6941.6	18.9	807664	5.5	0	2	26	67.5
MÜR 60	155.8	2.20	517.7	278.6	55841.3	3837.1	14.6	64923	6.4	0	2	23	67.5
MÜR 61	172.0	2.40	67.6	87.9	96350.1	11052.5	8.7	881542	7.5	0	2	27	127.5
MÜR 62	55.0	10.13	22.0	140.7	34138.3	2585.6	13.2	1143365	7.5	0	2	19	122.1
MÜR 63	172.0	2.00	0.0	199.6	9588.0	3792.9	2.5	2157723	7.0	0	2	10	142.5

Appendix Table 16 continued.

site	kf [cm*d^{-1}]	CEC$_{eff}$ [cmol$_c$*kg^{-1}]	P [kg*ha^{-1}]	K [kg*ha^{-1}]	C [kg*ha^{-1}]	N [kg*ha^{-1}]	C/N	CaCO3 [kg*ha^{-1}]	pH	change [0=no, 1=yes]	freq	magnit [%]	AW$_{eff}$ [mm]
MÜR 64	63.8	8.45	109.2	168.1	43432.3	4534.7	9.6	1213283	7.1	0	2	18	117.2
MÜR 65	233.5	3.32	8.0	123.8	106393.0	11284.8	9.4	0	5.7	0	2	27	58.0
MÜR 66	262.1	2.00	105.8	112.2	60637.5	8238.0	7.4	197049	6.2	0	2	9	58.0
MÜR 67	133.3	2.00	19.4	208.6	41671.3	932.0	44.7	1167712	7.0	0	2	24	67.5
MÜR 68	172.0	2.00	208.5	187.4	82151.1	5104.2	16.1	0	5.5	0	2	13	67.6
MÜR 69	289.1	2.23	31.2	122.0	82886.0	3214.1	25.8	177526	5.9	0	2	27	54.8
MÜR 70	172.0	2.00	57.7	91.9	35973.1	850.4	42.3	418462	7.7	0	2	5	67.6
MÜR 71	272.3	2.00	83.9	231.5	105733.7	14305.1	7.4	512507	7.4	0	2	21	54.7
MÜR 72	308.2	2.05	232.5	216.4	71667.1	6082.4	11.8	0	4.4	0	2	29	51.4
MÜR 73	172.0	2.00	0.7	147.7	33045.5	4707.9	7.0	1304319	7.3	0	2	27	170.2
MÜR 74	30.9	8.60	30.4	137.7	39626.3	3826.5	10.4	1450853	7.3	0	2	19	108.0
MÜR 75	172.0	2.00	37.3	97.4	115215.4	12265.1	9.4	969714	7.7	0	2	15	127.5
MÜR 76	186.9	2.76	147.6	142.4	75092.4	7879.4	9.5	427084	7.0	0	2	18	127.0
MÜR 77	178.6	2.00	248.5	137.7	160168.7	11617.6	13.8	0	6.1	0	3	22	124.7
MÜR 78	172.0	3.16	270.0	115.6	59721.5	5661.8	10.5	252677	7.3	0	2	32	127.0
MÜR 79	308.2	3.20	219.7	146.0	78709.2	8170.9	9.6	301424	7.6	0	2	18	51.4
MÜR 80	172.0	2.72	0.0	135.9	226897.5	22945.0	9.9	1547203	6.6	0	2	5	130.0
MÜR 81	300.7	2.68	205.3	120.2	28088.3	4631.7	6.1	639815	7.0	0	2	9	116.7
MÜR 82	81.6	4.87	60.1	123.9	179518.2	20101.7	8.9	1303500	7.6	0	3	27	73.2
MÜR 83	268.0	2.48	176.1	85.4	56518.2	4165.4	13.6	0	5.2	0	2	21	113.0
MÜR 84	281.1	2.63	135.9	148.3	120250.8	6998.7	17.2	0	6.0	0	2	10	183.1
MÜR 85	172.0	2.13	69.7	147.6	31531.0	2858.0	11.0	223941	6.1	0	3	32	67.6
MÜR 86	172.0	2.52	0.0	59.6	39213.9	4838.3	8.1	1067280	7.5	0	2	39	176.4
MÜR 87	172.0	2.00	303.4	181.3	169483.3	12267.8	13.8	69806	6.6	0	3	9	220.4
MÜR 88	172.0	2.47	67.2	1075.3	45484.7	4912.1	9.3	151822	5.9	0	3	26	67.6
MÜR 89	172.0	2.00	175.8	86.4	7919.7	1445.5	5.5	0	3.8	0	3	30	67.6
MÜR 90	172.0	2.00	187.0	302.1	29241.3	1982.9	14.7	0	5.2	0	3	22	67.6
MÜR 91	374.2	51.79	32.3	45.9	367751.1	20855.9	17.6	0	6.6	0	3	22	135.4
MÜR 92	550.4	2.00	9.8	73.9	43791.9	2017.6	21.7	0	4.5	0	3	35	36.9
MÜR 93	122.5	6.57	204.1	76.0	53430.1	4686.7	11.4	0	6.8	0	3	7	67.5
MÜR 94	297.8	34.23	13.5	48.0	266878.4	20228.8	13.2	0	6.3	0	3	20	139.9
MÜR 95	172.0	2.30	79.6	89.1	60708.5	2890.1	21.0	0	6.8	0	3	13	67.6

Appendix Table 16 continued.

site	kf [cm*d^{-1}]	CEC$_{eff}$ [cmol$_c$*kg^{-1}]	P [kg*ha^{-1}]	K [kg*ha^{-1}]	C [kg*ha^{-1}]	N [kg*ha^{-1}]	C/N	CaCO3 [kg*ha^{-1}]	pH	change [0=no, 1=yes]	freq	magnit [%]	AW$_{eff}$ [mm]
MÜR 96	172.0	2.26	86.6	122.9	35053.2	3966.5	8.8	94407	6.0	0	2	21	67.6
MÜR 97	300.0	30.00	105.5	104.2	1494100.1	82857.6	18.0	0	6.4	0	2	23	169.8
MÜR 98	371.9	2.08	156.8	92.4	19680.3	2897.1	6.8	0	5.2	0	2	33	33.0
MÜR 99	172.0	2.13	47.2	363.9	37274.5	3446.0	10.8	55328	6.0	0	2	20	67.6
MÜR 100	390.0	8.43	192.4	75.6	562366.3	25379.3	22.2	16010	6.0	0	2	19	136.0
MÜR 101	492.4	2.09	103.9	64.3	28107.8	2614.7	10.7	108450	5.2	0	2	16	36.9
MÜR 102	172.0	2.10	101.6	409.5	39424.6	4321.8	9.1	83364	5.6	0	2	27	67.6
MÜR 103	342.4	2.93	56.4	73.5	23672.4	3049.0	7.8	248670	7.4	0	2	15	118.8
MÜR 104	335.7	3.65	20.0	150.6	112546.3	5152.1	21.8	149414	6.1	0	2	31	36.9
MÜR 105	172.0	2.00	169.8	112.3	40028.0	3909.2	10.2	0	5.3	0	2	23	67.6
MÜR 106	224.7	19.20	226.9	143.9	1035757.9	47154.3	22.0	91575	6.7	0	2	4	220.2
MÜR 107	172.0	2.63	174.2	91.0	42925.4	3881.1	11.1	0	6.9	0	2	13	67.6
MÜR 108	332.1	18.51	235.5	87.7	1273775.2	67308.0	18.9	0	6.3	0	2	16	223.7
MÜR 109	445.4	2.20	184.8	81.3	58654.4	4952.9	11.8	142531	6.0	0	2	4	147.7
MÜR 110	172.0	2.18	341.8	129.8	11705.4	2852.6	4.1	0	5.7	0	2	21	67.6
MÜR 111	460.1	2.00	3.8	33.4	16430.2	1595.9	10.3	0	5.3	0	2	31	33.0
MÜR 112	427.0	4.80	168.2	211.8	142693.0	13365.6	10.7	135184	6.8	0	2	26	111.8
MÜR 113	610.2	2.00	34.6	60.4	18970.0	1457.5	13.0	9264	6.3	0	2	33	36.9
MÜR 114	587.5	2.00	57.4	87.9	30462.7	1999.1	15.2	0	4.0	0	2	24	40.7
MÜR 115	296.3	11.15	269.2	110.1	566552.5	35774.0	15.8	53302	6.4	0	2	27	159.5
MÜR 116	404.3	2.37	11.9	94.9	34800.2	2717.0	12.8	2546	4.9	0	2	37	40.7
MÜR 117	311.1	13.60	227.7	144.5	705515.5	33094.7	21.3	29048	6.7	0	2	9	171.3
MÜR 118	361.2	3.35	45.4	75.8	56246.8	3958.4	14.2	0	4.6	0	2	34	48.0
MÜR 119	581.0	2.63	22.6	143.2	87621.4	2604.0	33.6	0	5.3	0	2	25	40.7
MÜR 120	157.3	6.29	88.0	418.5	68713.6	7367.9	9.3	350019	7.2	0	2	41	126.3

Appendix Table 17: Hassberge and Müritz: Species codes.

species	code
Achillea millefolium	sp1
Agrimonia eupatoria	sp2
Agropyron repens	sp3
Agrostis capillaris	sp4
Agrostis stolonifera	sp5
Alopecurus pratensis	sp6
Anthoxanthum odoratum	sp7
Armeria maritima ssp. *elongata*	sp8
Arrhenatherum elatius	sp9
Avenula pubescens	sp10
Brachypodium pinnatum	sp11
Briza media	sp12
Bromus erectus	sp13
Bromus hordeaceus	sp14
Bromus sterilis	sp15
Bupleurum falcatum	sp16
Calamagrostis epigejos	sp17
Calamagrostis stricta	sp18
Capsella bursa-pastoris	sp19
Carex arenaria	sp20
Carex disticha	sp21
Carex flacca	sp22
Carex hirta	sp23
Carex nigra	sp24
Carex panicea	sp25
Centaurea jacea	sp26
Centaurea scabiosa	sp27
Cerastium arvense	sp28
Cerastium brachypetalum	sp29
Cerastium glomeratum	sp30
Cirsium arvense	sp31
Cirsium palustre	sp32
Cladium mariscus	sp33
Convolvulus arvensis	sp34
Cornus sanguinea	sp35
Crataegus monogyna	sp36
Cynosurus cristatus	sp37
Dactylis glomerata	sp38
Danthonia decumbens	sp39
Daucus carota	sp40
Deschampsia cespitosa	sp41
Dianthus carthusianorum	sp42
Eleocharis uniglumis	sp43
Erodium cicutarium	sp44
Euphorbia cyparissias	sp45
Falcaria vulgaris	sp46
Festuca ovina agg.	sp47
Festuca pratensis	sp48
Festuca rubra	sp49
Fragaria viridis	sp50
Galium aparine	sp51
Galium mollugo	sp52
Galium palustre	sp53
Galium uliginosum	sp54
Galium verum	sp55
Genista tinctoria	sp56
Gentianella uliginosa	sp57
Geum urbanum	sp58
Holcus lanatus	sp59
Hydrocotyle vulgaris	sp60
Hypericum perforatum	sp61
Inula conyza	sp62
Juncus articulatus	sp63
Juniperus communis	sp64
Knautia arvensis	sp65
Lathyrus pratensis	sp66
Leontodon autumnalis	sp67
Leontodon hispidus	sp68
Leucanthemum vulgare	sp69
Linum catharticum	sp70
Lolium perenne	sp71
Lotus corniculatus	sp72
Lotus uliginosus	sp73
Luzula campestris	sp74
Medicago lupulina	sp75
Mentha aquatica	sp76
Molinia caerulea	sp77
Myosotis ramosissima	sp78
Odontites vulgaris	sp79
Ononis repens	sp80
Origanum vulgare	sp81
Parnassia palustris	sp82
Phragmitis australis	sp83
Pimpinella saxifraga	sp84
Pinguicula vulgaris	sp85
Plantago lanceolata	sp86
Plantago media	sp87
Poa annua	sp88
Poa pratensis agg.	sp89
Poa trivialis	sp90
Polygala vulgaris	sp91
Potentilla anserina	sp92
Potentilla erecta	sp93
Potentilla neumanniana	sp94
Potentilla reptans	sp95
Primula veris	sp96
Prunella vulgaris	sp97
Prunus spinosa	sp98
Ranunculus acris	sp99
Ranunculus bulbosus	sp100
Ranunculus flammula	sp101
Ranunculus repens	sp102
Rhinanthus minor	sp103
Rhinanthus serotinus	sp104
Rosa canina agg.	sp105
Rumex acetosa	sp106
Rumex acetosella	sp107
Salix repens	sp108
Salvia pratensis	sp109
Sanguisorba minor	sp110
Saxifraga granulata	sp111
Stellaria graminea	sp112
Succisa pratensis	sp113
Taraxacum officinale agg.	sp114
Taraxacum palustre	sp115
Thlaspi perfoliatum	sp116
Tragopopgon pratensis	sp117
Trifolium fragiferum	sp118
Trifolium pratense	sp119
Trifolium repens	sp120
Trisetum flavenscens	sp121
Valeriana dioica	sp122
Valerianella locusta	sp123
Veronica arvensis	sp124
Veronica chamaedrys	sp125
Vicia angustifolia	sp126
Vicia cracca	sp127
Vicia tetrasperma	sp128
Viola canina	sp129
Viola hirta	sp130

Appendix Table 18: Hassberge and Müritz: Plant functional groups with statistical values and their species with traits. For index explanation see Chapters 3 and 4.

PFG	species	aeren-chyma	other physical defence	woodi-ness	spacers	SLI	SLA $[mm^2*mg^{-1}]$	canopy height [mm]	clonality	thorny physical defence	plant life span	seed mass [mg]	seed number	start seed shedding [month]
1	*Cirsium palustre*	1	0	0	0	0.41	25.4	190	0	1	0.5	0.84	814	7
	Danthonia decumbens	1	0	0	0.5	0.46	22.6	129	0.5	0	1	0.70	22	7
	Juncus articulatus	1	0	0	1	0.79	19.5	294	1	0	1	0.02	3176	8
	Molinia caerulea	1	0	0	0.5	0.50	25.4	297	1	0	1	0.27	413	9
	Potentilla anserina	1	0	0	0.75	0.44	26.0	201	1	0	1	0.70	14	-
	Potentilla reptans	1	0	0	0.5	0.50	23.0	159	1	0	1	0.31	93	8
	Ranunculus acris	1	0	0	0.5	0.39	21.7	196	0.5	0	1	1.35	235	7
	Ranunculus flammula	1	0	0	0.5	0.77	20.0	196	0.83	0	1	0.10	1406	8
	Ranunculus repens	1	0	0	0.5	0.73	26.7	187	0.83	0	1	1.81	60	7
	median	1	0	0	0.5	0.5	23.0	196	0.83	0	1	0.70	235	8
	mean	1.0	0.0	0.0	0.5	0.6	23.4	205.4	0.7	0.1	0.9	0.68	693	8
	standard deviation	0.00	0.00	0.00	0.26	0.16	2.65	55.97	0.34	0.33	0.17	0.60	1039.65	0.74
	coefficient of variation	0.00	0.00	0.00	0.50	0.29	0.11	0.27	0.47	3.00	0.18	0.88	1.50	0.10
2	*Bromus erectus*	0	0	0	0.5	0.20	20.6	297	0.5	0	1	3.69	83	6
	Bupleurum falcatum	0	0	0	0.5	0.00	19.3	565	1	0	1	1.85	988	9
	Cynosurus cristatus	0	0	0	0.5	0.06	23.2	338	0.5	0	1	0.41	139	7
	Knautia arvensis	0	0	0	0.5	0.08	20.2	409	1	0	1	3.34	192	7
	Primula veris	0	0	0	0.5	0.18	20.7	158	1	0	1	0.86	271	7
	Salvia pratensis	0	0	0	0.5	0.22	18.9	271	1	0	1	2.56	528	6
	Sanguisorba minor	0	0	0	0.5	0.33	21.2	293	1	0	1	2.84	106	6
	Trisetum flavenscens	0	0	0	0.5	0.00	32.1	493	0.5	0	1	0.19	258	7
	Viola hirta	0	0	0	0.5	0.29	19.5	199	1	0	1	2.27	-	6
	median	0	0	0	0.5	0.18	20.6	297	1	0	1	2.27	225	7
	mean	0.0	0.0	0.0	0.5	0.2	21.7	335.9	0.8	0.0	1.0	2.00	321	7
	standard deviation	0.00	0.00	0.00	0.00	0.12	4.08	132.51	0.25	0.00	0.00	1.27	304.07	0.97
	coefficient of variation	0.00	0.00	0.00	0.00	0.81	0.19	0.39	0.30	0.00	0.00	0.63	0.95	0.14

Appendix Table 18 continued.

PFG	species	aeren-chyma	other physical defence	woodi-ness	spacers	SLI	SLA [mm^2*mg^{-1}]	canopy height [mm]	clonality	thorny physical defence	plant life span	seed mass [mg]	seed number	start seed shedding [month]
3	*Carex disticha*	1	1	0	1	0.44	19.5	306	1	0	1	0.50	219	-
	Carex flacca	1	1	0	0.83	0.53	20.8	326	0.75	0	1	0.73	195	5
	Carex hirta	1	1	0	1	0.25	22.8	221	1	0	1	2.23	35	7
	Carex nigra	1	1	0	1	0.42	22.2	287	1	0	1	0.68	146	8
	Carex panicea	1	1	0	1	0.36	23.0	267	1	0	1	1.61	27	8
	Deschampsia cespitosa	1	1	0	0.5	0.34	16.2	256	0.5	0	1	0.24	486	8
	Succisa pratensis	1	1	0	0.5	0.20	17.8	54	0.5	0	1	0.66	124	9
	median	1	1	0	1	0.36	20.8	267	1	0	1	0.68	146	8
	mean	1.0	1.0	0.0	0.8	0.4	20.3	245.3	0.8	0.0	1.0	0.95	176	8
	standard deviation	0.00	0.00	0.00	0.24	0.11	2.64	91.02	0.24	0.00	0.00	0.71	155.08	1.38
	coefficient of variation	0.00	0.00	0.00	0.28	0.31	0.13	0.37	0.29	0.00	0.00	0.74	0.88	0.18
4	*Agrostis capillaris*	0	0	0	0.83	0.67	39.9	149	1	0	1	0.04	110	8
	Anthoxanthum odoratum	0	0	0	0.75	0.38	36.6	260	1	0	1	0.34	102	6
	Cerastium arvense	0	0	0	1	0.57	46.4	121	1	0	1	0.15	240	-
	Holcus lanatus	0	0	0	0.5	0.61	38.5	301	0.5	0	1	0.24	122	7
	Lolium perenne	0	0	0	1	0.46	33.1	218	1	0	1	1.39	58	8
	Lotus corniculatus	0	0	0	0.75	0.46	35.7	255	0.5	0	1	0.96	318	7
	Luzula campestris	0	0	0	1	0.46	30.8	111	1	0	1	0.57	41	6
	Rumex acetosa	0	0	0	0.5	0.48	31.5	194	1	0	1	0.44	978	6
	Rumex acetosella	0	0	0	0.75	0.75	41.1	118	1	0	1	0.27	391	6
	Saxifraga granulata	0	0	0	0.75	0.57	27.4	138	1	0	1	0.02	554	5
	Stellaria graminea	0	0	0	0.75	0.45	43.8	183	1	0	1	0.19	329	7
	Trifolium repens	0	0	0	0.5	0.60	29.6	170	1	0	1	0.39	38	6
	Veronica chamaedrys	0	0	0	0.83	0.40	36.7	175	1	0	1	0.18	188	7
	Viola canina	0	0	0	0.75	0.56	35.2	119	0.75	0	1	0.85	96	7
	median	0	0	0	0.75	0.52	36.2	172.625	1	0	1	0.31	155	7
	mean	0.0	0.0	0.0	0.8	0.5	36.2	179.2	0.9	0.0	1.0	0.43	254	7
	standard deviation	0.00	0.00	0.00	0.17	0.11	5.46	60.01	0.19	0.00	0.00	0.39	257.88	0.87
	coefficient of variation	0.00	0.00	0.00	0.23	0.20	0.15	0.33	0.20	0.00	0.00	0.91	1.01	0.13

Appendix Table 18 continued.

PFG	species	aeren-chyma	other physical defence	woodi-ness	spacers	SLI	SLA $[mm^2*mg^{-1}]$	canopy height [mm]	clonality	thorny physical defence	plant life span	seed mass [mg]	seed number	start seed shedding [month]
5	*Fragaria viridis*	0	0	0	0.5	0.60	18.4	190	1	0	1	0.47	-	6
	Plantago lanceolata	0	0	0	0.75	0.54	21.8	226	1	0	1	1.30	283	7
	Plantago media	0	0	0	0.75	0.42	21.3	191	1	0	1	0.30	282	8
	Potentilla neumanniana	0	0	0	0.5	0.60	16.8	58	1	0	1	0.48	203	5
	Ranunculus bulbosus	0	0	0	1	0.50	19.7	144	1	0	1	3.51	124	6
	Trifolium pratense	0	0	0	0.75	0.49	24.6	269	0.75	0	1	1.24	256	8
	median	0	0	0	0.75	0.52	20.5	190.5	1	0	1	0.86	256	7
	mean	0.0	0.0	0.0	0.7	0.5	20.4	179.5	1.0	0.0	1.0	1.22	230	7
	standard deviation	0.00	0.00	0.00	0.19	0.07	2.75	72.84	0.10	0.00	0.00	1.20	67.49	1.21
	coefficient of variation	0.00	0.00	0.00	0.27	0.14	0.13	0.41	0.11	0.00	0.00	0.99	0.29	0.18
6	*Agrostis stolonifera*	1	0	0	0.67	0.50	59.2	200	1	0	1	0.06	544	8
	Hydrocotyle vulgaris	1	0	0	0.75	0.30	35.9	125	1	0	1	0.24	24	-
	Lotus uliginosus	1	0	0	0.75	0.38	40.0	176	0.5	0	1	0.49	181	8
	Mentha aquatica	1	0	0	0.75	0.43	33.9	219	1	0	1	0.10	475	9
	Parnassia palustris	1	0	0	0.5	0.14	36.6	50	0.83	0	1	0.03	1972	8
	Potentilla erecta	1	0	0	0.5	0.58	35.7	145	1	0	1	0.29	461	7
	Trifolium fragiferum	1	0	0	0.5	0.00	31.5	189	1	0	1	1.07	41	8
	Valeriana dioica	1	0	0	0.75	0.00	33.9	83	0.83	0	1	0.53	102	6
	median	1.0	0.0	0.0	0.7	0.3	35.8	160.0	1.0	0.0	1.0	0.26	321	8
	mean	1.0	0.0	0.0	0.6	0.3	38.3	148.1	0.9	0.0	1.0	0.35	475	8
	standard deviation	0.00	0.00	0.00	0.12	0.22	8.80	59.28	0.18	0.00	0.00	0.35	639.39	0.95
	coefficient of variation	0.00	0.00	0.00	0.19	0.76	0.23	0.40	0.20	0.00	0.00	0.99	1.35	0.12

Appendix Table 18 continued.

PFG	species	aeren-chyma	other physical defence	woodi-ness	spacers	SLI	SLA $[mm^2*mg^{-1}]$	canopy height [mm]	clonality	thorny physical defence	plant life span	seed mass [mg]	seed number	start seed shedding [month]
7	*Agrimonia eupatoria*	0	0	0	1	0.13	20.9	453	1	0	1	3.61	66	7
	Brachypodium pinnatum	0	0	0	1	0.10	28.1	440	1	0	1	2.77	83	7
	Briza media	0	0	0	0.83	0.00	25.5	259	1	0	1	0.26	18	6
	Eleocharis uniglumis	1	0	0	1	0.00	14.3	327	1	0	1	0.68	24	-
	Falcaria vulgaris	0	0	0	0.75	0.00	11.8	344	1	0	0.75	1.78	4432	-
	Pimpinella saxifraga	0	0	0	0.75	0.08	21.5	274	1	0	1	1.10	268	9
	Polygala vulgaris	0	0	0	1	0.13	22.3	116	0.5	0	1	2.21	48	7
	median	0.0	0.0	0.0	1.0	0.1	21.5	327.0	1.0	0.0	1.0	1.78	66	7
	mean	0.1	0.0	0.0	0.9	0.1	20.6	316.1	0.9	0.0	1.0	1.77	706	7
	standard deviation	0.38	0.00	0.00	0.12	0.06	5.79	115.66	0.19	0.00	0.09	1.19	1645.35	1.10
	coefficient of variation	2.65	0.00	0.00	0.13	0.96	0.28	0.37	0.20	0.00	0.10	0.67	2.33	0.15
8	*Bromus hordeaceus*	0	0	0	0	0.44	35.5	295	0	0	0.25	2.19	48	5
	Capsella bursa-pastoris	0	0	0	0	0.91	30.7	91	0	0	0.25	0.10	1838	-
	Cerastium glomeratum	0	0	0	0	0.50	41.0	105	0	0	0	0.09	761	-
	Erodium cicutarium	0	0	0	0	0.33	45.0	88	0	0	0.75	0.50	70	5
	Rhinanthus minor	0	0	0	0	0.60	26.6	244	0	0	0	2.54	187	7
	Thlaspi perfoliatum	0	0	0	0	0.75	22.7	80	0	0	0	0.27	131	6
	Veronica arvensis	0	0	0	0	0.50	30.3	75	0	0	0	0.10	383	5
	median	0.0	0.0	0.0	0.0	0.5	30.7	91.0	0.0	0.0	0.0	0.27	187	5
	mean	0.0	0.0	0.0	0.0	0.6	33.1	139.6	0.0	0.0	0.2	0.83	488	6
	standard deviation	0.00	0.00	0.00	0.00	0.20	7.91	90.28	0.00	0.00	0.28	1.07	644.82	0.89
	coefficient of variation	0.00	0.00	0.00	0.00	0.34	0.24	0.65	0.00	0.00	1.56	1.29	1.32	0.16

Appendix Table 18 continued.

PFG	species	aeren-chyma	other physical defence	woodi-ness	spacers	SLI	SLA $[mm^2*mg^{-1}]$	canopy height [mm]	clonality	thorny physical defence	plant life span	seed mass [mg]	seed number	start seed shedding [month]
9	*Achillea millefolium*	0	0	0	0.83	0.26	31.4	302	1	0	1	0.13	420	8
	Alopecurus pratensis	0	0	0	1	0.39	25.8	466	1	0	1	0.67	414	8
	Arrhenatherum elatius	0	0	0	1	0.20	32.0	818	1	0	1	2.68	-	7
	Dactylis glomerata	0	0	0	0.75	0.39	27.7	588	1	0	1	0.68	771	6
	Vicia cracca	0	0	0	1	0.10	42.4	241	1	0	1	12.28	280	7
	median	0.0	0.0	0.0	1.0	0.3	31.4	466.0	1.0	0.0	1.0	0.68	417	7
	mean	0.0	0.0	0.0	0.9	0.3	31.9	482.9	1.0	0.0	1.0	3.29	471	7
	standard deviation	0.00	0.00	0.00	0.12	0.13	6.44	231.90	0.00	0.00	0.00	5.12	210.22	0.84
	coefficient of variation	0.00	0.00	0.00	0.13	0.47	0.20	0.48	0.00	0.00	0.00	1.56	0.45	0.12
10	*Centaurea jacea*	0	1	0	1	0.19	24.7	384	1	0	1	1.71	250	8
	Centaurea scabiosa	0	1	0	0.75	0.25	18.3	231	0.75	0	1	6.74	210	7
	median	0.0	1.0	0.0	0.9	0.2	21.5	307.3	0.9	0.0	1.0	4.22	230	8
	mean	0.0	1.0	0.0	0.9	0.2	21.5	307.3	0.9	0.0	1.0	4.22	230	8
	standard deviation	0.00	0.00	0.00	0.18	0.04	4.52	107.83	0.18	0.00	0.00	3.55	27.99	0.71
	coefficient of variation	0.00	0.00	0.00	0.20	0.19	0.21	0.35	0.20	0.00	0.00	0.84	0.12	0.09
11	*Cladium mariscus*	1	1	0	1	0.00	6.3	1372	1	0	1	2.36	1603	8
	Phragmitis australis	1	1	0	0.75	0.10	12.1	1224	1	0	1	0.12	4085	11
	median	1.0	1.0	0.0	0.9	0.1	9.2	1298.0	1.0	0.0	1.0	1.24	2844	10
	mean	1.0	1.0	0.0	0.9	0.1	9.2	1298.0	1.0	0.0	1.0	1.24	2844	10
	standard deviation	0.00	0.00	0.00	0.18	0.07	4.12	104.65	0.00	0.00	0.00	1.58	1754.80	2.12
	coefficient of variation	0.00	0.00	0.00	0.20	1.41	0.45	0.08	0.00	0.00	0.00	1.28	0.62	0.22
12	*Euphorbia cyparissias*	0	0	0	1	0.71	34.1	335	1	0	1	2.21	435	5
	Hypericum perforatum	0	0	0.25	0.83	0.83	33.2	665	1	0	1	0.08	3036	9
	Inula conyza	0	0	0	1	1.00	20.0	293	1	0	1	0.23	-	9
	Origanum vulgare	0	0	0	1	0.75	23.7	514	1	0	1	0.10	316	10
	median	0.0	0.0	0.0	1.0	0.8	28.4	424.5	1.0	0.0	1.0	0.16	435	9
	mean	0.0	0.0	0.1	1.0	0.8	27.7	451.8	1.0	0.0	1.0	0.65	1262	8
	standard deviation	0.00	0.00	0.13	0.08	0.13	6.98	171.45	0.00	0.00	0.00	1.04	1537.19	2.22
	coefficient of variation	0.00	0.00	2.00	0.09	0.15	0.25	0.38	0.00	0.00	0.00	1.59	1.22	0.27

Appendix Table 18 continued.

PFG	species	aeren-chyma	other physical defence	woodi-ness	spacers	SLI	SLA $[\mathrm{mm^2*mg^{-1}}]$	canopy height [mm]	clonality	thorny physical defence	plant life span	seed mass [mg]	seed number	start seed shedding [month]
13	*Cornus sanguinea*	0	0	1	1	0.20	17.6	1366	1	0	1	35.16	1750	9
	Prunus spinosa	0	0	1	1	0.50	18.8	1221	1	1	1	427.13	96	9
	Rosa canina agg.	0	0	1	1	0.00	13.0	928	1	1	1	22.63	3623	9
	median	0.0	0.0	1.0	1.0	0.2	17.6	1221.0	1.0	1.0	1.0	35.16	1750	9
	mean	0.0	0.0	1.0	1.0	0.2	16.5	1171.7	1.0	0.7	1.0	161.64	1823	9
	standard deviation	0.00	0.00	0.00	0.00	0.25	3.06	223.13	0.00	0.58	0.00	230.01	1764.80	0.00
	coefficient of variation	0.00	0.00	0.00	0.00	1.08	0.19	0.19	0.00	0.87	0.00	1.42	0.97	0.00
14	*Galium palustre*	1	1	0	1	0.39	59.7	228	1	0	1	1.23	645	7
	Galium uliginosum	1	1	0	0.5	0.17	48.1	187	1	0	1	0.17	547	9
	median	1.0	1.0	0.0	0.8	0.3	53.9	207.5	1.0	0.0	1.0	0.70	596	8
	mean	1.0	1.0	0.0	0.8	0.3	53.9	207.5	1.0	0.0	1.0	0.70	596	8
	standard deviation	0.00	0.00	0.00	0.35	0.16	8.14	28.99	0.00	0.00	0.00	0.75	69.30	1.41
	coefficient of variation	0.00	0.00	0.00	0.47	0.57	0.15	0.14	0.00	0.00	0.00	1.07	0.12	0.18
15	*Armeria maritima* ssp. *elongata*	0	0	0.5	0.5	0.00	25.9	63	1	0	1	1.03	72	-
	Genista tinctoria	0	0	1	0	0.00	19.7	133	0	0	1	2.44	32	8
	Salix repens	1	0	1	0.5	0.00	18.1	164	1	0	1	-	1532	6
	median	0.0	0.0	1.0	0.5	0.0	19.7	132.5	1.0	0.0	1.0	1.73	72	7
	mean	0.3	0.0	0.8	0.3	0.0	21.2	119.5	0.7	0.0	1.0	1.73	545	7
	standard deviation	0.58	0.00	0.29	0.29	0.00	4.13	51.74	0.58	0.00	0.00	1.00	854.52	1.41
	coefficient of variation	1.73	0.00	0.35	0.87	0.00	0.19	0.43	0.87	0.00	0.00	0.58	1.57	0.20

Appendix Table 19: Hassberge and Müritz: Regression coefficients and goodness of fit measures for the responsive species. Grey marked PFGs show low quality models. Species in grey letters are predicted for both investigation areas. '2' labels the square of the environmental variable. (AWeff=effectively available water, kf=water permeability in saturated soil, K=plant available potassium, freq=disturbance frequency, P=plant available phosphorus, magnit=disturbance magnitude, C/N=relation between total carbon and total nitrogen, change=change in disturbance magnitude)

PFG	species	AUC	R^2_N	AW_{eff}	$AW_{eff}2$	kf	kf2	K	K2	freq	freq2	P	P2	pH	pH2	magnit	magnit2	C/N	C/N2	change
1	*Cirsium palustre*	0.930	0.4006	0.09704	-0.0003	0.00675	-	-	-	-	-	-	-	-	0.09936	-	-	-	-	-
	Danthonia decumbens	0.905	0.4926	-	-	-	-	-	-	-	-	-	-	0.60665	-	0.32672	-0.00757	-	-	-
	Juncus articulatus	0.924	0.5121	0.13044	-0.00041	-	1.2E-05	-	-	-	-	-	-	-	0.0828	-	-	-	0.00092	-
	Molinia caerulea	0.971	0.7157	0.07062	-0.00025	-	-	-	-	-	-0.66621	-	-	-	0.13224	0.37971	-0.00962	-	-	-
	Potentilla anserina	0.919	0.5250	0.08315	-0.00025	0.00833	-	-	-	-	-	-	-	-	0.08107	-	-	-	-	-
	Potentilla reptans	0.812	0.3212	-	-8.7E-05	-	-	-0.00047	-	2.25164	-0.40347	-	-	6.93051	-0.50712	-	-	-	-	-
	Ranunculus acris	0.791	0.3170	-	-	-	-	-0.00057	-	0.66354	-	-	-	0.40564	-	0.09983	-0.0014	-	-	-
	Ranunculus flammula	0.845	0.3018	0.01445	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Ranunculus repens	0.885	0.4562	-	-	0.00453	-	-0.00124	-	1.08713	-	-	-	0.85363	-	0.20782	-0.00239	-	-	-
2	*Bromus erectus*	0.867	0.3979	-	-	-0.04495	-	-	-	-	-	-	-4.2E-06	-	-	-	-	-	-	-
	Bupleurum falcatum	0.937	0.4968	-	-	-0.10139	-	-	-	-2.71952	0.40857	-0.0034	-	-	-	-	-	-	-	-
	Cynosurus cristatus	0.872	0.4216	-	-5.7E-05	-	-	-	-	7.0921	-1.20067	-	-	-	0.07899	0.17709	-0.00295	-	-	-
	Knautia arvensis	0.852	0.3514	-	-	-0.04092	-	-	-	-	-	-0.00213	-	-	-	-	-	-	-	1.19461
	Primula veris	0.946	0.5749	0.09965	-0.00054	-	-	-	-	-	-	-	-2.1E-06	-	-	60.0099	-0.40219	-	-	-17.2324
	Salvia pratensis	0.942	0.6005	-	-	-0.05419	-	-	-	-	-	-0.006	-	27.4627	-2.00787	3.33432	-0.02241	-	-	-
	Sanguisorba minor	0.925	0.6163	-	-	-0.05824	-	0.00273	-7.6E-07	-	-0.1061	-0.00232	-	-	-	-	-	-	-	-
	Trisetum flavenscens	0.859	0.4632	-	-	-0.04001	-	-	-	-	-	-0.00168	-	-0.60243	-	-	-	-	-	-
	Viola hirta	0.925	0.5306	0.03128	-	-	-	-	-1.7E-07	-0.55118	-	-	-	1.29611	-	28.0982	-0.18751	-	-	-
3	*Carex disticha*	0.941	0.4968	0.12581	-0.00035	0.00651	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Carex flacca	0.906	0.4917	-	-	-	-	-0.0042	-	-	-0.29019	-	-	-	0.09576	-	-	-	-	-
	Carex hirta	0.917	0.5529	-	-0.00012	-	-	-	-3.9E-06	25.8349	-5.07461	-	5.6E-07	8.35555	-0.64031	-	0.00098	-	-	-
	Carex nigra	0.915	0.4423	0.09499	-0.00029	0.00674	-	-	-	-	-	-	-	-	-	-	-	0.0518	-	-
	Carex panicea	0.943	0.5953	-	-	-	-	-	-	-	-0.25907	-	-	1.23526	-	0.43036	-0.00981	-	-	-
	Deschampsia cespitosa	0.931	0.5782	0.07107	-0.00033	-	-	-0.00363	-	-	-	-	-	-	0.08016	-	-	-	-	-
	Succisa pratensis	0.938	0.4282	0.19163	-0.00065	-	-	-	-	-	-	-	-	-	0.09308	-	-	-	-	-

Appendix Table 19 continued.

PFG	species	AUC	R^2_N	AW_eff	AW_eff2	kf	kf2	K	K2	freq	freq2	P	P2	pH	pH2	magnit	magnit2	C/N	C/N2	change
4	*Agrostis capillaris*	0.912	0.5625	-	-0.00013	-	-4E-06	-0.00192	-	3.04094	-0.50549	-	-	-	-0.05449	-	-	-	-	-
	Anthoxanthum odoratum	0.927	0.6107	0.10562	-0.00069	-0.00275	-	-	-	4.30107	-0.80252	-0.003	-	10.4044	-0.92434	-	-	-	-	-
	Cerastium arvense	0.904	0.4746	-	-7.6E-05	-	-	-0.00348	-	-	-	-	-	5.78589	-0.58401	0.045	-	-	-	3.40179
	Holcus lanatus	0.866	0.5334	0.03771	-0.0002	-	-	-	-	4.25318	-0.7395	-0.00281	-	-	-	-	-	-	-	-
	Lolium perenne	0.897	0.5191	-	-9.5E-05	-	-	-	-3.6E-07	7.88764	-1.42385	-	1.3E-06	-	-	0.05358	-	-	-	-
	Lotus corniculatus	0.857	0.4244	-	-	-0.0154	-	-	-	-	-	-0.00184	-	-	-	-	-0.00029	-	-	-8.20623
	Luzula campestris	0.864	0.4455	-	-9.5E-05	-0.00553	-	-	-	0.52517	-	-0.00185	-	6.01437	-0.54918	-	-0.00047	-	-	-
	Rumex acetosa	0.853	0.4093	-	-	-0.01816	2.2E-05	-	-	-	-	-	-	9.7158	-0.89728	-	-0.0003	-	-	-7.0504
	Rumex acetosella	0.948	0.6784	-0.02369	-	0.02574	-3.3E-05	-	-	-	-	-	-	-	-0.12525	0.0431	-	-	-	-
	Saxifraga granulata	0.962	0.5444	-	-	-0.05323	-	-	-	-	-	-	-	-	-0.20397	-	-	-	-	-
	Stellaria graminea	0.933	0.5764	-	-0.00015	-0.00307	-	-0.00171	-	1.35216	-	-	-	12.3391	-1.13117	-	-0.00057	-	-	-
	Trifolium repens	0.809	0.3320	-	-	-	-	-	-	3.94325	-0.69934	-	-	-	-	0.07798	-0.00055	-	-	-
	Veronica chamaedrys	0.834	0.3685	0.06086	-0.00039	-	-	-	-	-	-	0.00614	-1.3E-05	6.47408	-0.57239	-	-	-	-	-8.56881
	Viola canina	0.923	0.3941	-	-	-	-	-	-	-	-	-	-	-	-	1.32564	-0.02743	-	-	-
5	*Fragaria viridis*	0.909	0.5506	-	-	-0.0385	-	0.00167	-5.5E-07	-0.58371	-	-	-	-	-	-	-	-	-	-
	Plantago lanceolata	0.840	0.4415	-	-0.00011	-0.0115	1.3E-05	-	-	4.00139	-0.77549	-	-	-	-	-	-	-	-	-1.50336
	Plantago media	0.915	0.5292	-	-	-0.06886	-	-	-	3.20456	-0.74078	-	-	-	-	0.02575	-	-	-	-2.60039
	Potentilla neumanniana	0.912	0.4060	-0.03649	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.20016	-	1.90965
	Ranunculus bulbosus	0.868	0.4004	-	-	-0.04219	-	-	-	-	-	-0.00246	-	-	-0.0469	-	-	-	-	-
	Trifolium pratense	0.861	0.4560	-	-	-0.01087	1.2E-05	-	-	3.50425	-0.69186	-	-	5.66458	-0.44868	0.08707	-0.00068	-0.04197	-	-8.94344
6	*Agrostis stolonifera*	0.831	0.3140	0.06113	-0.00018	0.00421	-	-	-	-	-	-	-	-	0.03981	-	-	-	-	-
	Hydrocotyle vulgaris	0.934	0.5507	0.06897	-0.00019	0.02817	-3.4E-05	-	-	-	-	-	-	-	-	-	-	-	-	-
	Lotus uliginosus	0.837	0.3194	-	-	-	-	-0.00614	-	-	-	-	-	-	-	-	-	-	-	-
	Mentha aquatica	0.966	0.7200	0.02674	-	-	-	-0.00525	-	-	-	-	-	-	0.10253	-	-	-	-	-
	Parnassia palustris	0.952	0.5073	0.10448	-0.00037	-	-	-	-	-	-	-	-	-	0.19083	-0.06955	-	-	-	-
	Potentilla erecta	0.951	0.6664	-	-	-	-	-	-	-	-0.33059	-	-	-	0.07233	0.38043	-0.00984	-	-	-
	Trifolium fragiferum	0.882	0.4036	0.11597	-0.00035	-	8.3E-06	-	-	-	-	-	-	-	-	-	-	-	-	-
	Valeriana dioica	0.951	0.5271	0.2169	-0.00079	0.00517	-	-	-	-	-	-	-	-	0.17577	-	-	-	0.00179	-

Appendix Table 19 continued.

PFG	species	AUC	R^2_N	AW_eff	AW_eff2	kf	kf2	K	K2	freq	freq2	P	P2	pH	pH2	magnit	magnit2	C/N	C/N2	change
7	*Agrimonia eupatoria*	0.876	0.3835	-	-	-0.07748	-	-	-	-0.42252	-	-	-	-	-	-	-0.00019	-	-	-
	Brachypodium pinnatum	0.877	0.3326	-	-	-0.02603	-	-0.00061	-	-0.847	-	-	-	-	-	-	-	-	-	-
	Briza media	0.927	0.5559	0.07296	-0.00036	-	-	-0.00351	2.2E-07	-	-	-	-	-	0.08853	-	-	-	-	-
	Eleocharis uniglumis	0.942	0.5841	0.11451	-0.00035	-	-	-0.00679	-	-	-	-	-	-	-	-	-	-	-	-
	Falcaria vulgaris	0.863	0.3744	-0.03428	-	-	-	-	-	-	-	-	-	-	0.12035	-	-	-	-	-
	Pimpinella saxifraga	0.869	0.3993	-	-	-0.04465	-	-	-	-	-	-	-	-	-	-	-0.00024	-	-	-8.92023
	Polygala vulgaris	0.887	0.3285	-	-	-	-	-	-	-	-	-	-	-	-	0.33807	-0.00947	-	-	-
8	*Bromus hordeaceus*	0.865	0.4347	-0.02171	-	-	-	-	-	3.99451	-0.72542	0.00091	-	-	-0.04536	-	-	-	-	-
	Capsella bursa-pastoris	0.894	0.4262	-	-	-	-	-	-	-	-	0.0009	-	-1.18353	-	-	-	-	-	-
	Cerastium glomeratum	0.889	0.4303	0.07075	-0.00052	0.00485	-	-0.00158	-	0.66284	-	-	-	1.01722	-	0.15506	-0.00142	-	-	-
	Erodium cicutarium	0.958	0.6160	-	-	-	-	-	-	-	-	0.00122	-	-1.72537	-	-	-	-	-	-
	Rhinanthus minor	0.893	0.3824	-	-	-0.04012	-	-	-	-	-	-	-	-	-0.06476	-	-0.00048	-	-	-
	Thlaspi perfoliatum	0.876	0.4850	-0.04942	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.49774
	Veronica arvensis	0.847	0.3875	-0.03552	-	-0.01412	1.7E-05	-0.00041	-	2.24846	-0.38178	0.00404	-8.6E-07	-	-0.03804	-	-	-	-	-
9	*Achillea millefolium*	0.763	0.3057	0.07163	-0.0006	-	-	-	-	-	-	-0.00177	-	-	-	-	-	-	-0.00129	-
	Alopecurus pratensis	0.935	0.5830	-	-	-0.04305	-	-	-	-	-	-	-	-	-0.20092	-	-	-	-	-
	Arrhenatherum elatius	0.923	0.6574	-	-	-0.03684	-	0.00231	-5.2E-07	-	-0.09401	-	-	-	-0.06563	-	-	-	-	-
	Dactylis glomerata	0.860	0.4616	0.04183	-0.00037	-0.02406	2.9E-05	-	-	1.08969	-0.29122	-	-	4.57136	-0.43288	-	-	-	-	-
	Vicia cracca	0.868	0.3834	-	-5.2E-05	-	-	-	-	-	-	-	-	0.765	-	0.17089	-0.00417	-	-	-
10	*Centaurea jacea*	0.791	0.3016	0.04689	-0.00024	-	-4.9E-06	-	-	1.47343	-0.48253	-0.00295	-	-	-	-	-	-	-	-
	Centaurea scabiosa	0.968	0.5837	0.87075	-0.01098	-	-	-	-	-	-	-	-	-	0.25773	-	-	-	-	-
11	*Cladium mariscus*	0.975	0.5662	-	9.4E-05	-	-	-	-	-	-	-	-	-	0.12827	-0.09478	-	-	-	-
	Phragmitis australis	0.919	0.5785	0.0228	-	0.00303	-	-	-	-	-	-0.00371	-	-	-	-0.04468	-	-	-	-
12	*Euphorbia cyparissias*	0.927	0.5006	-	-	-	-	-	-1.1E-07	-	-1.27952	-	-	-	-	-	-0.00015	-0.15156	-	1.84869
	Hypericum perforatum	0.865	0.3791	-	-	-	-	-	-	-	-1.38584	-	-	-	-	-	-	-	-	-
	Inula conyza	0.929	0.4071	-0.05234	-	-	-	-	-	-	-	-	-	-	0.24319	-	-	-	-	-
	Origanum vulgare	0.872	0.3124	-	-	-	-	-	-	-1.85353	-	-	-	-	-	-	-	-	-	-
13	*Cornus sanguinea*	0.922	0.4362	-	-	-	-	-	-	-4.30376	-	-	-	-	-	-	-	-	-	-
	Prunus spinosa	0.872	0.4445	-0.02499	-	-	-	-	-	-0.78829	-	-	-	-	0.07204	-	-	-	-	-
	Rosa canina agg.	0.899	0.3965	-0.0378	-	-	-	-	-	-0.48613	-	-	-	-	0.09631	-	-	-	-	-

Appendix Table 19 continued.

PFG	species	AUC	R^2_N	AW_eff	AW_eff2	kf	kf2	K	K2	freq	freq2	P	P2	pH	pH2	magnit	magnit2	C/N	C/N2	change
14	*Galium palustre*	0.937	0.6309	0.17355	-0.0005	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Galium uliginosum	0.944	0.5953	0.10487	-0.00032	-	-	-	-	-	-0.37864	-	-	-	-	0.23732	-0.00574	-	-	-
15	*Armeria maritima* ssp. *elongata*	0.949	0.4742	-	-	0.00479	-	-	-	1.30444	-	-	-	-1.96535	-	-	-	-	-	-
	Genista tinctoria	0.861	0.3482	-	-	-	-	-0.0049	-	-	-	-0.00627	-	-	-	-	-	-	-	6.31411
	Salix repens	0.932	0.4983	-	-6.2E-05	-	-	-	-	-	-	-	-	-	0.09422	-	-0.00259	-	-	-
unmodelled species	*Calamagrostis stricta*	0.949	0.5142	0.03715	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Carex arenaria	0.976	0.7240	-	-	-	7.2E-06	-	-	-	-	-0.00977	-	-	-0.17456	-	-	-	-	-
	Gentianella uliginosa	0.956	0.5589	-	-	-	-	-	-	-	-	-	-	-	0.17285	0.27311	-0.00695	-	-	-
	Taraxacum palustre	1.000	1.0000	19.6895	-0.06211	-0.99587	-	-	-	-	-	-	-	38.3091	-	-1.4625	-	-	-	-
	Vicia angustifolia	0.907	0.5376	-	-	-0.06672	-	-0.00047	-	-	-0.07653	-	-	-	-	-	-	-0.08631	-	-1.25132

DANK

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Aber ich habe nicht aufgegeben, und wenn ich auf etwas in den letzten viereinhalb Jahren stolz bin, dann darauf, dass ich das hier durchgehalten habe. Es mag wie ein Leidensweg klingen, nun, es WAR ein Leidensweg. Promo–Viren sind äußerst hartnäckig, wie ich feststellen durfte. Schlimmer kann es nicht kommen…

Curriculum vitae

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Geburtsdatum	11.02.1974
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Ausbildung

1980 – 1990	Polytechnische Oberschule Rostock
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Hochschulbildung

1992 – 1999	Biologie–Studium an der Universität Rostock
1999	Abschluss: Diplom–Biologin

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1996 – 1997	Studium an der Waikato University in Hamilton/Neuseeland
1997	Abschluss: Diploma in Applied Science

Berufspraktika

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1999	Mitarbeit am Forschungs- und Entwicklungsvorhaben des Bundesamtes für Naturschutz „Methodische Standards und Mindestinhalte für naturschutzfachliche Planungen – Landschaftsplan / Pflege– und Entwicklungsplan“
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1997	Kartierungen von Söllen für das Staatliche Amt für Umwelt und Natur Rostock

Berufliche Tätigkeit

Mai 2000 – Dezember 2003	Wissenschaftliche Angestellte an der Carl–von–Ossietzky–Universität Oldenburg im Drittmittelprojekt MOSAIK
Mai 2000 – September 2004	Promotion bei Prof. Dr. Michael Kleyer AG Landschaftsökologie Carl–von–Ossietzky–Universität Oldenburg

Publications and Reports

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Talks and Posters

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Erklärung

gemäß § 10 Abs. 2 der Promotionsordnung der Fakultät für Mathematik und Naturwissenschaften der Carl–von–Ossietzky–Universität Oldenburg

Hiermit erkläre ich ehrenwörtlich, die vorliegende Arbeit in allen Teilen selbstständig und nur mit den angegebenen Quellen und Hilfsmitteln angefertigt zu haben. Diese Dissertation hat weder in gleicher noch in ähnlicher Form in einem anderen Prüfungsverfahren vorgelegen. Desweiteren erkläre ich, dass ich früher weder akademische Grade erworben habe, noch zu erwerben versucht habe.

Oldenburg, den 14.10.2004

Anke Kühner

(Anke Kühner)