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Investigation of the influence of light on the herbaceous layer in a near-natural/unmanaged beech forest of the temperate zone

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Recording from Zoë Bellwald, 24.05.2021

Abstract

The amount of light that penetrates the herb layer in beech forests is, because of its dense canopy, manly influenced by the tree layer. Thus, the influence of light on the species number of the herb layer in an unmanaged forest was surveyed in this paper. The study area is located in the Nature Discovery Park Sihlwald, which is a natural forest that was not managed since the year 2000. To gather data about the impact of the light, that penetrates the herb layer, a vegetation survey was conducted in the Sihlwald on 16 bright and dark plots with an area of 10 m^2. Furthermore, in each plot species coverage was determined as well as a measurement of the photosynthetic active radiation (PAR) with a smartphone application. The data was evaluated with the software VEGEDAZ and R-Studio. A positive correlation between the light availability and the species number in the herb layer could not be confirmed. The plots were probably grouped correctly in the two categories "bright" and "dark", because of the very significant difference between their PAR-values. Beside the light further factors like nutrient availability, pH-value and soil moisture have an influence on the species diversity in the herb layer. It is not sufficient to make a statement about the species number in the herb layer based solely on the factor light.

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1 Introduction

The ground-level vegetation (herb layer) is an important component in the forest ecosystem, as it contributes significantly to the functioning of these ecosystems (Augusto *et al.* 2003). It helps to store nutrients in the soil (Bolte 2006) and is indispensable for many forest-dwelling animals (Maurer & Rickenmann 2011). The herb layer is important for determining forest types according to Delarze et al. (Delarze *et al.* 2015a) and Ellenberg & Klötzli (Ellenberg & Klötzli 1998), and with the help of indicator values of individual plants, statements can be made about site conditions and available resources (Ellenberg & Leuschner 2010; Zirfass 2013). In addition, the herb layer is responsible for the majority of species diversity in most European temperate deciduous forests (Whigham 2004). How the herb layer develops in a forest ecosystem depends on many factors. Besides soil pH, nutrient availability, litter layer, soil moisture and distance from the forest edge, light availability is an important factor (Tinya *et al.* 2009; Vockenhuber *et al.* 2011), its intensity and distribution shape the number and abundance of herb layer species (Fortin *et al.* 2006). Thus, light availability is considered as a key factor for the diversity of the herb layer (Härdtle *et al.* 2003; Schmidt 2005). How much light is available to the herb layer is largely influenced by the tree layer, as different amounts of light penetrate into the herb layer depending on the density of the tree stand and the density of the canopy (i.e. depending on the tree species) (van Oijen *et al.* 2005; Barbier *et al.* 2008). Especially in beech forests, light availability can be very limited, as the crowns have low light transmission (Ellenberg & Leuschner 2010). Thus, due to light availability, the diversity of the herb layer is usually higher in mixed deciduous forests than in pure beech forests (Mölder *et al.* 2008). However, the intensity of light availability in beech forests is not only dependent on the degree of beech cover, but can also vary seasonally, and thus different species compositions can be found in the herb layer before and after beech foliage (Delarze *et al.* 2015a). All these factors underline the importance of light availability and thus of gaps in the canopy, which are essential for the survival of light-demanding species (Tinya & Ódor 2016).

Although beech forests often have low numbers of species in the herb layer, around 80% of managed beech forests in Central Europe also have disturbance indicators and open land species in the herb layer, which can be promoted in particular by forestry measures such as thinning (Meyer & Schmidt 2008). As the promotion of biodiversity is also an important goal in forestry (Dölle *et al.* 2017) and near-natural forest management is an instrument for the promotion of diversity (Barna & Bosela 2015), the Swiss forest is also increasingly managed in a near-natural way (Scheidegger *et al.* 2010). In a near-natural forest, all age structures of the trees (including deadwood) should be found in a heterogeneous mosaic (von Teuffel *et al.* 2005). The resulting heterogeneous light regime enables the selective emergence of light-demanding species and can thus lead to higher diversity on a larger scale (Valladares & Guzmán 2006). Although there are some studies on the influence of light in managed forests (Valladares & Guzmán 2006; Mölder *et al.* 2008), little is currently known about the influence of light on the herb layer in natural forests or virgin forests. In Switzerland in particular, this is due to the fact that the majority of Swiss beech forests are managed and there are only a few natural forests or no primeval forests (Bütler *et al.* 2015). This makes the Sihlwald Nature Discovery Park (ZH) an interesting object of study, as this natural forest has not been managed for forestry purposes since 2000 which allowed it to develop independently (Egger 2008). As a result of this change, the Sihlwald is once again developing into an original beech forest with natural processes and naturally occurring light conditions (due to ageing and dying or falling trees caused by storms) (Brändli *et al.* 2020). Since no studies have yet been carried out on the influence of light on the herbaceous layer in the Sihlwald, this gap should be filled with the present study. Thus, the following question should be answered by investigating this forest:

Does light positively correlate with the species diversity of the herb layer in an unmanaged mid-latitude natural beech forest?

2 Methods

2.1 Study area

The study area is located in the canton of Zurich at around 490 meters above sea level (GIS-ZH, Kanton Zürich 2021). The climate is influenced by the Atlantic (Wohlgemuth *et al.* 2020) and the vegetation sampling is carried out in a "Waldmeister-Buchenwald" (*Galio-Fagenion*). The soil in this type of habitat is a mature brown earth (Delarze *et al.* 2015a).

The selected area is located in the Sihlwald, which is an original beech forest. The area belongs to the Wilderness Park Zurich Sihlwald and is a Nature Discovery Park. The park divides its area into different zones/areas (core zone and transition zone), which can be used by people with different intensities. In the core zone, flora and fauna should be able to develop unhindered and undisturbed, which is guaranteed by strict protective regulations. In this area of the park it is not allowed to leave the paths and any collecting is forbidden. There are less strict protection regulations in the transition zone. Visitors to the wilderness park should have the opportunity to actively experience nature there. The division is based on the cantonal protection ordinance, which has been in force since October 2008 (Kanton Zürich 2008). The vegetation analysis is mostly carried out in the transition zone. Few plots are directly on the border with the core zone (Stiftung Wildnispark Zürich 2021).

2.2 Sampling design / Data collection

Light measurements and vegetation sampling of the herb layer was conducted within 16 plots. Each plot had an area of 10 m^2, which seems suitable for vegetation analysis of herb layers (Tremp, 2005; Traxler, 1997; Wildi, 1986).The shape of a circle was chosen, so that the light measurement can mark the centre point of the plots. Selection criteria for the position of the plots inside the "Waldmeister-Buchenwald" were light availability and dominance of *Fagus sylvatica* (>5% coverage). Eight plots were selected in areas with darker conditions and eight plots in relatively brighter conditions. Dominance of *F. sylvatica* was required to ensure a relatively constant effect of the canopy cover on the herb layer. Exclusion criteria were presence of shrubs and trees as well as confounding factors (large quantities of deadwood, boulders). The vegetation survey was conducted on 24.05.2021 and 30.05.2021.

Canopy coverage was estimated visually by the same person each time. This measure was used to generate the two categories for light availability "bright plot" and "dark plot" and is moreover frequently used in studies (Vockenhuber et al. 2011; Jennings et al. 1999).

Herb layer species richness was estimated by vegetation relevés. All present species were recorded in each of the 16 Plots. All plants with a height <50cm were considered as belonging to the herb layer. As an additional measurement height of the herb layer was measured with a measuring tape. Furthermore, total absolute cover of the herb layer as well as absolute cover of each species was estimated visually. The Landolt indicator value "light availability" of the recorded species will provide additional information about the present light conditions in every plot.

Light measurement was taken in the center of the circle on each plot. The same smartphone was used for each measurement (iPhone 12, model MGJ73ZD / A). The "Photone - Grow Light Meter" app (Version 2.5.3), developed by Lightray Innovation GmbH was selected for light measurement. The app determines PAR as PPFD in µmol / m²s. The lower the value determined, the less sunlight there is (Apple Inc. 2021).

2.3 Statistical methods

After the vegetation sampling, the VEGEDAZ program (Küchler 2019) was used to process the data. After importing, the data was prepared for analysis, only retaining species that could be identified at genus level. This led to the exclusion of a species (*Dicotyledonen sp.),* which was represented in five plots, with a maximum degree of coverage of two percent. VEGEDAZ was used to determine the habitat type according to Delarze (Delarze et al. 2015b), for the number of species, the Shannon Index and the Shannon Equitability (Evenness). In addition, the average weighted mean value (linear) of the Landolt indicator value ("Light availability") (Landolt *et al.* 2010) was determined.

For further analysis the data was exported from VEGEDAZ and integrated into R-Studio. To analyse whether the mean weighted species richness and Landolt indicator value "light availability" differ between the two categories of plots (bright and dark) two T-Tests were conducted. Due to the fact, that most of the previous studies observed a higher species richness the more light was available, a one-sided T-Test was chosen. For the Landolt indicator value a one-sided T-Test was chosen as well, because this value already indicates that species which grow in brighter areas also have a higher Landolt indicator value for the "light availability". To analyse whether the classification in "bright" and "dark" plots was correct, a one-sided T-Test was conducted with the measured PAR values. As additional parameters Shannon index and evenness were evaluated with a two-sided T-Test between the two categories of plots (see Appendix).

3 Results

3.1 Evaluation of the habitat types

The evaluation with the VEGEDAZ program with regard to the expected habitat type (according to the Delarze habitat classification) based on the mapped species mostly shows the expected result. In 14 of the 16 investigated plots, it is very likely that a *Galio-Fagenion* ("Waldmeister-Buchenwald") is referred to, which corresponds to the official mappings of the Canton of Zurich. According to VEG-EDAZ, the plots with ID 12 and 15 are a *Fraxinion* ("Hartholz-Auenwald") (see table 1).

Table 1 Different habitat types according to the Delarze habitat classification with the Galio-Fagenion as the most frequent result

Plot ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Rang TypoCode	6.2.3.	6.2.3.	6.2.3.	6.2.3.	6.2.3.	6.2.3.	6.2.3.	6.2.3.	6.2.3.	6.2.3.	6.2.3.	6.1.4.	6.2.3.	6.2.3.	6.1.4.	6.2.3.
1. Wert TypoCode	7	7	6	10	10	8	10	6	9	6	6	4	8	3	11	7
2. Rang TypoCode	6.3.1.	6.3.1.	6.3.1.	6.2.4.	6.2.1.	6.1.4.	6.2.5.	6.2.5.	6.2.5.	6.2.4.	6.2.5.	6.2.3.	6.2.5.	6.2.1.	6.2.5.	6.2.4.
2. Wert TypoCode	6	6	4	9	6	5	7	5	9	6	4	3	7	2	8	6
3. Rang TypoCode	6.2.1.	6.2.4.	6.2.5.	6.2.5.	6.2.5.	6.2.4.	6.2.2.	6.2.2.	6.3.1.	6.2.5.	6.2.1.	6.2.5.	6.2.4.	6.2.4.	6.2.4.	6.2.5.
3. Wert TypoCode	5	4	4	8	6	4	6	5	8	6	3	3	7	2	8	6

	Bright plot		*Abieti-Fagenion*
	Dark plot		*Lonicero-Fagenion*
	Galio-Fagenion		*Cephalanthero-Fagenion*
	Fraxinion		*Luzulo-Fagenion*
	Lunario-Acerion		*Lunario-Acerion*

Table 2 shows an overview of the alpha species diversity and the "Light availability" of the 16 plots. In addition to the diversity of species (average bright: 13 species, dark: 12 species), the Shannon Index is also looked at. This averages 1,979 for the bright plots and 1,952 for the dark plots. The Shannon Equitability or Shannon Evenness is an average of 0.798 for the bright plots and 0.81 for the dark ones. The Landolt indicator value "Light availability" is 1,796 (bright) and 1,649 (dark).

Table 2: Overview of the alpha species diversity (Species richness, Shannon Index, Shannon Equitability) and the Landolt indicator value "Light availability" of the bright and dark plots

Plot ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Species richness	12	11	10	16	14	12	15	10	18	13	6	10	16	4	16	11
Shannon Index	1.52	2.09	2.1	2.24	2.22	2.08	2.23	2.02	2.55	2.2	1.52	1.97	1.88	0.88	2.19	1.78
Shannon Equitability	0.61	0.87	0.91	0.81	0.84	0.84	0.82	0.88	0.87	0.86	0.85	0.86	0.68	0.63	0.79	0.74
«Light availability»	1.52	1.58	1.70	1.50	1.58	1.47	1.86	1.52	1.84	1.92	1.48	3.42	1.56	1.29	1.63	1.69

	Bright plot
	Dark plot

3.2 Biodiversity indices

Species richness differed not significantly between the bright and the dark plots with a mean value of 12.625 in the bright plots and 11.625 in the dark plots (one-sided t-test, *p*= 0.306, *t*= 0.51919, df = 13.995).

Shannon index also did not differ significantly between the bright and the dark plots with a mean value of 1.979 in the bright plots and 1.952 in the dark plots (two-sided t-test, *p*=0.897, *t*=0.132, df=12.914).

In addition, there was no significant difference in Evenness between the bright and the dark plots with a mean value of 0.798 in the bright plots and 0.810 in the dark plots (two-sided t-test, *p*=0.810, *t*= -0.245, df = 13.852).

3.3 Indicator value "light availability"

The indicator value "light availability" differed not significantly between the bright and the dark plots with a mean value of 1.796 in the bright plots and 1.649 in the dark plots (one-sided t-test, *p*=0.283, *t*= 0.59798, df = 8.2471).

3.4 Photosynthetically active radiation (PAR)

PAR differed very significantly between the bright and the dark plots with a mean of 51.125 in the bright plots and 13.374 in the dark plots (one-sided t-test, *p*=0.007, *t*=3.158, df = 7.723) as shown in figure 1.

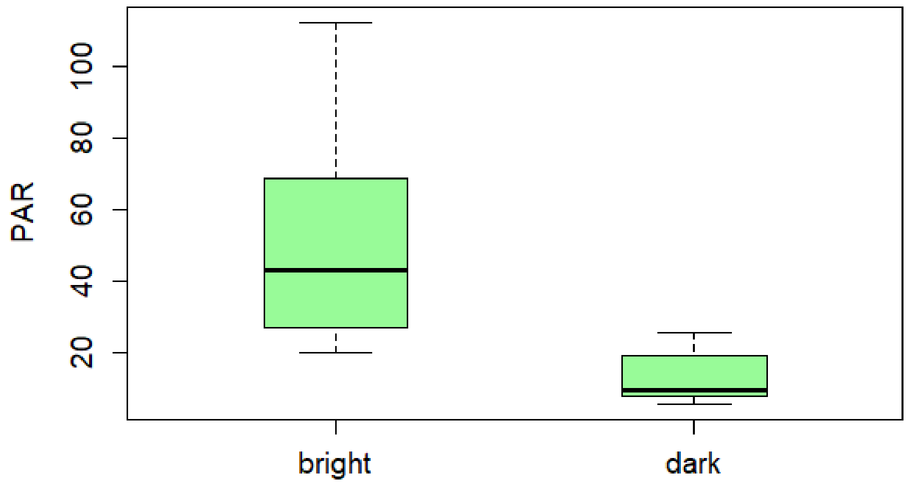

Figure 1 Visual representation of PAR between the bright and the dark plots in a boxplot. A significant difference is evident between the two categories (two-sided t-test, p=0.007, t=3.158, df=7.723).

4 Discussion

The evaluation of the species found by VEGEDAZ indicates with high probability that 14 of the 16 plots are indeed a *Galio-Fagenion*. For two of the plots, the evaluation rather points to a *Fraxinion*. Furthermore, no significant difference was found between the plot categories "bright" and "dark" for the other indices: species richness, Shannon index, Evenness and the Landolt indicator value "light availability". The evaluation of the species found with the help of the statistics programme R-Studio revealed a highly significant difference in the PAR values between the plot categories "bright" and "dark". This confirms the correct classification of the plots into the categories "bright" and "dark". This verification is important because of the non-significant differences in the biodiversity indices and species numbers.

4.1 Habitat types

According to the programme manual, the determination of habitats using the VEGEDAZ programme is more of an approximation and not a final determination (Grünig & Küchler 2004). However, the differently designated habitats are quite plausible, as the species *Carex pendula* was found in each of the plots with ID 12 and 15. This species is a character species of the *Fraxinion* (Delarze *et al.* 2015). Furthermore, another character species of the *Fraxinion*, *Carex remota* (Delarze *et al.* 2015), was found in the plot with ID 15. Since the plot with ID 12 was a brighter one (crown cover 0%, PAR 91) and the plot with ID 15 was a darker one (crown cover 95%, PAR 10), the change of habitat from *Galio-Fagenion* to *Fraxinion* cannot be solely dependent on light conditions. Since *Fraxinion* thrives in very humid, almost swampy places (Delarze *et al.* 2015), it can be assumed that soil moisture plays an equally important role. The fact that the species *Bromus hordeaceus*, which is light-demanding (light value 4) but rather drought-loving, nevertheless occurred in the plot with ID 12, indicates that the resources (such as light and moisture) in a beech forest can vary over very small areas (Al-Mufti *et al.* 1977; Adkison & Gleeson 2004).

4.2 Biodiversity incidences

The assumed positive correlation between light availability in the herb layer and species numbers in the herb layer could not be confirmed in this work, although this has been reported in different studies (Valladares & Guzmán 2006; Tinya & Ódor 2016). Although the highest number of species (18) was found in the bright plot with ID 9 (crown cover 0%, PAR 112) and the lowest number of species (4) in the plot with ID 14 (crown cover 95%, PAR 10), the overall mean species numbers were distributed very similarly between the bright and dark plots (bright 12,625, dark 11,625). The species numbers found are generally considered plausible, since a comprehensive study for the *Galio-Fagenion* determined a mean species diversity (incl. lichens and mosses) of 24 in the ground vegetation (Spellmann 2008).

Some studies mention that in mixed deciduous forests more species are found in the herb layer than in pure beech forests (Mölder *et al.* 2008). Although the Sihlwald is interspersed with other tree species such as the deciduous trees *Acer platanoides*, *Acer pseudoplatanus* and *Fraxinus excelsior*, as well as conifers such as *Picea abies*, beech is clearly predominant (own observation). Due to the difficulty to decompose beech litter, which in the Sihlwald sometimes makes up a layer more than 10 cm thick, the emergence of light-demanding species is very difficult in places, even if sufficient light were available (Chytrý *et al.* 2010). This could explain why in some bright plots (ID11 and ID 12) only few species (6 and 10) could be found despite low crown cover of the trees (35% and 0%). Furthermore, the beech litter changes the pH value of the soil to a more acidic milieu (Barbier et al. 2008), which in turn affects the predominant species and favours species with low reaction numbers (Landolt's indicator value (Landolt 1977)).

Since the number of species alone does not say much about diversity (Lanzerath *et al.* 2008), the Shannon index and the Evenness were also calculated. The expected significant difference could not be confirmed for these two diversity indices either, as very similar species numbers were counted in the two plot categories "bright" and "dark" and only in a few plots (ID 1, ID 13, ID 16) individual species were dominant (*Rubus sp., Oxalis acetosella, Oxalis acetosella*). The Shannon index was clearly below the value 2 in five plots (ID 1, ID 11, ID 13, ID 14 and ID 16), indicating a lower diversity (Peet 1974). Of these, however, three plots belonged to the "bright" category and two to the "dark" category. However, these are not the expected values, which should show higher diversity in a bright plot. In all other plots, "bright" and "dark", the Shannon index was above the value of 2, reflecting a uniform diversity.

Furthermore, in four of the five plots (2 bright, 2 dark) an Evenness closer to the value 0.5 than 1 was determined, which additionally indicates a one-sided distribution, i.e. the dominance of individual species (Jost 2010). It is striking that the dominant species in two cases are *Oxalis acetosella*. *Oxalis acetosella* is an acidophile with a reaction number (according to Landolt (Landolt 1977)) of 2 and occurs in a wide variety of beech forests (Info Flora 2021a). The fact that this species is dominant in a bright plot (ID 13) and a dark plot (ID 16) could indicate that in these plots the pH value of the soil (rather acidic, probably due to the beech litter) has a greater influence on species diversity than the light itself. However, the dominance of *Rubus sp*. could be due to the influence of light, as this plant with a light number of 3 is rather light-loving and likes to occur in herbaceous borders, mesophilic shrubs and forest edges (Info Flora 2021b).

4.3 Indicator value "light availability"

Only the plot with ID 12 ("bright", crown cover 0%) had a mean value of light numbers above 3, indicating that many light-demanding plants occur there (Zirfass 2013). In this example, these would be the species *Holcus lanatus*, *Bromus hordeaceus*, *Lonicera xylosteum* and *Prunus avium*. For the plot with ID 14 ("dark"), the mean value of 1.29 was clearly the lowest. This is plausible and an expected value, as the plot had a crown cover of 98% and thus very little light penetrated. However, in all other plots ("bright" and "dark") the mean value of the light availabillity was in a similar low range, between 1.47 and 1.92, indicating that there are generally few light-loving plants (Zirfass 2013).

4.4 Conclusion

It is logical to assume that, besides the factor light other factors like nutrient availability, pH-value and soil moisture have an influence on species diversity in the herb layer, because no positive correlation between the light availability in the herb layer and its biodiversity indices could be determined. Furthermore, it could be that the thick litter layer in the Sihlwald had a negative impact on the occurrence of light-demanding species in the bright plots. Thus, the factor light is not solely sufficient to make a statement about the species diversity in the herb layer.

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Appendix

R Code

```
#Read Data

setwd("~/ZHAW/Vegetations Analysis and Plant Systematics/Vegetation Analysis/Project_work")

VegAuf=read.csv("R_Auswertung_4.csv", sep=";", dec = ".", stringsAsFactors = T)

View(VegAuf)

str(VegAuf)

#alpha = 0.05

#T-Test Light availability

#H0: The mean weighted Landolt indicator value "light availability" does not differ significantly between the dark plots and the light plots or is even lower in the light plots compared to the dark plots.

#H1: The mean weighted Landolt indicator value "light availability" is significantly higher in the light plots than in the dark plots.

#oneway

t.test(VegAuf$light_availability~VegAuf$Light, alternative="greater")

#p-value = 0.283 -> no significant difference

#Visualization

boxplot(VegAuf$light_availability~VegAuf$Light, boxwex = 0.4, ylab = "Light availability", xlab="", cex.axis=1.2, cex.lab=1.2, col="palegreen")

###################################################################################

#T-Test Species richness

#H0: Species richness does not differ significantly between the dark and the bright plots or is even bigger in the dark plots.

#H1: Species richnes is significantly higher in the bright plots than in the dark plots.

t.test(VegAuf$species_richness~VegAuf$Light, alternative="greater")

#p-value = 0.3059 ->no significant difference
```

```
boxplot(VegAuf$species_richness~VegAuf$Light, boxwex = 0.4, ylab = "Species richness", xlab="", cex.axis=1.2, cex.lab=1.2, col="palegreen")

##################################################################################

#T-Test PAR

#H0: PAR does not differ between the dark and the light plots.

#H1: PAR differs significaly between the bright and the dark plots.

t.test(VegAuf$PAR~VegAuf$Light, alternative="greater")

#p-value = 0.007025 -> highly significant difference

boxplot(VegAuf$PAR~VegAuf$Light, boxwex = 0.4, ylab = "PAR", xlab="", cex.axis=1.2, cex.lab=1.2, col="palegreen")

##################################################################################

#T-Test Shannon Index

#H0: The Shannon Index does not differ significantly between the dark and the light plots.

#H1: The Shannon Index differs significaly between the bright and the dark plots.

t.test(VegAuf$shannon_index~VegAuf$Light)

#p-value = 0.897 ->  no significant difference

boxplot(VegAuf$shannon_index~VegAuf$Light, boxwex = 0.4, ylab = "Shannon Index", xlab="", cex.axis=1.2, cex.lab=1.2, col="palegreen")

##################################################################################

#T-Test Evenness

#H0: Evenness does not differ significantly between the dark and the light plots.

#H1: Evenness differs significaly between the bright and the dark plots.

t.test(VegAuf$Evenness~VegAuf$Light)

#p-value = 0.8097 ->  no significant difference

boxplot(VegAuf$Evenness~VegAuf$Light, boxwex = 0.4, ylab = "Evenness", xlab="", cex.axis=1.2, cex.lab=1.2, col="palegreen")
```

Relevé

Plot ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Total vegeation cover (%)	85	45	17	70	40	65	90	40	65	35	85	97	80	5	85	30
Slope (°)	35	25	85	45	85	40	90	98	0	85	35	0	30	98	95	90
PAR	40	46	6	20	16	26	23	10	112	26	46	91	28	8	10	8
Slope (°)	7	15	2	18	16	12	10	20	26	25	14	-	15	18	8	3
Exposure	east	east	east	east	east	east	east	east	east	east	east	-	east	east	east	east
Coordinate	2684623/1235626	2684678/1235621	2684662/1235607	2684590/1235572	2684605/1235456	2684681/1235451	2684681/1235427	2684867/1235203	2684692/1235367	2684686/1235379	2684579/1235167	2684639/1235045	2684673/1235450	2684560/1235216	2684632/1235166	2684593/1235093
Abies alba	0.2	3	0.5	4	0.5	2	1		1	2			0.5			
Acer platanoides	3	1	0.5	0.5	0.5		0.5		1	0.5		2	2			
Acer pseudoplatanus									3	1			1		0.5	
Ajuga reptans						2	17		0.5				5			
Anemone nemorosa	0.5		0.5	3	7	6	10	5	2				3			0.5
Arum maculatum	2	2			2		3								1	4
Athyrium filix-femina				2			10	3		0.5	20	4	4		25	
Bromus hordeaceus												18				
Carex digitata				10					3	7			4			
Carex pendula												5			8	
Carex remota															5	
Carex spiciata												30				
Carex sylvatica			4	1.5					5	2			1			0.5
Circaea lutetiana	5	5	2		3	10	2	4			10		4		3	2
Corylus avellana		6		1				1	2	1			3			
Dicotyledone sp.			0.5		0.5					2				0.5		0.5
Dryopteris carthusiana						3										
Dryopteris filix-mas	3		4		1				8							
Fagus sylvatica	4	3	3	2	4		0.5	0.5	6	2	6			1	1	1
Fraxinus excelsior		2		2	0.5	0.5	0.5		5	3	3		0.5	0.2		1
Galium odoratum	5	17		3		3		4					1		15	
Geranium robertianum															2	
Hedera helix	2	2	2		3	2	10		3							
cf Holcus lanatus												15				
Lamium galeobdolon	8	4	2	4	2	8	10	5					1		5	1
Lamium maculatum							2	3	4	5			4		3	5
Lonicera xylosteum					2							3				
Luzula pilosa				1												
Lysimachia nemorum				1												
Milium effusum				0.2					0.5						0.5	
Oxalis acetosella				15	12	20	20	13	20	8	35	2	45	0.2	20	12
Picea abies																0.5
Polystichum aculeatum									4			15				
Primula elatior															1	
Prunus avium										0.5		20				
Rubus sp.	55	6	2	15	4	10	6	2	8	2	35		10	3	1	0.5
Veronica montanum	3								3							
Vinca minor															7	
Viola reichenbachiana					0.5	1	1									