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Open grid pavement as a means to increase local biodiversity in cities

A vegetation analysis

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Abstract

Recently there has been a large push to include more biodiversity in cities to help combat some of the existing and increasing issues in cities related to climate change. One measure that could contribute to this goal is the implementation of open grid pavements. While the physical effects of open grid pavement have been studied, and research is still being performed, the advantages for biodiversity in the urban habitat were currently unknown. This research focussed on multiple knowledge gaps: 1) What is the plant species composition of the pavement? 2) What is the influence of usage intensity on possible ecological gradients? 3) What are the ecological characteristics of the plant community and do they show pattern? 4) What is the influence of neighbouring vegetation on the plant composition of the pavement?

These knowledge gaps were addressed using vegetation analyses on the vascular plants following the method of Den Held on parking areas with open grid pavement. A thorough vegetation analysis was performed by measuring 46 parking spaces while making a distinction between the position on the parking space, resulting in 138 plots. Seven additional locations with open grid pavement were investigated by analysing two plots using the same method. Also, two plots were investigated at six references (mainly road verges).

In total, 117 different species were found on open grid pavement. While the most common species mainly consist of the expected pavement flora, the total species list includes also a number of unexpected species. The usage intensity, using the distance from the entrance as a proxy, proved to have a significant quadratic relationship with the Shannon diversity. Different patterns in morphological characteristics were found at the micro-scale, so within the individual parking space. The plots furthest away on the individual parking spaces included few low growing plants and more high growing plants while the plots closest to the road on the parking space showed the opposite pattern. Another pattern that was observed was the micro-scale having opposite trends for the Shannon diversity and the height characteristics between the parking spaces at the inner part of the car park and the edge. The research showed the plots on the pavement and the reference are similar when it comes to the vegetation class they most likely fit in. The similarity index of all data combined indicated a moderate similarity of 0.7 between the two types. The pavement did have a relatively long list of unique species in comparison with the unique species of the references.

Overall, these results suggest that open grid pavements can contribute significantly to local biodiversity in the urban environment. Moreover, it underlines the high potential value of this form of pavement, which is currently vastly underutilized. As such, the results of this study call for a further investigation and implementation of this type of pavement and could convince municipalities to use this measure more often in regards to their combat against climate change issues.

Introduction

Humans created a new ecosystem, cities, also known as the urban ecosystem. Besides the important role cities have in driving climate change, urban ecosystems are also subject to the impacts of climate change. Climate change causes environmental changes which is one of the drivers of worldwide biodiversity loss. One of the most pronounced effects of the rising temperature is that it facilitates polewards range shifts of biodiversity. Also, on a smaller scale, the temperature causes a mismatches in interspecific relationships. Plants flower earlier, causing a mismatch in timing for the pollinators, which might therefore also causes difficulties further up in the food chain (Kudo & Cooper, 2019). Climate change causes the rising temperatures, different precipitation patterns and extreme weather. The urban area is affected by these changes, and some effects are even magnified in cities. The urban areas heat up faster than their environment causing an urban heat island effect. The characteristics of the urban environment amplify the rising temperature. This causes an urban heat island (UHI), which means the temperature of the urban area is higher than their rural surroundings (Taha, 2004). The higher temperature is caused by the increased coverage with dark, heat absorbent surfaces, increased anthropogenic activities and the reduction of vegetation (Cuculić et al., 2012). The amount of paved and built surface in cities is positively correlated to the Urban Heat Island effect (Klok et al., 2012). Evidence is gathered proving the urban heat island influences species richness, abundance and composition (McGlynn et al., 2019). For example, a study showed that flowers bloom earlier in dense cities than in their surroundings due to the UHI, causing problems for birds and insects in that area (Zipper et al., 2016). Besides expected effects on biodiversity, negative effects of the UHI for citizens also include the increase in heat-related illness and uncomfortable conditions in general, increased energy costs, and increased air pollution (EPA, n.d.-b; Hoegh-Guldberg et al., 2018). It is therefore very important to resolve the heat issue. Also, it is expected that the intensity and frequency of heavy precipitation increase, which the sewer systems cannot keep up with (EPA, n.d.-a; Hoegh-Guldberg et al., 2018) In addition, the urban areas itself causes more precipitation as the warmer air of the city goes up, forming rainclouds (NASA, n.d.; Shepherd & Burian, 2003). One of the options to mitigate these problems is through the inclusion of higher levels of biodiversity in the cities environment and therefore making the area more resilient to climate change (Malhi et al., 2020). Opportunely, many municipalities have goals to increase biodiversity in cities.

Introducing more vegetation to cities not only facilitates a cooling effect on the urban heat island, but can also improve the drainage capacities and the local biodiversity (Aram et al., 2019). Regarding the former effect, this can make a difference multiple degrees Celsius depending on the amount and type of vegetation. Also, more water will be absorbed into the soil, and the vegetation conserves water which mitigates drought (Klimaatadaptatie Kennisportaal, n.d.). A moist and oxygenated soil also stimulates the productivity of multiple soil organisms, which is needed in a healthy soil (HAS Hogeschool, 2018; IBED, 2022). Adding vegetation to the city can be accomplished in multiple way: More parks can be created, removing tiles and replacing them with plants, and creating green roofs/facades can all make a difference. The measure which this research will be focussed on helps with climate adaptation by the replacement of normal non-permeable tiles on parking places with open-grid pavement (*Box 1: Background on permeable pavement*). Increasing the amount of 'green' areas in the urban environment by implementing this growable pavement could potentially have a great impact, like other using other 'green' measures as green roofs.

So while the physical effects of open grid pavement have been studied in great detail, and research has been and is still being performed, it is currently unknown what the advantages for biodiversity in the urban habitat are, and whether this has any positive repercussions regarding drainage capacities and the urban cooling effect. In this research, I focus on the missing knowledge about the biodiversity aspect of the open grid pavement. More specifically, I identified four knowledge gaps, which are discussed below, followed by an expectation and a short overview of the approach.

1) What is the plant species community of open grid pavement composed of?
Based on previous studies in urban settings, it is expected that species known as pavement flora will be present in the open-grid pavement. Pavement flora species are adapted to anthropogenic disturbances and the conditions of pavement. They disperse easily due to their light seeds which can be carried by wind, water or animals (Hortus Botanicus Leiden, 2021). The pavement flora and other ruderal species are characterized by often having a fast reproduction, high mobility and often being annual species (Denters, 2020). Because the flora is expected to be trampled, it is useful to look into plants linked to grazing. To address this knowledge gap, a vegetation analysis of the flora present in open grid pavement will assess the value of a 'green parking area' to biodiversity, both species- and fundamental diversity.

2) How is the usage of the area and the ecological gradients of the pavement reflected in the plant community?
The growable pavement will increase the biodiversity of parking lots. While normal parking lots could be an biodiversity desert, the growable parking lot has the potential to support a lot of species. While it is stated that open grid pavement could very well be used on parking areas, the usage intensity could make some car parks more beneficial to biodiversity than others. The different usage rates on one car park could create ecological gradients which could support more species opposed to a complete homogeneous environment. The ecological gradient is likely to follow the pattern of the intermediate disturbance hypothesis: a specific amount of disturbance could actually improve the species diversity, it will prevent the dominant species from outcompeting others (Osman, 2015). It is expected the species diversity will experience the pattern of the intermediate disturbance hypothesis on both macro-scale (the car park as a whole) and micro-scale (the individual parking spaces). The approach that will be used is to thoroughly investigate a whole car park using vegetation analyses to identify possible differences caused by the usage intensity.

3) What are the ecological characteristics of the plant community and do they follow patterns on car parks?
It is likely to find more plants with characteristics specific for trampling resistant flora at locations of the car park with the highest usage intensity as the vegetation is more often being trampled. The null hypothesis states that no difference in the spatial distribution these characteristics across the car park will be found. Due to the possible ecological gradient, a diverse species composition could be found during the vegetation analysis. The usage intensity causes multiple micro climates with different characteristics, therefore a greater spectrum of plant species will be able to settle.

4) Is the vegetation in the neighbourhood a depending factor for the (biodiversity related) success of the open grid pavement?
The question is to what extent the surroundings play a role in the vegetation composition of the pavement. Reasonably, when comparing the investigated car parks to other grassland-type areas in the neighbourhood, it is expected the vegetation composition will experience similarities with other types of grassland due to local seed dispersal. Therefore it is predicted that the success of the car park in terms of biodiversity will be dependent of the vegetation in the neighbourhood. Car parks close to areas with a high vegetation diversity will then be more diverse than car park which lack high biodiversity in their surroundings.

Using a combination of a paired setup and an in depth study of a single large open pavement parking lot, all four knowledge gaps will be addressed.

Box 1: Background on permeable pavements

Multiple types of climate adaptive pavement exist. There are tiles which are porous and therefore water-permeable, water passes through the tiles and ends up in the soil. Water-passing pavements let water pass through the joints. It is known these the effectivity of these types of tiles reduce in time. Because of sediments, the pores and joints will get blocked and thus reducing the water-permeability. (Kennisbank GroenBlauw, n.d.; Schoenmaker & Klück, 2020) The effectivity of the infiltration of growable pavement (open grid pavement) is not thoroughly investigated, but it is thought the infiltration percentage can get up to 100%, dependent on the soil (Amsterdam Rainproof, n.d.). This could make growable pavement the most advantageous type of tile.

Open grid pavement is defined by the pavement being less than 50 per cent impervious and containing vegetation in the open cells (Illustrated Dictionary of Architecture, n.d.). The use of open-grid pavement is useful in spaces that do not have very intensive use, car parks are a good example (Bouwnatuurinclusief.nl, n.d.). The plants growing in the open cells will consist of low growing plants also known as step vegetation (NL: tredvegetatie) which maintain themselves, no extra maintenance is needed (Bouwnatuurinclusief.nl, n.d.).

A study by students of the HAS Hogeschool found open pavement to be the best pavement type for soil health. (HAS Hogeschool, 2018). The results showed that every pavement type scores bad when it come to the amount of soil organisms in comparison to a reference site without pavement, however, open-grid pavement had the least negative effect on the soil organisms. Also the tested abiotic factors, water permeability, PH, and soil texture, showed the best results on the open pavement. The open-grid pavement has a porous soil which allows water and air to enter the soil, which creates a suitable habitat for soil organisms. These organisms, especially earth worms, are important to maintain the porous structure of the soil so water and air can enter, therefore creating carbon storage and a reduce flood risk. Other advantages of the growable pavement in comparison to pavement without vegetation include the creation of a cooling effect which vegetation proves to possess.

Municipalities are hesitant to use growable pavement, even though it has the ambition to make their urban environment more climate resistant, the lack of knowledge on long term effects of the pavement makes them decide against it (KAN, 2022). Municipalities often do not implement open grid pavement due to the following reasons: It can be argued the growable pavement has a disorderly appearance and therefore experiences resistance from citizens ((KAN, 2022)). Citizens often consider plants between pavement to be unwanted, disorderly weeds. This could also raise the worry about costs because of the thought the pavement would have to be mowed. However, it has been hypothesized that with some education about the pavement and the benefits for biodiversity, this could be mitigated. Furthermore, the growable pavement is considered not suitable for all locations, for example, it is thought to be unsuitable for heavy traffic. However, it is known many types of paved areas remain suitable for different types of growable pavement. ((Kennisbank GroenBlauw, n.d.)

Figure 1 Car park with open grid pavement.

Figure 2 Water infiltration through open grid pavement.(Kennisbank Groenblauw)

Method

Data was collected on parking areas with growable open-grid pavement in Leiden. The fieldwork consisted on two parts: 1) a thorough vegetation analysis on one parking area and 2) Vegetation analyses on seven additional parking areas throughout Leiden for the investigation of general patterns (Appendix 1). Some sub questions will be answered by data from one part, others will combine the data. Both parts answered the question about the plant species that can be found on open grid pavement. The aim for the thorough analysis was to create a clear view of the influence of the usage intensity and to test the expectation of the presence of the possible patterns. The analyses at the other locations in Leiden, combined with the analyses on the reference verges gave insight in the possible similarities between the pavement and those references.

Vegetation analysis UVS

The thorough vegetation analysis took place on the parking area accommodated to the soccer club (Address: Oegstgeesterweg 4b, 2334 BZ Leiden). The car park is situated between multiple soccer fields and a canteen. The car park has one entrance for cars and two for pedestrians and cyclists. The elongated car park has one asphalt road connecting the two entrances and cleaving the terrain in two. These two parts mostly consist of growable open-grid pavement with undesignated parking spaces.

At the car park, the vegetation analysis was performed, the field protocol is given in Appendix 2. To create a complete picture of the vegetation and their patterns on the terrain, many areas scattered over the car park were investigated. Figure 3 shows all locations of the investigated study sites. In total, 46 parking spaces were investigated, resulting in 138 plots. At every study site three plots of $1m^2$ were laid out using wooden sticks. At the sites alongside the hedge (Edge), plot 'Back' was placed at 75 cm from the hedge, then the other plots (Mid and Front) were placed with 1 meter between them. (Figure 4) The sites along the asphalt road has plot 'Front' placed at 75 cm from the road. It was chosen to make the plots 2 by 0,5 meters to ensure homogeneity of the plot as the effect of the tire tracks are included. The vegetation analysis of each plot followed the method of Den Held, and only included vascular plants (Den Held & Den Held, 1973). This method included the notation of every species and their abundance, mean height, phenological stage and vitality. After this analysis, the coordinates of the plot were noted, and a picture of the plot was taken.

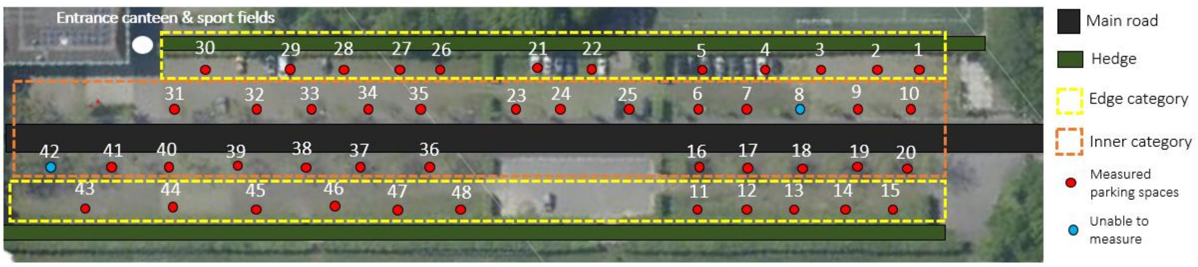

Figure 3 Placement of the studies parking spaces. Red dot means it was studied. Blue dots were planned, but not able to be studied

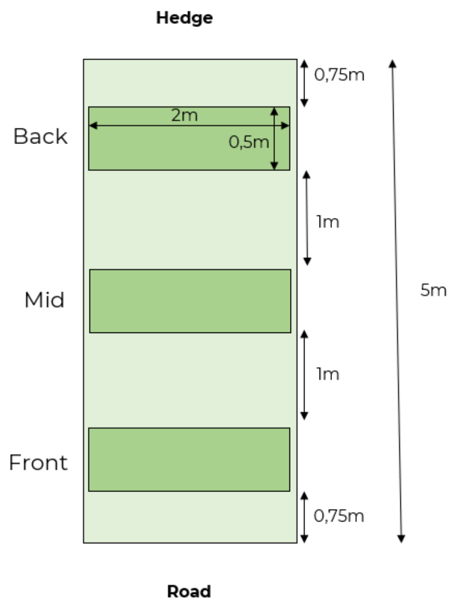

Figure 4 Placement and naming of the plots within the parking space.

Vegetation analysis multiple locations Leiden

For the investigation throughout Leiden, plots located at multiple car parks were investigated using the same vegetation analysis used at UVS. Seven extra locations with growable pavement were selected in the city of Leiden. The locations given in Appendix 1 were visited. Figure 5 shows maps for every locations including some of their surroundings, Figure 6 gives the locations in a map of Leiden. The sites were selected using little criteria, the area needed to have any form of growable pavement. The usage destination and usage intensity of the sites were not considered and are therefore very diverse.

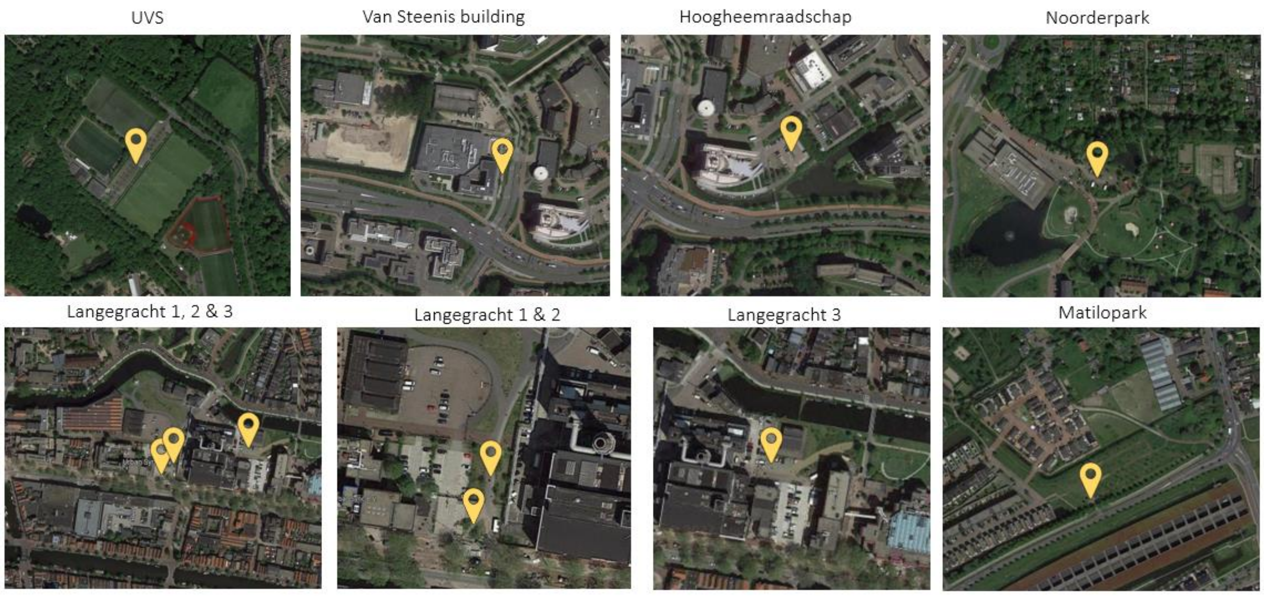

Figure 5 Detailed maps of all locations measured, indicated with a yellow indicator.

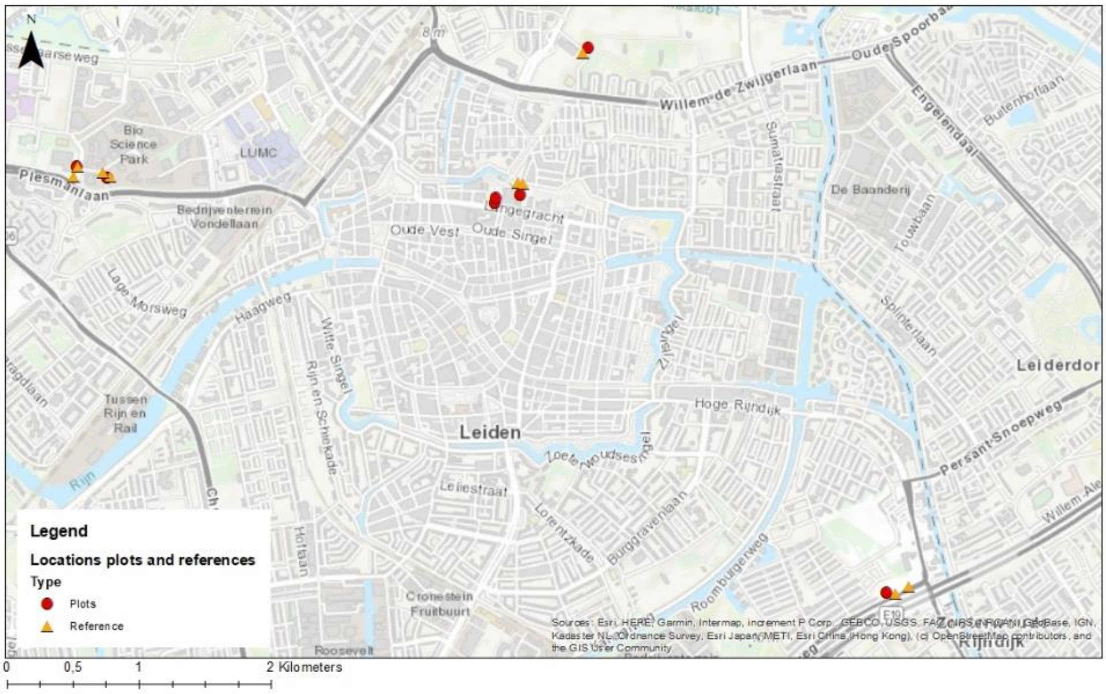

Figure 6 Locations of the study sites with open-grid pavement (red circle) and the references (orange triangle)

At every location, two plots were placed on the growable pavement. The exact appointment of each plot was random. The plots were 0.5 meters wide by 2 meters length. At every plot, a vegetation analysis following the method of Den Held was performed (Den Held & Den Held, 1973). This method included the notation of every species and their abundance, mean height, phenological stage and vitality. After this analysis, a picture of the plot was taken.
After the vegetation analyses, a species list of the whole parking area was conducted by walking over the entire surface of the parking area and documenting every unique species found. These species lists helped answering sub question 1.
Further, at a road verge nearby study site two plots were investigated in the same manner as before.

Sub question 1

Which plant species occur on open-grid pavement?

Using the field data of the UVS analysis, a frequency table of the species was computed in Excel in order to identify the most common species found on the car park. A similar frequency table was computed of the data of the eight locations in Leiden. In order to answer the sub question, the frequency table of UVS combined with the data from the other locations in Leiden were used.

Sub question 2

Does the distance from the place of interest influence the diversity?

After the fieldwork, some calculations using only the data of UVS were made in Excel. The species richness, total coverage (%) and the Shannon Diversity index were computed per plot. The species richness is the sum of all different species per plot. The Shannon Diversity Index considers the species richness and their abundance. It gives values between 0 and 5, 0 being a poor diversity and 5 6 being a very high diversity. The total coverage was calculated by using the sum of the abundance (%) per species. Categorizing the variable ‘usage intensity’ proved difficult. No clear boundaries could be formulated. Therefore, it was chosen to use the distance of the plot to the entrance as a proxy to usage intensity. It was assumed that people will park as close to the entrance as possible, limiting the walking distance. The distance of the plots to the place of interest (entrance to the sport fields) was measured in ArcGIS in meters. These distances were used as an explanatory variable in the statistical analysis. Using the calculations in Excel and the measurements in ArcGIS, an ANCOVA was performed in Rstudio.

Sub question 3

Can a difference be found in morphological characteristics between area with different intensity usages?

To answer the sub question, the list of plant species found on the UVS car park was put into a matrix. In this matrix, multiple characteristics of tramping resistant, typical pavement flora were given to every species. The presence of the category per characteristic was used by calculating the percentage which that category occupies per plot. The spatial division of these characteristics were all separately visualized in ArcMap. Possible visual patterns were described using the created maps. The following characteristics were used (Flora van Nederland, n.d.):

- Lifeform
  - Therophyte: Annual plants. Survive the winter via seeds
  - Hemicryptophyte: buds at or near the soil surface
  - Geophyte: Underground parts to survive winter, buds are well protected.
- Tolerance to salt (Ellenberg value)
- Min height <5cm
- Min height <10cm
- Max height >40cm
- Presence rosette

Sub question 4

Does the parking area compare to other grassland-type areas in the neighbourhood?

During the fieldwork of both parts, data was gathered on the road verges adjacent of nearby every study site. This data was used to compare the plant composition of the open grid pavement with the road verges. The data which was already entered in Turboveg and SynBioSys was used to compare the vegetation class, group and community which the plots fit into. A table was made with a list of the overlapping species and the unique species for the pavement and the references.

Results

Sub question 1

Which plant species occur on open-grid pavement?

A frequency table of the data from the UVS car park was computed in Excel, Appendix 3 includes this table. It shows each species found on the UVS car park and in how many plots each species occurred. In total, 60 different species were found on the car park. The division of the plant families on this car park is given in Table 1, it is composed of all field data from the UVS car park. The table shows that the most prominent plant families on the car park were *Poaceae* and *Plantaginaceae*. Table 2 reveals the ten most common species. Many of these species also belong to the most prominent plant families.

Table 1 Division of the plant families of the UVS car park. Their total coverage is given, as well as their percentage of the total coverage.

PLANT FAMILY	COVERAGE IN PLOTS (%)	PERCENTAGE OF TOTAL COVERAGE
POACEAE	1887,5	39,0%
PLANTAGINACEAE	1462,25	30,2%
ASTERACEAE	515,25	10,7%
FABACEAE	420	8,7%
JUNCACEAE	349	7,2%
GERANIACEAE	84,51	1,7%
CYPERACEAE	49	1,0%
CARYOPHYLLACEAE	33,5	0,7%
ROSACEAE	9,25	0,2%
BRASSICACEAE	3,25	0,1%
CONVULVULACEAE	5	0,1%
ONAGRACEAE	2,75	0,1%
RANUNCULACEAE	6,75	0,1%
EQUISETACEAE	1	0,0%
LAMIACEAE	1,5	0,0%
OXALIDACEAE	1,75	0,0%
POLYGONACEAE	1,5	0,0%
PRIMULACEAE	0,25	0,0%
URTICACEAE	0,25	0,0%
GRAND TOTAL	**4834,26**	**100,0%**

Table 2 The ten most common species found on the car park of UVS and their presence in all plots (n=138 plots)

SPECIES (SCIENTIFIC)	SPECIES (DUTCH)	IN # PLOTS PRESENT	PERCENTAGE
Plantago coronopus	Hertshoornweegbree	115	83%
Poa annua	Straatgras	103	75%
Taraxacum officinale	Paardenbloem	91	66%
Lolium perenne	Engels raaigras	84	61%
Plantago lanceolata	Smalle weegbree	73	53%
Trifolium dubium	Kleine klaver	71	51%
Plantago major	Grote weegbree	68	49%
Trifolium repens	Witte klaver	59	43%
Bellis perennis	Madeliefje	56	41%
Geranium molle	Zachte ooievaarsbek	45	33%

In this paragraph a short description of characteristics of the species in the table is given. The information on the species originates from the website Flora van Nederland and the book Zakgids Stoepplanten. The plant species which occurs much more than others is *Plantago coronopus*, this species is common in the dune areas. However, its occurrence is increasing in verges alongside roads throughout the rest of the country. This is explained by the good salt tolerance of the species, therefore they pioneer the road verges of roads where in winter salt gets distributed against slipperiness. The other *Plantago* species are, like *P. coronopus*, very tolerant to trampling and are found regularly in the urban environment. *Plantago lanceolata* and *major* can be found in road verges and sidewalks, their size depends on the available nutrients. *Poa annua* is a grass species which can occur everywhere, even on stony surfaces and asphalt, and at any time. *Poa annua* is very tolerant to trampling (Zakgids Stoepplanten). The other grass-type, *Lolium perenne,* is highly used with sowing in fields in the Netherlands. The grass is very tolerant to trampling, therefore the plant is also very likely to be found on pavements and other part of the urban area. The *Trifolium* species are both very common in the Dutch landscape and occur on many different soil types. They prefer a compacted soil and tolerate different water availabilities. *Taraxacum officinale* is a very common species of the *Asteraceae*. The species grows on moist and nutrient rich soils as well as dry nutrient poor soils. Besides the appearance in grasslands is the species also commonly found in stony areas like sidewalks and alongside facades (Zakgids Stoepplanten). *Bellis perennis* is a very common plant in grasslands. They can flower throughout the most of the year. Lastly, *Geranium molle* is another common species in the Dutch landscape which can be found in many environments.

The abundancy curve below indicates that few species were found over the whole surface of the car park (Figure 7). 33 Species were only present in 5 plots. Fifteen species only occurred in one plot, which is not visible in the histogram but was calculated in Excel. Appendix 5 includes a table with the species which were only found in 1-3 plots. The abundancy curve suggests that there are few common species on the car park, which are the species from Table 2. Also, looking at even more plots could result more detected species since a lot of species only occurred on <5 plots.

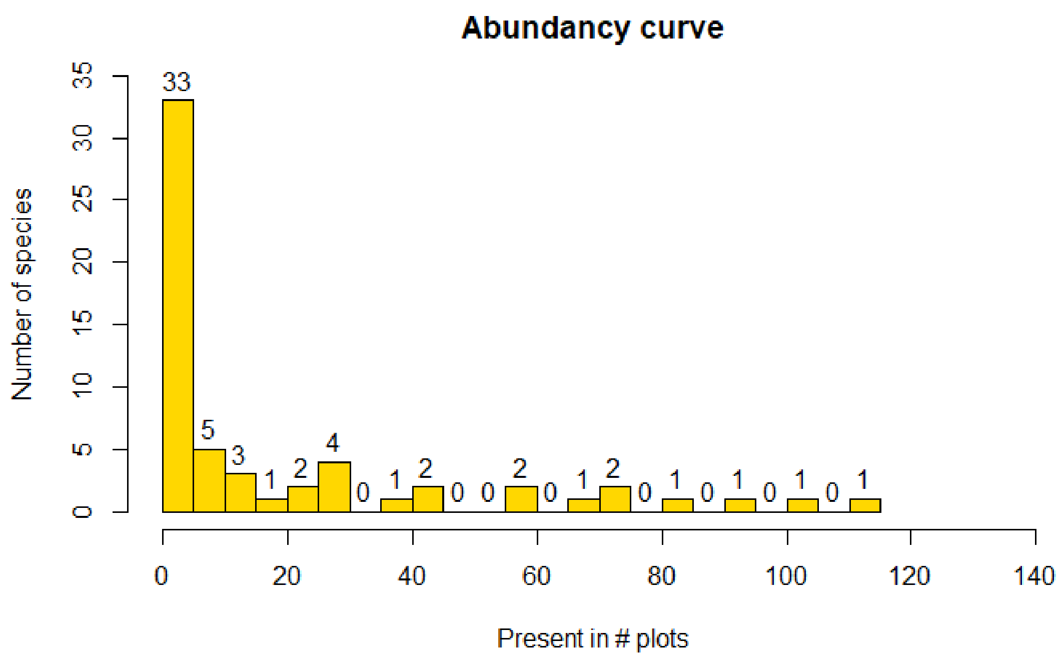

Figure 7 Abundancy curve of the species found at the UVS car park. It shows how many species were found at a specific number of plots. The histogram has breaks of 5 plots. (n=138 plots)

In Appendix 4 the complete table of the presence of species of all measured locations throughout Leiden is given. It shows at how many times study sites each species was present. Table 3 gives the species richness per location. The species which were found on almost every site (6-7-8/8) were Medicago lanceolata, Taraxacum officinale, Hypochaeris radicata, Lolium perenne, Poa annua, Achillea millefolium, Festuca sp., Jacobaea vulgaris, Leontodon saxatilis and Plantago coronopus (

Table 4). All these species are associated with pavement flora and the urban environment. Also the non-native species found on the pavement are indicated in the Appendix, in total, 28 species were non-native (Appendix 4).

Table 3 The species richness per location

LOCATION	SPECIES RICHNESS
UVS	60
VAN STEENIS BUILDING	16
HOOGHEEMRAADSCHAP RIJNLAND	46
LANGEGRACHT 1	25
LANGEGRACHT 2	21
LANGEGRACHT 3	52
NOORDERPARK	24
MATILOPARK	34

Table 4 The most common species found on the eight different locations and at how many locations it was present. (n=8)

SPECIES (SCIENTIFIC)	SPECIES (DUTCH)	IN # LOCATIONS PRESENT	PERCENTAGE
Medicago lupulina	Hopklaver	8	100%
Plantago lanceolata	Smalle weegbree	8	100%
Taraxacum officinale	Paardenbloem	8	100%
Hypochaeris radicata	Gewoon biggenkruid	7	87.5%
Lolium perenne	Engels raaigras	7	87.5%
Poa annua	Straatgras	7	87.5%
Achillea millefolium	Duizendblad	6	75%
Festuca sp.	Zwenkgras sp.	6	75%
Jacobaea vulgaris	Jacobskruiskruid	6	75%
Leontodon saxatilis	Kleine leeuwentand	6	75%
Plantago coronopus	Hertshoornweegbree	6	75%
Plantago major	Grote weegbree	6	75%

Sub question 2

Does the distance from the place of interest influence the diversity?

At the parking area of UVS, in total 138 plots, evenly divided between the plot types, were analysed. A brief summary of the data is given in Table 5. In total, 60 species were found in the plots. The minimal number of species found on a plot was 3 and the maximum number is 20. The Shannon diversity of the plots is between 0.39 and 2.56 and the coverage of the plots between 17 and 75.5%.

Table 5 Summary of the fieldwork data of UVS containing the minimum, mean and maximum of relevant variables

		TOTAL	MIN	MEAN	MAX
SPECIES RICHNESS	All plots	60	3	8.608696	20
	Plots Front		3	7.957	17
	Plots Mid		5	8.478	18
	Plots Back		4	9.391	20
	All plots		0.391157	1.590508	2.570408
	Plots Front		0.3912	1.4859	2.4742

SHANNON DIVERSITY	Plots Mid	0.8207	1.5719	2.3169
	Plots Back	0.876	1.714	2.570
COVERAGE (%)	All plots	17	35.04717	75.5
	Plots Front	17	33.50	62.25
	Plots Mid	18.25	35.41	58.75
	Plots Back	18	36.23	75.50

During the data diagnostics, the response variable ‘Shannon diversity’ proved normally distributed and therefore suitable for an ANCOVA analysis. The model used to investigate the influence of every explanatory variable on the response variable was:
Model 1: “Shannon diversity ~ Distance from entrance + Plot type + Position on terrain + Coverage”.
Also, the data of every plot type was analysed separately from each other using the following model:
Model Front/Mid/Back: “Shannon diversity ~ Distance from entrance + Position on terrain + Coverage”
The assumptions of the test were checked for the data. Homogeneity of variance was proved, as well as normality of residuals. There were no outliers and there appeared to be linearity for all variables except for the variable ‘distance from entrance’. Performing a Generalized Linear Model showed which variables from the model influence the Shannon diversity. The complete analysis including tests and output can be found in Appendix 6.

```
Call:
glm(formula = formula, family = gaussian(link = "identity"),
    data = PlotsAll)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.0926  -0.2576   0.0290   0.2441   0.9335

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)               1.1890879  0.1337198   8.892 3.93e-15 ***
PlotsAll$PlotB            0.0630981  0.0818487   0.771 0.442137
PlotsAll$PlotC            0.1950399  0.0821051   2.375 0.018964 *
PlotsAll$Coverage         0.0120263  0.0033111   3.632 0.000401 ***
PlotsAll$Distance_entrance -0.0007824  0.0004090  -1.913 0.057939 .
PlotsAll$PositionInner    0.0260214  0.0676745   0.385 0.701221
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for gaussian family taken to be 0.1531645)

    Null deviance: 23.588  on 137  degrees of freedom
Residual deviance: 20.218  on 132  degrees of freedom
AIC: 140.57

Number of Fisher Scoring iterations: 2
```

Figure 8 Result from the Generalized Linear Model.

The Distance variable is almost significant (p=0.057939) , so it is worth looking at closer. The test indicates a significant effect of Plot type and Coverage. (Figure 8)

<u>Distance from entrance</u>
This sub question focused on the influence on usage intensity on the Shannon diversity. Therefore this variable, using the proxy ‘distance from entrance’, is discussed first. The next graphs reveals the influence of the distance of the plot from the entrance of the place of interest to the Shannon diversity. The statistics of the GLM proved no significant influence of the variable. However, it was almost significant, revealing a possible influence. The left graph gives a trendline following a linear model, the right graph gives a trendline following the data. It seems the data has a quadratic relation. Using a quadratic model the influence of the quadratic variable ‘distance from entrance’ is tested. These results showed a significant influence (p=0.000308), so there appears to be a quadratic relation between the distance and the Shannon diversity.

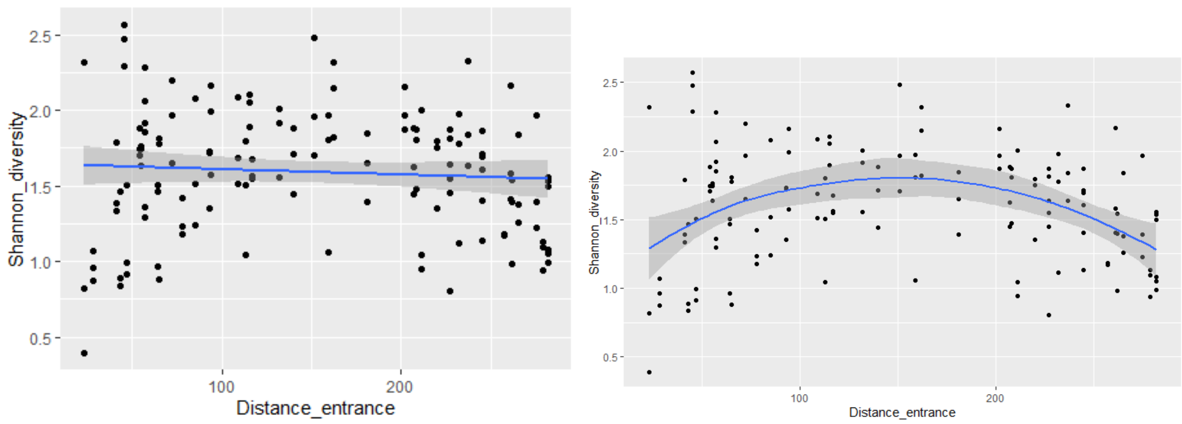

Figure 9 Graphs of the Shannon diversity of the explanatory variable 'Distance from entrance'. Left: trendline following a linear model. Right: trendline following the data.

The spatial visualization below shows how the Shannon diversity is distributed over the car park (Figure 10). No clear pattern can be found. However, it can be discussed that the diversity follows the parabolic distribution of Figure 9 (right).

Figure 10 Spatial distribution of the Shannon diversity of each plot.

<u>Position/Plot type</u>

Figure 11 shows the boxplots of the two categorical explanatory variables from the model.
The left boxplot visualizes the Shannon diversity of the two different positions on the car park, ‘Edge’ and ‘Inner’, no significant difference could be found. The boxplot on the right shows the differences in Shannon diversity on the micro-scale, so between the different plot types. Plot ‘Front’ proved significantly different from Plot ‘Back’ after performing an ANOVA (p=0.0279) and a post hoc test (p=0.0220890). Thus the ‘Back’ plot has a significantly higher Shannon diversity than the ‘Front’ plot.

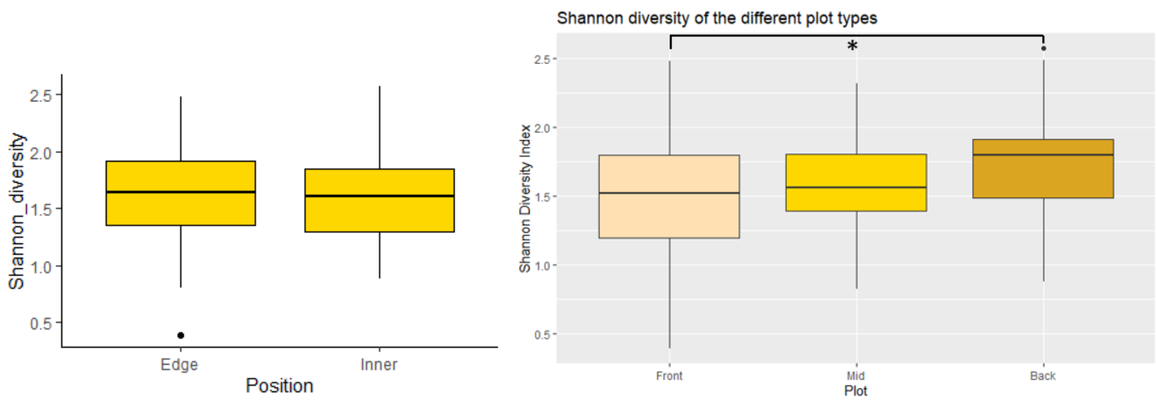

Figure 11 (Left) Boxplot of the Shannon diversity of the explanatory variable 'Position' and (Right) the variable 'Plot. 'Position' does not show significance. Plot 'Front' and 'Back' differ significantly. (p=0.0220890).

Looking at the micro-scale, the difference in species diversity per position of the plots on the car park (Edge/Inner) was investigated using statistics. These statistics proved plot 'Back' to have a different Shannon diversity between the Edge plots and the Inner plots (p=0.024). The 'Back-Edge' plots have a higher diversity. The other plot types do not statistically differ from each other whether they are on the Inner part of the Edge. However, when looking at the Edge plots, a significant increase in diversity is proven between the 'Front' and 'Back' plots (p=0.0000402). (Figure 12)

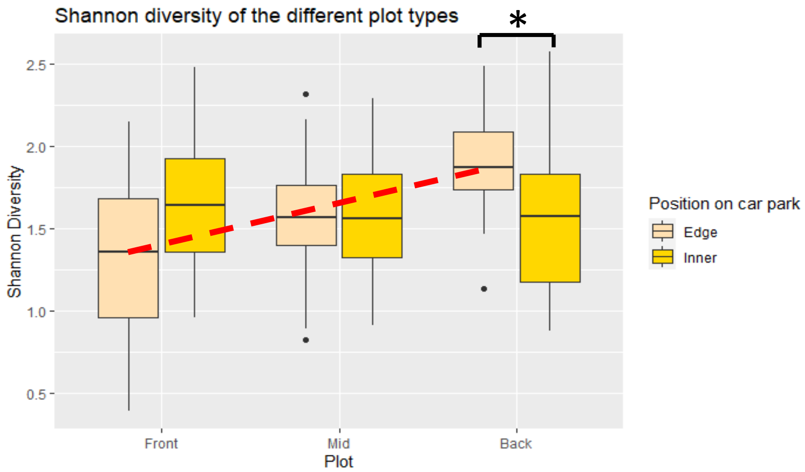

Figure 12 Boxplot of the Shannon diversity of each plot type making a division in the position on the car park. A significant difference is present between the Inner and Edge plot of plot type Back. (p=0.024) Also, a difference is present between the Front and Back plot type at the Edge plots (p=0.0000402) and between the Mid and Back plot type at the Edge plots (p=0.0156360). No difference is present between the Front and Mid plot type at the Edge plots (p=0.16…).

<u>Coverage</u>

In Figure 13 the spatial distribution of the coverage per plot over the car park is showed, so on macro-scale. The least amount of coverage appears to be at the left side of the car park. No clear pattern can be found, however, it seems the edges of the car park have the most amount of coverage. Also, the left side of the car park, where the entrance to the sport facility is located, the coverage seems lowest.

Figure 13 Spatial distribution of the vegetation coverage per plot over the car park.

The graph below illustrates the influence of the total coverage of the plots on the Shannon diversity (Figure 14). As the GLM proved a significantly influence, there appears to be a positive relation. The graph on the right shows the species richness against coverage, this also shows a positive trend. It is thus suspected while a high coverage means a higher Shannon diversity, the species richness is also higher.

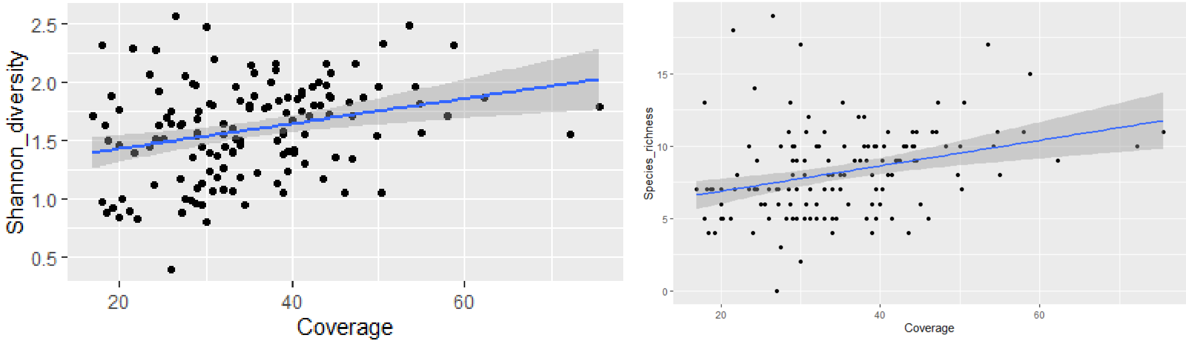

Figure 14 Left: Graph of the Shannon diversity of the explanatory variable 'Coverage'. Right: Graph of the species richness of the variable 'Coverage'.

When testing the data of the plot types separately, the same analysis was performed. Statistics showed 'Coverage' to be significant in explaining the Shannon diversity for plot type 'Mid' (p=0.0147). This was also the case with the data of plots 'Back', Coverage was significant (p=0.024).

The two boxplots below give insight in effect of coverage on the micro-scale (Figure 15). The left boxplot shows no difference between the plot types, while there does appear to be a difference when the position on the car park is taken into consideration. The right boxplot shows this difference, the coverage on plots 'Inner-Mid' and 'Inner-Back' show a lower coverage than on the edge of the car park. Statistics confirms only the higher coverage of the Edge plots 'Back' in comparison to the Inner plots using an Anova and Tukey test (p= 0.0012139). Another test found a significant difference between the plot type 'Front' and 'Back' at the Edge plots. (p=0.0264657)

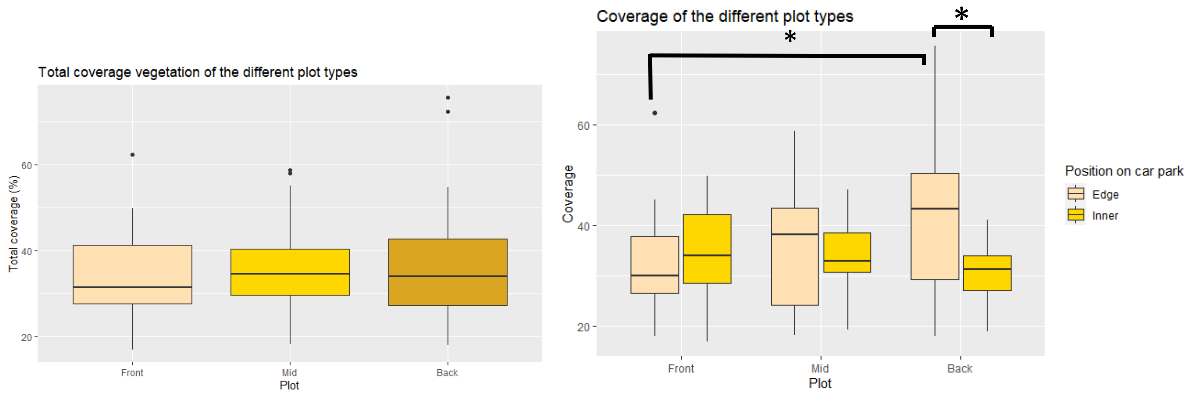

Figure 15 Left: Boxplot of the coverage per plot type. Right: Boxplot of the coverage of each plot type making a division in position on the car park. The difference between the Inner and Edge plots of the plot type Back is significant. (p= 0.0012139). Another test found a significant difference between the plot type Front and Back at the Edge plots. (p=0.0264657)

Sub question 3

Can a difference be found in morphological characteristics between area with different intensity usages?

In the following paragraphs, each chosen characteristic is presented. A matrix was composed in Excel with list of all species and their corresponding characteristics (Appendix 7Appendix). A map of the car park with all plots and their corresponding value per characteristic is given, detecting possible patterns on macro-scale. Also, the micro-scale is considered in the given boxplots.

Lifeform

The lifeform which dominated the plots of the carpark was hemicryptophyte. Table 6 shows the presence of each lifeform. The hemicryptophyte lifeform included the highest number of species and the highest total coverage. It is also interesting to see how many rosette forming plants each lifeform included as this was expected to be an advantageous characteristic on the parking area. It appears that more than half of the hemicryptophyte coverage is explained by rosette forming plants. The other 40% is thus composed of the 18 other hemicryptophyte species.

Table 6 The number of species per lifeform and the total coverage of each lifeform when all plots are combined.

LIFEFORM	# SPECIES FOR EACH LIFEFORM	# SPECIES WITH ROSETTE	COVERAGE|PERCENTAGE ROSETTE FORMING PLANTS	TOTAL COVERAGE
GEOPHYTE	6	0	0|0%	396.25
HEMICRYPTOPHYTE	28	10	1903.75|61.74%	3083.50
THEROPHYTE	26	4	84.51|6.24%	1354.51

To create a better view of these lifeforms, multiple boxplots were made to visualize possible differences in characteristics. First of all, the geophytes appear to be higher than the other two lifeforms. Both the maximum and minimum height are higher than the others (Figure 16). High plants are less likely to have an advantage at locations with much tread.

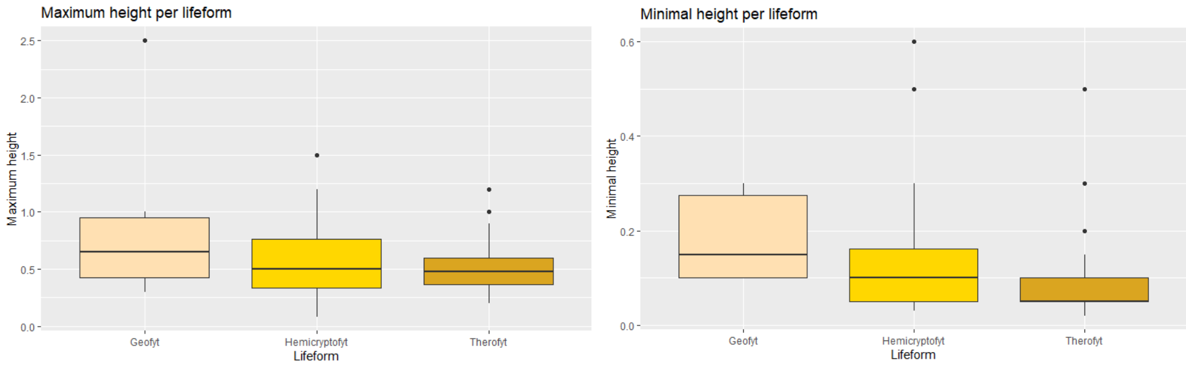

Figure 16 Boxplot of the height per lifeform. Left: Maximum height. Right: Minimum height.

Salt

The characteristic 'salt tolerance' could be a defining factor for the presence of certain species on the car park. The salt concentration could be highest alongside the asphalted road in the middle, causing a pattern. As the Ellenberg value for salt tolerance was 0.5 or 0.25 for almost all species, the coverage of *Plantago coronopus* (Ellenberg value of 2.5) was chosen to visualize possible patterns. Figure 22 in Appendix 8 shows the distribution of *Plantago coronopus* on the car park on the macro-scale. Notable is the low coverage in close range to the trees on the car park. Along road, at both sides, are trees present (map is not the real situation), these trees are all the same size, except for the middle of the car park. In Figure 22, directly beside the road in the middle of the car park, dark points indicate a high coverage of *Plantago coronopus*. The map shows no trees present, however, there are relatively newly planted trees present, which are smaller than the others on the car park. Using an ANOVA, no significant difference was found between the plot types on micro-scale (Figure 27 in Appendix 9). However, when the data from the 'Inner' and 'Edge' plots are separated, a difference was found (Figure 17). An opposite effect is found between the salt tolerance of the 'Inner' and 'Edge' plots. A statistical difference is proven between the 'Front' and 'Mid' plot with the 'Back' plot. It suggests a decrease in coverage of *Plantago coronopus* when moving away from the main road. While the 'Inner' data suggests the opposite, although not proven significantly.

Figure 17 Salt tolerance of the different plot types per position on the car park. The salt difference is given in the coverage of Plantago coronopus *(%). The difference between the 'Edge-Front' and 'Edge-Back' plot is significant (p=0.0006444). The difference between the 'Edge-Mid' and 'Edge-Back' plot is also significant (p=0.0165607). No difference is found between the 'Inner' plots.*

Percentage coverage height group 'minimal height of 0-10cm'

On this macro-scale, no clear patterns are visible. The percentage of plants in the minimal height group of 0-10 cm per plot is given in a spatial visualization (Figure 23 in Appendix 8). When looking at the micro-scale, a significant difference was found between the 'Mid' and 'Back' plot (p=0.023…)(Figure 28 in Appendix 9). The boxplot indicates that the 'Back' plot includes less plants in the height group '0-10cm' than the 'Mid' plot. When the 'Inner' and 'Edge' data is separated, the same pattern is found on micro-scale (Figure 18). The difference between the 'Edge-Front' and 'Edge-Back' plot is significant (p=0.0005400). The difference between the 'Edge-Mid' and 'Edge-Back' plot is also significant (p=0.0005957). No difference is found between the 'Inner' plots. As with the salt tolerance, the 'Inner' and 'Edge' data show opposite trends.

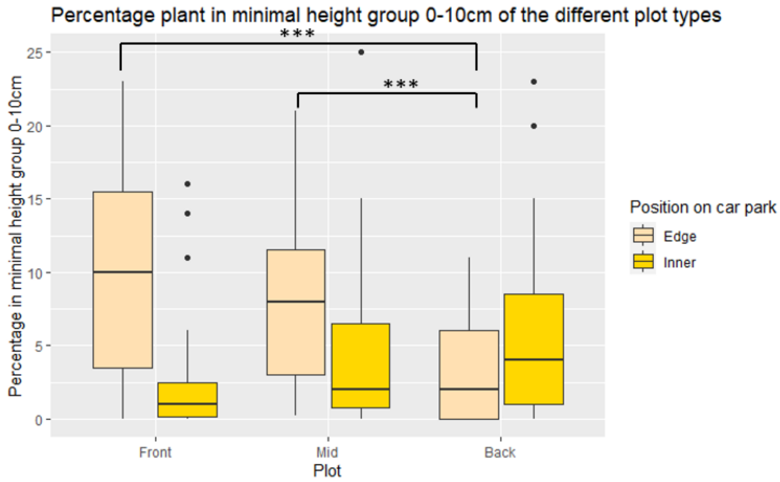

Figure 18 Percentage of plants in the minimal height group 0-10cm of the different plot types per position on the car park. The difference between the 'Edge-Front' and 'Edge-Back' plot is significant (p=0.0005400). The difference between the 'Edge-Mid' and 'Edge-Back' plot is also significant (p=0.0005957). No difference is found between the 'Inner' plots.

Percentage coverage height group 'minimal height 0-5cm'

In the figure below, the percentage of plants in the minimal height group of 0-5cm per plot is given in a spatial visualization to visualize the macro-scale (Figure 24). In comparison to the height group including plants of 10cm, the left side of the car park includes less plants with a minimal height up to 5cm than the rest of the car park.

At the micro-scale, no statistical difference could be found between the plot types (Figure 29). Separating the 'Inner' and 'Edge' data did find a difference (Figure 19). The difference between the 'Edge-Front' and 'Edge-Back' plot is significant (p=0.0067587). Again, opposite trend are visible. It suggests that the amount of plants in the height group 0-5cm decreases when moving away from the main road at the 'Edge' plots, but increases moving away from the road at 'Inner' plots.

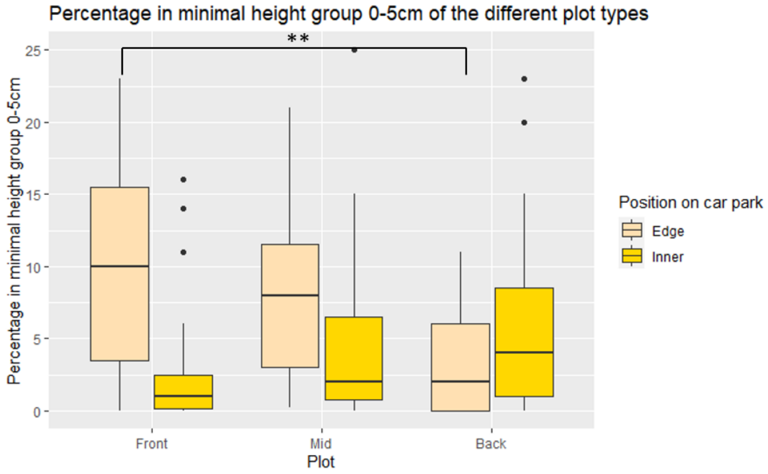

Figure 19 Percentage of plants in the minimal height group 0-5cm of the different plot types per position on the car park. The difference between the 'Edge-Front' and 'Edge-Back' plot is significant (p=0.0067587)

Percentage coverage height group 'maximum height >40cm'

The spatial map shows that, in general, the plots on the edge include more species with a maximal height >0.4m (Figure 25 in Appendix 8). At micro-scale, a difference is found between the 'Front' and 'Back' plot (p=0.0301275)(Figure 30 in Appendix 9). Separating the 'Inner' and 'Edge' data found more differences (Figure 20). The difference between the 'Edge-Front' and 'Edge-Back' plot is significant (p=0.0000016). Another difference is found between the 'Edge-Mid' plot and the 'Edge-Back' plot (p=0.0004202). In 'Inner' plots do not differ from each other statistically. Again, opposite trends are visible. It suggests that the amount of plants in the height group >40cm increases when moving away from the main road at the 'Edge' plots, but decreases moving away from the road at 'Inner' plots.

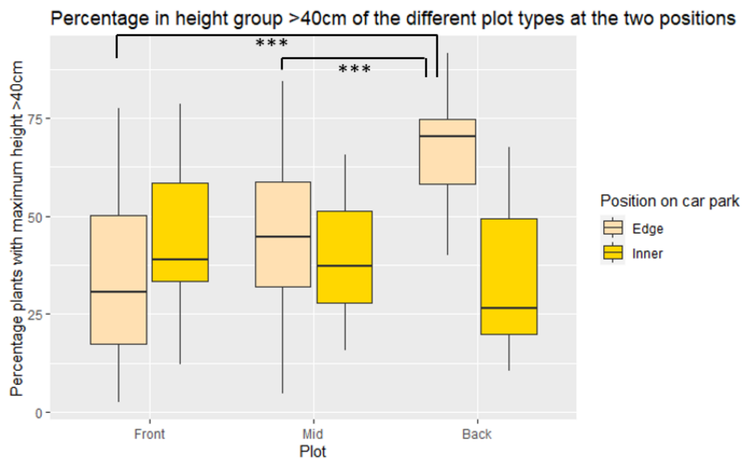

Figure 20 Percentage of plants in the maximum height group >40cm of the different plot types per position on the car park. The difference between the 'Edge-Front' and 'Edge-Back' plot is significant (p=0.0000016). Another difference is found between the 'Edge-Mid' plot and the 'Edge-Back' plot (p=0.0004202).

Percentage rosette forming plants

In the figure below, the percentage of rosette forming plants per plot is given in the macro-scale, the spatial visualization (Figure 26 in Appendix 8). No clear pattern can be found, however, the left side of the car park has a low percentage of rosette forming plants. At the micro-scale, no difference can be found between the plot types (Figure 31 in Appendix 8). When looking at the 'Inner' and 'Edge' data separately, again no difference was found (Figure 21).

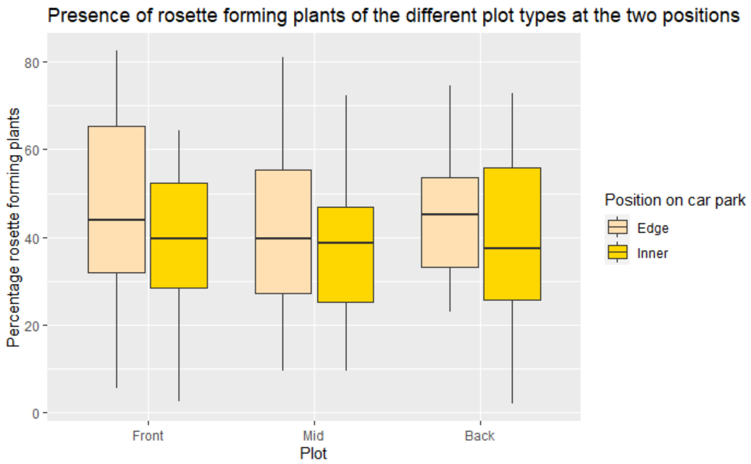

Figure 21 Percentage of rosette forming plants of the different plot types per position on the car park. No significant differences were found.

Sub question 4

Does the parking area compare to other grassland-type areas in the neighbourhood?

The table below shows the results of the SynBioSys analysis and gives an overview of the frequency of every vegetation class per plot type (Table 7). The results of the analysis in SynBioSys show a dominant vegetation class: 16 Molinio-Arrhenatheretea. The class is characterized by plant communities of moist and nutrient-rich grasslands.
Three plots fitted the vegetation class 12 Plantaginetea majoris. This class knows communities which are characteristic for compacted, very nutrient-rich and oxygen-poor soils. The communities have many species known as 'tredplanten' or tramping-resistant plants. One plot fitted the class 21 Asplenietea trichomanis and one other plot class 31 Artemisietea vulgaris. Class 12 is typical for stony surfaces and class 13 is a typical ruderal class. Vegetation class 30 Stellarietea mediae fitted 2 plots. This class is characterized by plant communities typical for arable lands. One plot fitted class 37 Rhamno prunetea best. This class occurs on dry, neutral-basic soils, characterized by thorn bushes. However, the confidence of the fit is below 15 percent and therefore not trustworthy in comparison with the rest of the fits which are around 30 percent confident.

To quantify the similarity between the pavement and the references, the Sorensen Similarity index was calculated. The index has a value of 0,7 for the plant communities of the pavement and the references when all data is combined. The Sorensen Similarity index has values between 0 and 1, 1 meaning the plant communities are exactly the same. It considers the unique and overlapping species and ignores the abundance of those species. When looking at the Pavement-Reference pairs the similarity is lower than the overall similarity.

Table 7 Overview of the occurrence of every vegetation class per location and plot type. A total per vegetation class is also given.

MOST LIKELY VEGETATION CLASS	GRAND TOTAL	HOOGHEEMRAADSCHAP		LANGEGRACHT 1	LANGEGRACHT 2	LANGEGRACHT 3	MARESINGEL	MATILOPARK		NOORDERPARK		OEGSTGEESTERWEG	VAN STEENIS	
		Pavement	Reference	Pavement	Pavement	Pavement	Reference	Pavement	Reference	Pavement	Reference	Reference	Pavement	Reference
12 PLANTAGETEA MAJORIS	3							1		2				
16 MOLLINIO-ARRHENATHERETEA	19	2	2		2	2		1	2		1	3	2	2
21 ASPLENIETEA TRICHOMANIS	1			1										
30 STELLARIETEA MEDIAE	2						2							
31 ARTEMISIETEA VULGARIS	1			1										
37 RHAMNO PRUNETEA	1											1		
GRAND TOTAL	27	3	1	2	2	2	2	2	2	2	1	4	2	2
SORENSEN SIMILARITY	0,7	0,59		-	-	-	-	0,44		0,38			0,46	

In Table 8, an overview is given of every overlapping species for pavement and the references, and a list of unique species the open grid pavement and the references. Notable is the list of the unique species of the pavement, which is outstandingly longer than the other lists.

Table 8 Overlapping and unique species of the locations with open grid pavement and the measured references.

Overlapping species	**Unique species for Pavement**		**Unique species for Reference**
Achillea millefolium	*Agrostis capullaris*	*Malva moschata*	*Agrostemma githago*
Arrhenatherum elatius	*Anisantha sterillis*	*Matricaria discoidea*	*Agrostis* sp.
Artemisia vulgaris	*Anthoxanthum odoratum*	*Mauranthemum paludosum*	*Anisantha sterilis*
Centaurea jacea	*Bellis perennis*	*Melilotus albus*	*Anthriscus sylvestris*
Cirsium arvense	*Bromus hordeaceus*	*Myosotis arvensis*	*Calystegia sepium*
Dactylis glomerata	*Capsella bursa-pastoris*	*Oenothera* sp.	*Cichorium intybus*
Daucus carota	*Carex hirta*	*Origanum sp.*	*Epilobium hirsutum*
Elymus repens	*Cerastium fontanum*	*Oxalis corniculate*	*Heracleum mantegazzianum*
Equisetum arvense	*Cerastium glomeratum*	*Oxalis stricta*	*Luzula* sp.
Festuca rubra	*Cirsium vulgare*	*Persicaria maculosa*	*Lycopus europaeus*
Geranium molle	*Convolvulus arvensis*	*Plantago major*	*Pentaglottis sempervirens*
Glechoma hederacea	*Cortaderia selloana*	*Poa pratensis*	*Juncus* sp.
Holcus lanatus	*Crepis capillaris*	*Polycarpon tetraphyllum*	*Silene dioica*

Hordeum murinum	*Digitaria sanguinalis*	*Polygonum aviculare*	*Sinapis arvensis*
Jacobaea vulgaris	*Draba verna*	*Potentilla indica*	*Tanacetum vulgare*
Leontodon saxatilis	*Dysphania ambrosioides*	*Potentilla reptans*	*Vicia cracca*
Lolium perenne	*Echinacea purpurea*	*Prunella vulgaris*	*Vicia* sp.
Lotus corniculatus	*Epilobium parviflorum*	*Pulicaria dysenterica*	
Matricaria chamomilla	*Erigeron canadensis*	*Ranunculus repens*	
Medicago lupulina	*Erodium cicutarium*	*Rorippa palustris*	
Papaver rhoeas	*Erodium cicutarium subsp. dunense*	*Rumex acetosella*	
Phleum pratense	*Eschscholzia californica*	*Sagina procumbens*	
Plantago coronopus	*Festuca filiformis*	*Salvia officinalis*	
Plantago lanceolata	*Festuca* sp.	*Scorzoneroides autumnalis*	
Poa annua	*Filago germanica*	*Sedum acre*	
Poa trivialis	*Galinsoga quadriradiata*	*Senecio inaequidens*	
Potentilla anserina	*Geranium dissectum*	*Senecio vulgaris*	
Ranunculus acris	*Geranium pusillum*	*Silene armeria*	
Rumex obtusifolius	*Geranium robertianum*	*Silene conica*	
Sisymbrium officinale	*Gnaphalium luteo-album*	*Silene vulgaris*	
Taraxacum officinale	*Hieracium aurantiacum*	*Sisymbrium orientale*	
Trifolium dubium	*Hypochaeris radicata*	*Sonchus asper*	
Trifolium pratense	*Juncus articulatus*	*Sonchus oleraceus*	
Trifolium repens	*Juncus bufonius*	*Stellaria media*	
Urtica dioica	*Juncus compressus*	*Trifolium arvense*	
	Lamium purpureum	*Tripleurospermum maritimum*	
	Lepidium didynum	*Verbena bonariensis*	
	Leucanthemum vulgare	*Veronica arvense*	
	Lobularia maritima	*Vicia* sp.	
	Lysimachia	*Viola tricolor*	
		Vulpia myuros	

Discussion

The study aimed to fill the knowledge gaps about the biodiversity aspects of open grid pavement by addressing four gaps: the plant species composition, the influence of usage intensity on ecological gradients, the ecological characteristics of the plant community and lastly the influence of neighbouring vegetation being a depending factor on the plant composition. The key results included the observed 117 different species in total on open grid pavement, which is a greater number than the expected species group. As predicted, the most common group of species was mainly composed of the expected pavement flora, but the total species list includes also other flora types likes typical grassland flora and occasional swamp and dune species. The macro- (100m) and micro (1-5m) scale of the thoroughly investigated car park showed interesting differences. The usage intensity, using the distance from the entrance as a proxy, proved to have a significant quadratic relationship with the Shannon diversity. This is in line with the expected intermediate disturbance hypothesis pattern. At the micro scale, so within the individual parking spaces, three patterns of morphological characteristics were observed. First of all, the plot-types (Front, Mid, Back) on the car park differed from each other in diversity between the two positions (Inner, Edge). Secondly, the plots at the edge of the car park differed in the presence of plant species from a certain height class. The last observed pattern was that the plots at the inside of the car park had the opposite trend to the edge plots. These height differences were predicted, however, an alternative pattern was suspected. The research also showed the plots on the pavement and the reference are similar when it comes to the vegetation class they most likely fit in. While the similarity index of 0.7 indicates moderate similarity, the list of unique species of the pavement was relatively long. The influence of the neighbouring vegetation was predicted to be greater than established in this research. These main results are further discussed in the following paragraphs, including the limitations and shortcomings of the method, and a critical discussion of the key findings.

There are limitations to the research which affect generalisability. First of all, the number of study sites is small and limited to the city of Leiden. Including more sites could either narrow down or increase the list of most common species found on the open-grid pavement. Due to the wide variation of usage type, environmental differences (different soil types, tiles, and age) and spatial context, the species list could have been influenced by these non-tested variables. The weeks in which this research was performed, June and July 2022, included many dry and warm periods. The drought and heat will have influenced the size and phenological state of the species present on the pavement. It could also have inhibited the germination of seeds, therefore some species might not be detected or presented themselves in other abundances than they would have during different weather circumstances (Benvenuti, 2004). Performing more vegetation analyses over the years could give insight in the influence of the weather on the plant composition of the pavement. Now that this research found a wide variety of species can colonize the pavement, studies on the other variables could provide a clearer picture of the behaviour of the pavement vegetation. The key findings are therefore an important starting point for the topic of biodiversity on open grid pavement.

My research observed a variety of species which consists of 117 different species, which shows that a broad spectrum of species can colonize and survive in that specific environment. Multiple observations were made on the vegetation composition and their structure on the car park of UVS, for example, species like *Plantago* grew much higher and bigger at the edge areas. Another remarkable field observation is the occurrence of some very diverse spots on the parking lot which included species that were found nowhere else on the car park, for example, *Potentilla indica, Anagallis arvensis* and *Erodium cicutarium* subsp. *dunense*. While research on spontaneous vegetation on open-grid pavement is lacking, multiple studies have been performed on vegetation on the pavement. The most common species found in other research on pavements included *Poa annua, Sagina* sp., *Senecio vulgaris, Crepis* sp., *Hypochaeris radicata*, *Cardamine hirsuta, Sonchus oleraceus*, *Cerastium glomeratum*, and *Draba verna*. (Bonthoux *et al*., 2019) These species were all observed in my research, even though not all belonged to the most common species. The list of species in my research is also much longer and not limited to pavement flora. Research by Melander also proves *Poa annua* to be the most common species on pavement, this is in line which my research which observed *Poaceae* as the most common family (Melander et al., 2009).

Since no analysis was performed on the soil, it is not conclusive if the broad spectrum could be explained by the influence that different soil conditions could have on the composition (Rodrigues et al., 2018). The different micro habitats, nutrient levels, oxygen levels, soil structure, and compaction could all create different niches for different plants, which might explain the wide variety of species observed (Deák et al., 2017; Ohler et al., 2020). The high species richness could have been caused by the cells of the pavement all acting as islands, which can be colonized individually. The abundancy curve of UVS shows many species which only occurred in a few plots, it is therefore reasonable to think many species remained undetected. Another hypothesis is that the existence of a few dominant species prevent new species from colonizing the area therefore the abundancy curve will remain skewed.. Not all species found on the open grid pavement would be native species (Hortus Botanicus Leiden, 2021), in this research, 28 non-native species were found. Some species derived from nearby planters and are therefore unlikely to occur in other locations with open grid pavement. There also appeared to be a great difference in species richness between the investigated locations. Further research could test if the species richness is influenced by the limitations mentioned earlier. The species richness of UVS was the highest, this could be logical since many plots were investigated and therefore more thoroughly studied than other locations. The lowest species richness at the Van Steenis building could be explained by this locations having the lowest surface area of all locations and therefore has less niches. The species richness found on the pavement is high and could have been caused by the existence of these niches and microhabitats but could also form patterns on the car park, the presence of patterns was investigated in this research.

The macro- and micro-scale of the car park of UVS showed different patterns regarding the Shannon diversity and the morphological characteristics. While the macro-scale showed an intermediate disturbance hypothesis pattern and no clear patterns for the other variables, the micro-scale showed patterns for multiple variables. The patterns will be further described in this paragraph.

Starting with the patterns found on macro-scale, two patterns are discussed in this paragraph. The first pattern addresses the second knowledge gap, the usage intensity (using the distance from the entrance as a proxy) proved to have a significant quadratic relationship with the Shannon diversity. This means that it follows the pattern of the intermediate disturbance hypothesis. The performed GLM indicated a possible influence of the distance from the entrance as it was close to the significance threshold. The quadratic model indicated the significant influence of the quadratic distance variable on the Shannon diversity. The car park consists of free parking spaces with an undesignated driving lane, so the expected usage intensity might be different from the actual intensity. People will drive over the inner parking spaces to get to the outer parking spaces, causing an elevated usage intensity on the inner spaces. The existence of multiple places of interest for the car park also questions the accuracy of the proxy for usage intensity. However, as these destination options were close to each other, the data is still useful. Also, a small facility of the municipality including some machines is located at the right side, making it possible the people from the municipality use that side of the car park often. The second pattern regards the third knowledge gap. While in general no clear division in morphological characteristics on macro-scale was present, the salt tolerance did show some interesting spatial aspects. In the figure, it could be seen that the coverage of *Plantago coronopus* is lower alongside the main road. This could be explained by the presence of the trees alongside that road. Besides the effects of salt itself, there could be a physiological drought caused by salt at the car park affecting plant growth. But as the shade of the trees could mitigate evaporation, having more water to dissolve the salt, *Plantago coronopus* does not have an advantage anymore. At these locations, there could be more opportunities for other plants (dos Santos *et al*., 2022). This explanation is further supported when looking at the size of the trees. In the middle of the car park, the map shows three parking spaces with a very high abundance of *Plantago coronopus* alongside the road. The trees present beside these plots looked smaller and planted more recent than the other trees on the car park which created far less shade, which could mean less evaporation than around the other trees. Another explanation could be the trees being a physical barrier for cars, limiting the amount of disturbance and effecting the physical factors in the soil, allowing different species to grow.

The micro-scale showed more patterns than the macro-scale, in total two different patterns will be discussed in this paragraph. The first pattern is the difference in Shannon Diversity between the positions on the car park. When the position on the car park (Inner/Edge) is considered the plots do differ significantly. At the edge plots the Shannon diversity increases significantly when moving further up a parking space, while a negative trend is visible on the inner plots. This indicates that the hedges around the car park play a very interesting role in causing diversity patterns on the car park. It is not clear whether the hedge itself caused this difference, by providing possible shade, seed dispersal by animal visitors or their root system or if the hedge is just a physical protection against trampling. The second pattern shows a decrease in the amount of low growing plants, and an increase in high growing plants from Front to Back on the parking space. At the Inner plots, the opposite trends were visible (not significant). This could be explained by the effect of the hedge and the free parking spaces. Cars will drive frequently over the Inner plots, while the edges are more or less protected against trampling because of the hedge. Also, the presence of trees and green areas proved to positively impact the plant cover. According to other research, plants appeared in better condition adjacent to the hedge or the trees (Bonthoux *et al*., 2019). Research also stated the importance of adjacent vegetation to the colonization of pavement (Melander *et al*., 2009).
It is clear that characteristics of the car park cause patterns on both macro- and micro-scale in the species composition and their distribution. While the effects of one of these characteristics, the green structures on the car park, was not investigated, the influence of another green structure, neighbouring verges, was tested.

This research investigated the importance of the adjacent grasslands to the vegetation of the open grid pavement, no convincing link was found. The chosen adjacent grasslands might still have been too far away from the pavement to have the impact the research by Melander suggested (Melander et al., 2009). There appeared to be similarities, but also a great list of unique species to the pavement was identified. But also the grasslands had multiple unique species, which suggests both types have some characteristics, like surface size and the level of disturbance, preventing species from occurring in the area (Čepelová & Münzbergová, 2012). The fitted vegetation classes were mostly similar between the pavement and the references, the similarity index was low for the pavement-reference pairs. This could be explained by the absence of criteria to both the pavement locations and the reference locations. Possible criteria for the references which could have benefitted the results are for example: setting a distance range for the chosen reference to the pavement, selecting a size range for the reference, allowing no references alongside water. Criteria for the pavement locations that could have made the results more generalized could for example be: only allow one type of tile, all locations being a similar size, only use locations with the same usage type. However, despite the absence of clear criteria, the results are still worth considering. The results show how diverse the pavement can be in contrast to the reference locations. The list of unique species of the pavement is triple the list of the references. It could be argued that the measured references are therefore less valuable than the pavement and pavement should therefore be implemented more than, for example, high growing road verges. However, while a high species richness is considered valuable for biodiversity, the characteristics of the road verges support biodiversity in another way. It can provide shelter for animals such as insects. So while both habitats have their own contribution to the local biodiversity, the great amount of plant diversity of the pavement is thus not the result of the surrounding grasslands as they appear not similar.

Overall, the results of this research show that open grid pavement contributes to local biodiversity in the urban environment. The pavement shows a lot of potentials for biodiversity because of the great diversity of plant species found, and is therefore more beneficial than other pavement types. It is interesting for future research to investigate other types of biodiversity on the open grid pavement. For example, do insects make use of the plant diversity in the open grid pavement and it more attractive than other structures? Research on the other variables (soil type, surface area, tile type, etc.) will also contribute to the ability to manipulate the species composition of open-grid pavement. Using this the insights of this research and the suggested additional research, municipalities could be convinced to construct open grid pavement as a way to combat the existing and increasing issues in cities related to climate change.

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Appendix 1

Table 9 List of visited locations and the link to their exact location.

LOCATION	ADRESS
UVS	https://goo.gl/maps/jtontaj2Pk2ShW6d8
VAN STEENIS BUILDING	https://goo.gl/maps/dRgGkpQ1kwSuEMBM7
HOOGHEEMRAADSCHAP RIJNLAND	https://goo.gl/maps/kgXC6ewXUVmhczybA
LANGEGRACHT 1	https://goo.gl/maps/YobEFf1YWd5yygwM6
LANGEGRACHT 2	https://goo.gl/maps/yLc2nkVoZwkuQC6R7
LANGEGRACHT 3	https://goo.gl/maps/wNQ2wiDEaoUcLvG39
NOORDERPARK	https://goo.gl/maps/LT4RUXgPmKYoBgb79
MATILOPARK	https://goo.gl/maps/6YTPwthEMz7F6PFX9

Appendix 2

Field protocol

Materials

- Excel sheet for data (“Data Fieldwork”)
- Measuring tape
- Sticks of 1m and 0,5m
- Heukels flora
- Loupe
- Portable herbarium
- Camera/Phone
- GPS/Phone
- Soil sample
- Map of car park
- Pen/Pencil
- 100 cm^2 with sticks

Car park UVS

1. Choose a random parking space on the parking lot to sample.
2. Set three plots of $1m^2$ with the sticks (make sure the plots are homogeneous) and number them. (Example: 1.A, 1.B, 1.C) See figure 1.
    a. The first plot (A/C) is set by either being 75 cm from the hedge (C.) or being 75 cm from the road (A).
    b. Between the plots needs to be a space of 1 meter.
3. Note the coordinates of each plot using a gps.
4. Perform the vegetation analysis on each plot:
    a. Note every species present.
        i. Unsure identifications of species will require a collected specimen in the portable herbarium.
    b. Estimate the abundance of each species using the Braun-Blanquet scale.
    c. Estimate the abundance of each species using a percentage.
    d. Measure the minimal and maximal height of each species.
    e. Note the general vitality per species.
    f. Note the general phenological stage per species.
5. Make a picture of each plot. (mark them!)
6. Step 1-5 will be repeated 36 times.
7. Observe the occupancy of the car park during the time of fieldwork. Draw the cars in the map.

Reference area

1. Set 4 plots of $1m^2$ in a road verge next to the measured car park.
2. Note the coordinates of each plots using a gps.
3. Perform the vegetation analysis on each plot:
    a. Note every species present.
    b. Estimate the abundance of each species using the Braun-Blanquet scale.
    c. Measure the minimal and maximal height of each species.
    d. Note the general vitality per species.
    e. Note the general phenological stage per species.
4. Make a picture of each plot. (mark them!)

Appendix 3

Species list UVS and their presence in the plots

SPECIES (SCIENTIFIC)	SPECIES (ENGLISH)	SPECIES (DUTCH)	#	PERCENTAGE
Plantago coronopus	Buck's-horn plantain	Hertshoornweegbree	115	83%
Poa annua	Evening primrose	Straatgras	103	75%
Taraxacum officinale	Round-fruited Rush	Paardenbloem	91	66%
Lolium perenne	Perennial ryegrass	Engels raaigras	84	61%
Plantago lanceolata	Ribwort Plantain	Smalle weegbree	73	53%
Trifolium dubium	Lesser trefoil	Kleine klaver	71	51%
Plantago major	Greater Plantain	Grote weegbree	68	49%
Trifolium repens	White Clover	Witte klaver	59	43%
Bellis perennis	Daisy	Madeliefje	56	41%
Vulpia myuros	Rat's-tail Fescue	Langbaardgras	45	33%
Geranium molle	Dove's-foot Crane's-bill	Zachte ooievaarsbek	45	33%
Juncus compressus	Common stork's-bill	Platte rus	38	28%
Medicago lupulina	Black medick	Hopklaver	28	20%
Veronica arvensis	Wall Speedwell	Veldereprijs	28	20%
Hypochaeris radicata	Common Cat's-ear	Gewoon biggenkruid	26	19%
Matricaria discoidea	Pineapple Weed	Schijfkamille	26	19%
Scorzoneroides autumnalis	Autumnal Hawkbit	Vertakte leeuwentand	24	17%
Holcus lanatus	Procumbent Yellow-sorrel	Gestreepte witbol	22	16%
Cerastium glomeratum	Sticky Mouse-ear	Kluwenhoornbloem	20	14%
Achillea millefolium	Yarrow	Duizendblad	15	11%
Sagina procumbens	Procumbent Pearlwort	Liggende vetmuur	14	10%
Bromus hordeaceus	Soft-brome	Zachte dravik	12	9%
Jacobaea vulgaris	Tansy ragwort	Jacobskruiskruid	8	6%
Carex hirta	Hairy Sedge	Ruige zegge	8	6%
Trifolium pratense	Red Clover	Rode klaver	7	5%
Juncus bufonius	Toad Rush	Greppelrus	6	4%
Geranium pussillum	Small-flowered Cranesbill	Kleine ooievaarsbek	6	4%
Ranunculus repens	Creeping Buttercup	Kruipende boterbloem	5	4%
Tripleurospermum maritimum	Scentless Mayweed	Reukeloze kamille	5	4%
Polygonum aviculare	Knotgrass	Gewoon varkensgras	4	3%
Equisetum arvense	Field horsetail	Heermoes	4	3%
Capsella bursa-pastoris	Shepherd's purse	Herderstasje	4	3%
Poa pratensis	Smooth Meadow-grass	Veldbeemdgras	4	3%
Stellaria media	Common Chickweed	Vogelmuur	4	3%
Erodium cicutarium	Dandelion	Gewone reigersbek	3	2%
Rorippa palustris	Marsh Yellow-cress	Moeraskers	3	2%
Convolvulus arvensis	Field bindweed	Akkerwinde	1	1%
Erigeron canadensis	Canadian horseweed	Canadese fijnstraal	2	1%
Erodium cicutarium subsp. dunense	Dune storksbill	Duinreigersbek	1	1%
Oxalis corniculate	Yorkshire-fog	Gehoorde klaverzuring	2	1%
Prunella vulgaris	Selfheal	Gewone brunel	2	1%
Arenaria serpyllifolia	Thyme-leaved sandwort	Gewone zandmuur	2	1%

Urtica dioica	Stinging Nettle	Grote brandnetel	1	1%
Pulicaria dysenterica	Common fleabane	Heelblaadjes	1	1%
Anisantha sterillis	Barren brome	Ijle dravik	1	1%
Crepis capillaris	Smooth Hawksbeard	Klein streepzaad	1	1%
Leontodon saxatilis	Lesser Hawkbit	Kleine leeuwentand	1	1%
Lepidium didynum	Lesser Swine-cress	Kleine varkenskers	1	1%
Hordeum murinum	Wall Barley	Kruipertje	2	1%
Geranium robertianum	Herb-Robert	Robertskruid	1	1%
Anagallis arvensis	Scarlet Pimpernel	Rood guichelheil	1	1%
Rumex acetosella	Sheep's Sorrel	Schapenzuring	1	1%
Potentilla indica	Indian Strawberry	Schijnaardbei	2	1%
Cirsium vulgare	Upright Yellow-sorrel	Speerdistel	1	1%
Oxalis stricta	Annual Meadow-grass	Stijve klaverzuring	1	1%
Oenothera sp.	Knotgrass	Teunisbloem onbekend	1	1%
Potentilla reptans	Creeping Cinquefoil	Vijfvingerkruid	2	1%
Epilobium parviflorum	Hoary Willowherb	Viltige basterdwederik	2	1%
Potentilla arserina	Silverweed	Zilverschoon	1	1%
Juncus articulatus	Jointed Rush	Zomprus	2	1%

Appendix 4

Presence of species at the 8 locations

(*=Neophyte/Exotic species ; **= Feral/adventitious species ; ***=From nearby planters ; ****= Possibly from seed mixture ; *****=Archeophyte)

SPECIES	#	SPECIES	#	SPECIES	#
Medicago lupulina	8	Juncus compressus	2	Glechoma hederacea	1
Plantago lanceolata	8	Lotus corniculatus	2	Gnaphalium luteo-album	1
Taraxacum officinale	8	Matricaria chamomilla	2	Hieracium aurantiacum *	1
Hypochaeris radicata	7	Melilotus albus	2	Juncus articulatus	1
Lolium perenne	7	Myosotis arvensis	2	Juncus bufonius	1
Poa annua	7	Oxalis corniculate *	2	Lamium purpureum	1
Achillea millefolium	6	Poa pratensis	2	Lepidium didynum	1
Festuca sp.	6	Potentilla indica	2	Leucanthemum vulgare	1
Jacobaea vulgaris	6	Prunella vulgaris	2	Lobularia maritima *	1
Leontodon saxatilis	6	Rumex acetosella	2	Lysimachia sp.	1
Plantago coronopus	6	Rumex obtusifolius	2	Malva moschata ****	1
Plantago major	6	Salvia officinalis	2	Mauranthemum paludosum *	1
Bellis perennis	5	Sedum acre	2	**Origanum sp.** **	1
Crepis capillaris	5	Senecio inaequidens	2	Oxalis stricta *	1
Equisetum arvense	5	Sonchus asper	2	Papaver rhoeas *****	1
Holcus lanatus	5	Stellaria media	2	Persicaria maculosa	1
Scorzoneroides autumnalis	5	Tripleurospermum maritimum	2	Phleum pratense	1
Trifolium dubium	5	Anisantha sterillis	1	Poa trivialis	1
Erigeron canadensis *	4	Anthoxanthum odoratum	1	Polycarpon tetraphyllum	1
Geranium molle	4	Artemisia vulgaris	1	Potentilla reptans	1
Matricaria discoidea *	4	Centaurea jacea ****	1	Pulicaria dysenterica	1
Polygonum aviculare	4	Cerastium fontanum	1	Ranunculus acris	1
Sagina procumbens	4	Cirsium arvense	1	Rorippa palustris	1
Trifolium repens	4	Cirsium vulgare	1	Silene armeria	1
Vulpia myuros	4	Convolvulus arvensis	1	Silene conica	1
Agrostis capullaris	3	Cortaderia selloana ***	1	Silene vulgaris	1
Bromus hordeaceus	3	Dactylis glomerata	1	Sisymbrium officinale	1
Capsella bursa-pastoris	3	Digitaria sanguinalis *	1	Sisymbrium orientale	1
Cerastium glomeratum	3	Draba verna	1	Trifolium arvense	1
Daucus carota	3	Dysphania ambrosioides *	1	Urtica dioica	1
Oenothera sp. *	3	Echinacea purpurea ***	1	Verbena bonariensis	1
Potentilla anserina	3	Elymus repens	1	Vicia sp.	1
Ranunculus repens	3	Epilobium parviflorum	1	Viola tricolor	1
Senecio vulgaris	3	Erodium cicutarium	1	Anagallis arvensis	1
Sonchus oleraceus	3	Erodium cicutarium subsp. dunense	1		
Trifolium pratense	3	Eschscholzia californica *	1		
Veronica arvense	3	Festuca filiformis	1		
Arrhenatherum elatius	2	Festuca rubra	1		
Carex hirta	2	Filago germanica	1		
Geranium pusillum	2	Galinsoga quadriradiata *	1		

Geranium robertianum	2	*Geranium dissectum*	1	
Hordeum murinum	2			

Appendix 5

Table 10 The species which only occurred in 1-3 plots at the UVS carpark. (n=138 plots)

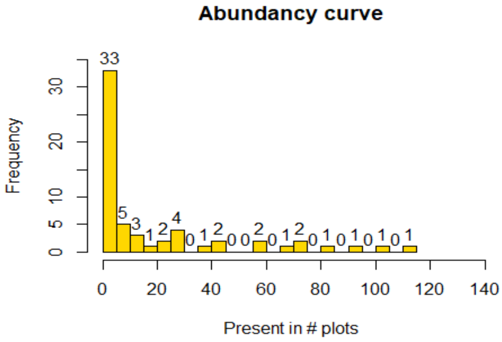
SPECIES	SPECIES (DUTCH)	IN # PLOTS PRESENT
Anagallis arvensis	Rood guichelheil	1
Anisantha sterillis	IJle dravik	1
Cirsium vulgare	Speerdistel	1
Convolvulus arvensis	Akkerwinde	1
Crepis capillaris	Klein streepzaad	1
Erodium cicutarium subsp. *dunense*	Duinreigersbek	1
Geranium robertianum	Robertskruid	1
Leontodon saxatilis	Kleine leeuwentand	1
Lepidium didynum	Kleine varkenskers	1
Oenothera sp.	Teunisbloem onbekend	1
Oxalis stricta	Stijve klaverzuring	1
Potentilla arserina	Zilverschoon	1
Pulicaria dysenterica	Heelblaadjes	1
Rumex acetosella	Schapenzuring	1
Urtica dioica	Grote brandnetel	1
Arenaria serpyllifolia	Gewone zandmuur	2
Epilobium parviflorum	Viltige basterdwederik	2
Erigeron canadensis	Canadese fijnstraal	2
Hordeum murinum	Kruipertje	2
Juncus articulatus	Zomprus	2
Oxalis corniculate	Gehoorde klaverzuring	2
Potentilla indica	Schijnaardbei	2
Potentilla reptans	Vijfvingerkruid	2
Prunella vulgaris	Gewone brunel	2
Erodium cicutarium	Gewone reigersbek	3
Rorippa palustris	Moeraskers	3

Appendix 6

All statistics

#Subquestion 1: Which plant species occur on open-grid pavement? #Abundancy curve

```
library(readxl)
FrequencyTable <- read_xlsx("/Users/birgi/OneDrive/Documenten/Msc Stage 2/Statistiek uitwerking/FrequencyTable.xlsx")

h<- hist(FrequencyTable$Frequency,
     breaks=35,
     main="Abundancy curve",
     xlab="Present in # plots",
     xlim=c(0,138),
     ylim=c(0,35),
     col="gold")
text(h$mids, h$counts, labels=h$counts, adj=c(0.5,-0.5))
```



#Subquestion 2: Does the distance from the place of interest influence the diversity? #Loading in data

```
library(readxl)
PlotsAll <- read_xlsx("/Users/birgi/OneDrive/Documenten/Msc Stage 2/Statistiek uitwerking/PlotsAll.xlsx")

library(readxl)
AllData <- read_xlsx("/Users/birgi/OneDrive/Documenten/Msc Stage 2/Statistiek uitwerking/AllData.xlsx")
```

#Data diagnostics

```
str(PlotsAll)
#Position not recognized as factor

PlotsAll$Position <- factor(PlotsAll$Position)
PlotsAll$Plot <- factor(PlotsAll$Plot)
str(PlotsAll)
```

#Data summary

```
summary(PlotsAll)

##       Area         Position   Plot    Species_richness    Coverage
##  Min.   : 1.00   Edge :69   A:46   Min.   : 0.000   Min.   :17.00
##  1st Qu.:13.00   Inner:69   B:46   1st Qu.: 6.000   1st Qu.:27.69
##  Median :24.50              C:46   Median : 8.000   Median :33.75
##  Mean   :24.48                     Mean   : 8.203   Mean   :35.05
##  3rd Qu.:36.00                     3rd Qu.:10.000   3rd Qu.:41.00
##  Max.   :48.00                     Max.   :19.000   Max.   :75.50
##  Shannon_diversity Distance_entrance
##  Min.   :0.3912    Min.   : 23.0
##  1st Qu.:1.3390    1st Qu.: 65.0
##  Median :1.6320    Median :145.5
##  Mean   :1.5905    Mean   :152.3
##  3rd Qu.:1.8708    3rd Qu.:232.0
##  Max.   :2.5704    Max.   :282.0
```

#Testing the response variable ##Species richness

```
shapiro.test(PlotsAll$Species_richness)
#p-value=3.864e-06 >> not normally distributed
```

##Shannon diversity

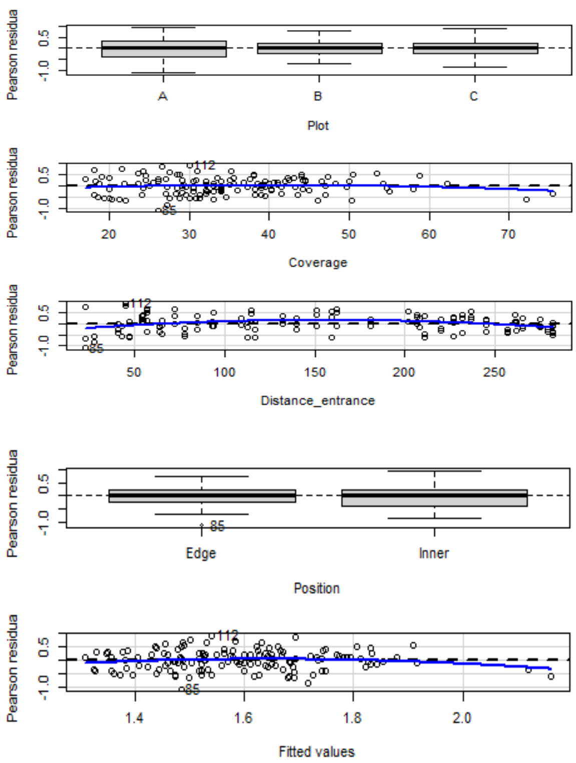
```
shapiro.test(PlotsAll$Shannon_diversity)
#p-value=0.3972 >> normally distributed
```

#1 Analysis Shannon diversity #Model specification

```
Model_SD_All<- lm(Shannon_diversity~Plot+Coverage+Distance_entrance+Position, data=PlotsAll)
```

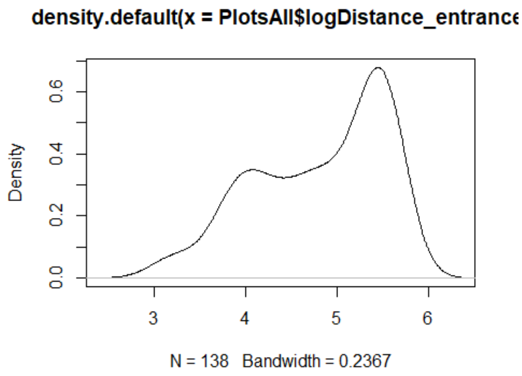
#Model diagnostics

```
residualPlots(Model_SD_All, layout = c(3,1), id = TRUE)
```

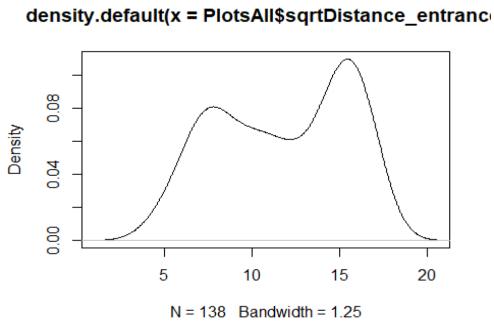



```
##                     Test stat Pr(>|Test stat|)
## Plot
## Coverage              -1.1652        0.2460562
## Distance_entrance     -3.7077        0.0003076 ***
## Position
## Tukey test            -1.6780        0.0933374 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

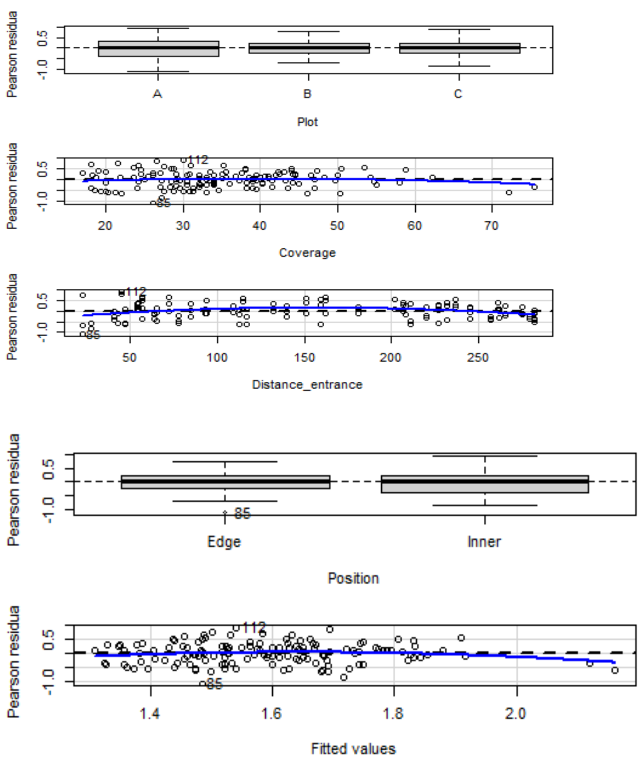
```
#Distance entrance shows curvature >> (transformations made it worse, p<<<0,05)

PlotsAll$logDistance_entrance <- log(PlotsAll$Distance_entrance)
PlotsAll$sqrtDistance_entrance <-sqrt(PlotsAll$Distance_entrance)

plot(density(PlotsAll$logDistance_entrance))
```




```
plot(density(PlotsAll$sqrtDistance_entrance))
```




```
residualPlots(Model_SD_All, layout = c(3,1), id = TRUE)
```




```
##                   Test stat Pr(>|Test stat|)
## Plot
## Coverage            -1.1652        0.2460562
## Distance_entrance   -3.7077        0.0003076 ***
## Position
```

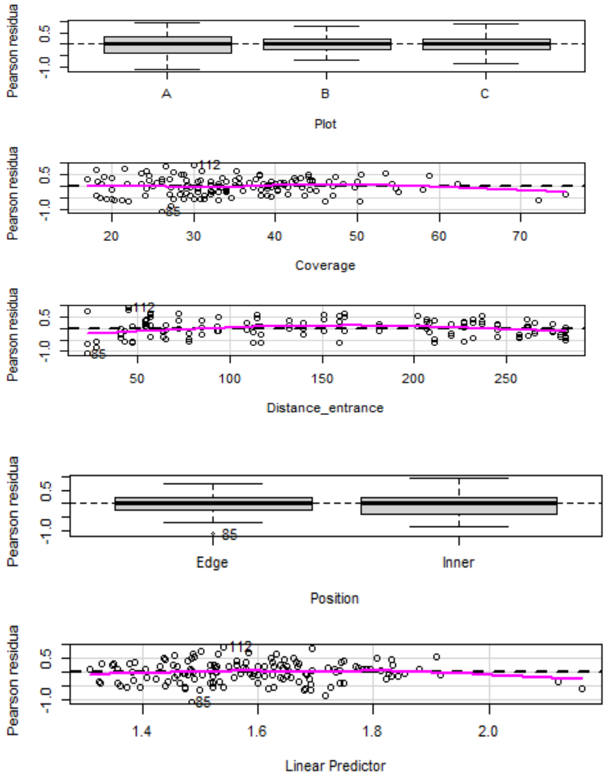
```
## Tukey test           -1.6780        0.0933374 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

#Distance entrance shows curvature >> (transformations made it worse)
```

#>> GLM

```
formula=PlotsAll$Shannon_diversity~PlotsAll$Plot+PlotsAll$Coverage+PlotsAll$Distance_entrance+PlotsAll
$Position

GLM_SD_All<-glm(Shannon_diversity~Plot+Coverage+Distance_entrance+Position, family = gaussian(link = "
identity"), data=PlotsAll)

summary(GLM_SD_All)

##
## Call:
## glm(formula = Shannon_diversity ~ Plot + Coverage + Distance_entrance +
##     Position, family = gaussian(link = "identity"), data = PlotsAll)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.0926  -0.2576   0.0290   0.2441   0.9335
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)        1.1890879  0.1337198   8.892 3.93e-15 ***
## PlotB              0.0630981  0.0818487   0.771 0.442137
## PlotC              0.1950399  0.0821051   2.375 0.018964 *
## Coverage           0.0120263  0.0033111   3.632 0.000401 ***
## Distance_entrance -0.0007824  0.0004090  -1.913 0.057939 .
## PositionInner      0.0260214  0.0676745   0.385 0.701221
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.1531645)
##
##     Null deviance: 23.588  on 137  degrees of freedom
## Residual deviance: 20.218  on 132  degrees of freedom
## AIC: 140.57
##
## Number of Fisher Scoring iterations: 2
```

#Model diagnostics

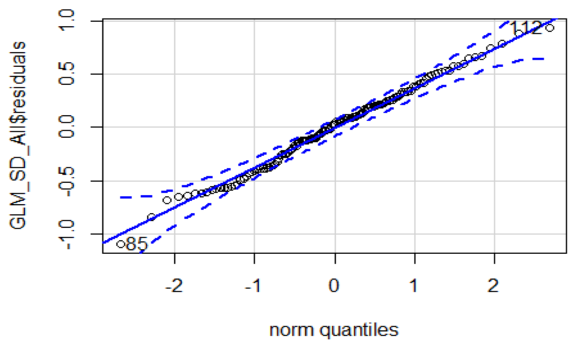
```
residualPlots(GLM_SD_All, layout = c(3,1), id = TRUE)
```



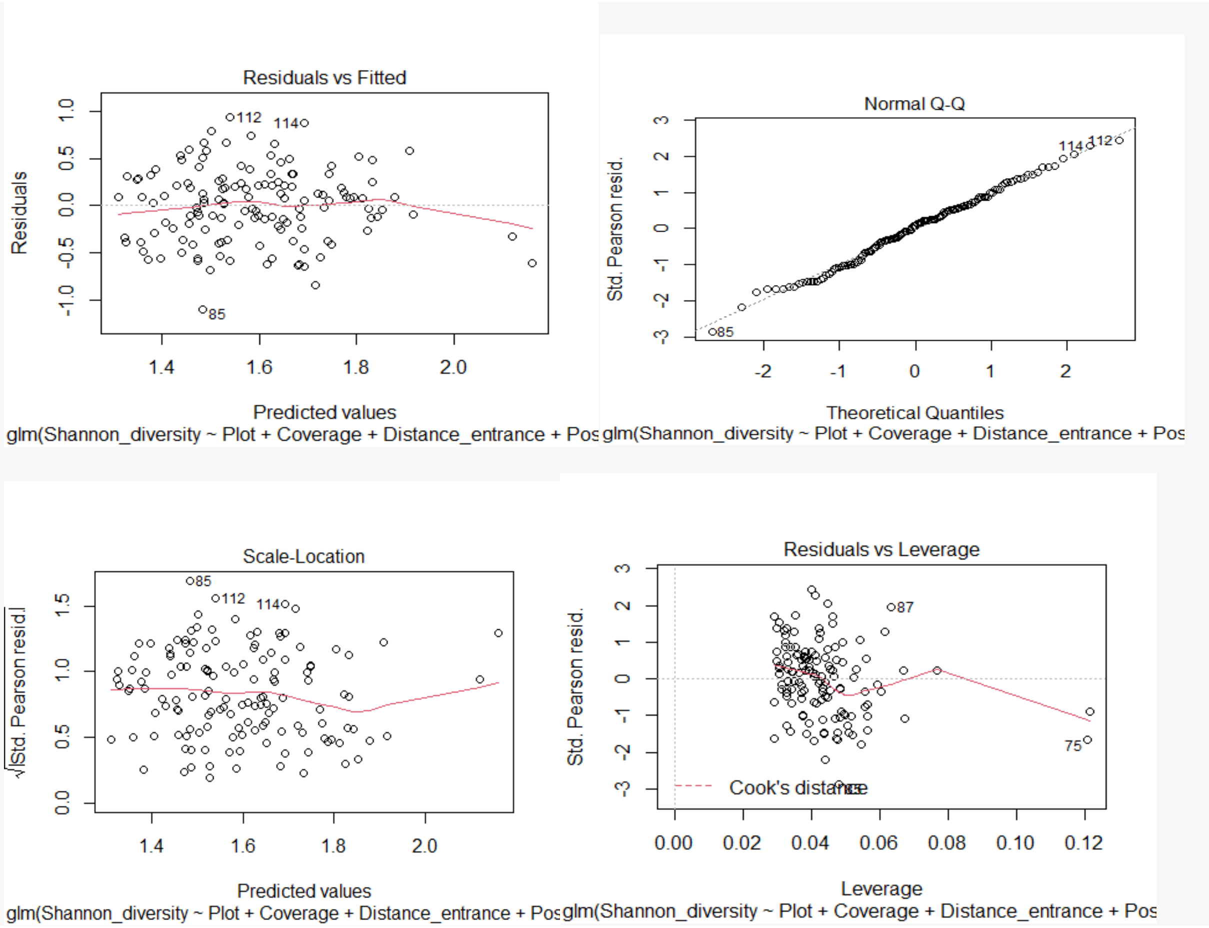

```
##                    Test stat Pr(>|Test stat|)
## Plot
## Coverage              0.2074           0.6488
## Distance_entrance     1.9202           0.1658
## Position
```

#Normal distributed residuals

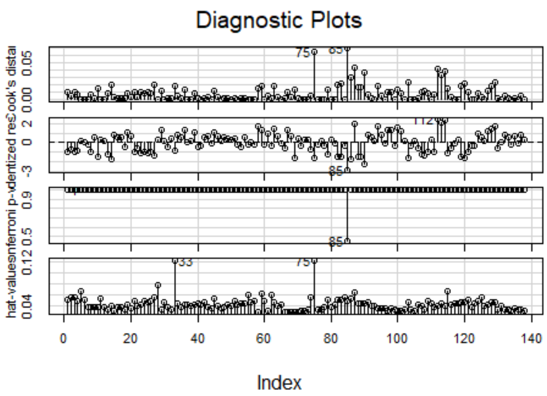
```
qqPlot(GLM_SD_All$residuals, id = TRUE)
```




```
## [1]  85 112

#All values between boundaries

plot(GLM_SD_All)
```




```
#No values beyond Cook's distance

shapiro.test(GLM_SD_All$residuals)

##
##  Shapiro-Wilk normality test
##
## data:  GLM_SD_All$residuals
## W = 0.99314, p-value = 0.7482

#residuals normally distributed (p=0.7482)

influenceIndexPlot(GLM_SD_All)
```

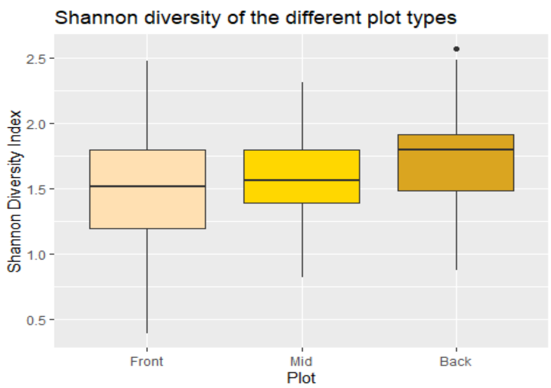


```r
outlierTest(GLM_SD_All)

## No Studentized residuals with Bonferroni p < 0.05
## Largest |rstudent|:
##     rstudent unadjusted p-value Bonferroni p
## 85 -2.943351          0.0032468      0.44806

#No outliers

which(hatvalues(GLM_SD_All)> mean(hatvalues(GLM_SD_All))*2.5)

## 33 75
## 33 75

#Point 33 and 75 are influencial points

summary(GLM_SD_All)

##
## Call:
## glm(formula = Shannon_diversity ~ Plot + Coverage + Distance_entrance +
##     Position, family = gaussian(link = "identity"), data = PlotsAll)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.0926  -0.2576   0.0290   0.2441   0.9335
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)        1.1890879  0.1337198   8.892 3.93e-15 ***
## PlotB              0.0630981  0.0818487   0.771 0.442137
## PlotC              0.1950399  0.0821051   2.375 0.018964 *
## Coverage           0.0120263  0.0033111   3.632 0.000401 ***
## Distance_entrance -0.0007824  0.0004090  -1.913 0.057939 .
## PositionInner      0.0260214  0.0676745   0.385 0.701221
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.1531645)
##
##     Null deviance: 23.588  on 137  degrees of freedom
## Residual deviance: 20.218  on 132  degrees of freedom
## AIC: 140.57
##
## Number of Fisher Scoring iterations: 2

#Underdispersion? 20- 132
#Take out Position

GLM_SD_All2 <- glm(Shannon_diversity~Plot+Coverage+Distance_entrance, family = gaussian(link = "identi
ty"), data=PlotsAll)
summary(GLM_SD_All2)

##
## Call:
## glm(formula = Shannon_diversity ~ Plot + Coverage + Distance_entrance,
##     family = gaussian(link = "identity"), data = PlotsAll)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -1.10697  -0.26693   0.02657   0.25330   0.94604
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)        1.2090523  0.1228324   9.843  < 2e-16 ***
## PlotB              0.0635137  0.0815790   0.779 0.437625
## PlotC              0.1956354  0.0818270   2.391 0.018211 *
## Coverage           0.0118085  0.0032518   3.631 0.000401 ***
## Distance_entrance -0.0007801  0.0004077  -1.914 0.057819 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.1521831)
```

```
##
##     Null deviance: 23.588  on 137  degrees of freedom
## Residual deviance: 20.240  on 133  degrees of freedom
## AIC: 138.73
##
## Number of Fisher Scoring iterations: 2

#Can not take out Distance_entrance, because it is almost significant
```

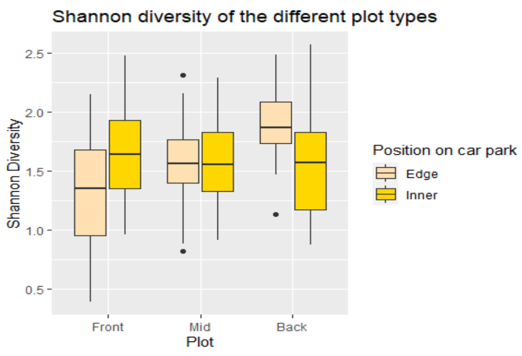
#PLOT TYPE

```
summary(aov(PlotsAll$Shannon_diversity~PlotsAll$Plot))

##                  Df Sum Sq Mean Sq F value Pr(>F)
## PlotsAll$Plot     2  1.219  0.6093   3.677 0.0279 *
## Residuals       135 22.369  0.1657
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

TukeyHSD(aov(PlotsAll$Shannon_diversity~PlotsAll$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = PlotsAll$Shannon_diversity ~ PlotsAll$Plot)
##
## $`PlotsAll$Plot`
##           diff         lwr       upr     p adj
## B-A 0.08603707 -0.11510932 0.2871835 0.5695427
## C-A 0.22791364  0.02676725 0.4290600 0.0220890
## C-B 0.14187657 -0.05926982 0.3430230 0.2198908

# grouped boxplot
ggplot(PlotsAll, aes(x=Plot, y=Shannon_diversity)) +
  labs(title="Shannon diversity of the different plot types",y="Shannon Diversity Index")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```

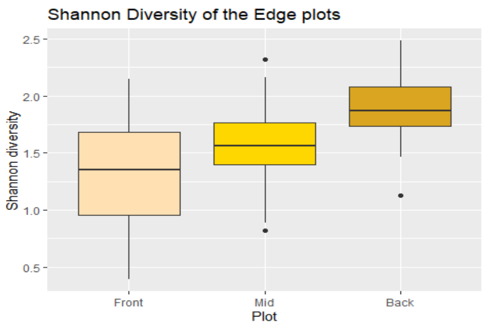


Finding differences between the edge and inner data seperately

```
# grouped boxplot
ggplot(PlotsAll, aes(x=Plot, y=Shannon_diversity, fill=Position)) +
  labs(title="Shannon diversity of the different plot types",y="Shannon Diversity", fill="Position on
car park")+
    geom_boxplot()+
  scale_fill_manual(values=c("#FFE0B2", "gold"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```

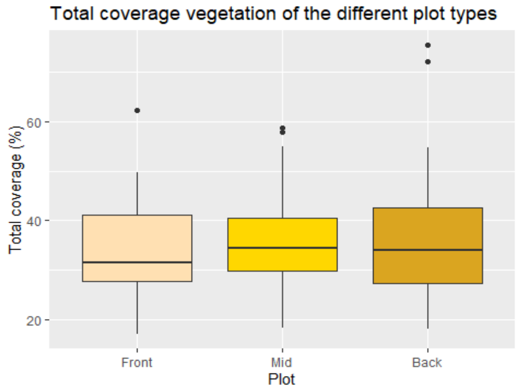



```
library(readxl)
EdgeData <- read_xlsx("/Users/birgi/OneDrive/Documenten/Msc Stage 2/Statistiek uitwerking/EdgeData.xls
x")

summary(aov(EdgeData$`Shannon diversity`~EdgeData$Plot))

##                Df Sum Sq Mean Sq F value   Pr(>F)
## EdgeData$Plot   2  3.433   1.716   11.22 6.39e-05 ***
## Residuals      66 10.096   0.153
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

TukeyHSD(aov(EdgeData$`Shannon diversity`~EdgeData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = EdgeData$`Shannon diversity` ~ EdgeData$Plot)
##
## $`EdgeData$Plot`
##          diff         lwr       upr     p adj
## B-A 0.2128837 -0.06365553 0.4894229 0.1628571
## C-A 0.5422058  0.26566654 0.8187450 0.0000402
## C-B 0.3293221  0.05278284 0.6058613 0.0156360

ggplot(EdgeData, aes(x=Plot, y=`Shannon diversity`)) +
  labs(title="Shannon Diversity of the Edge plots",y="Shannon diversity")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```

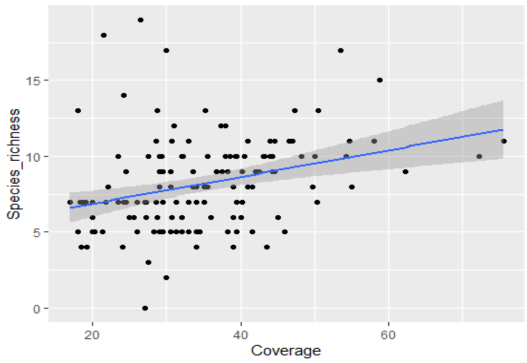


#COVERAGE

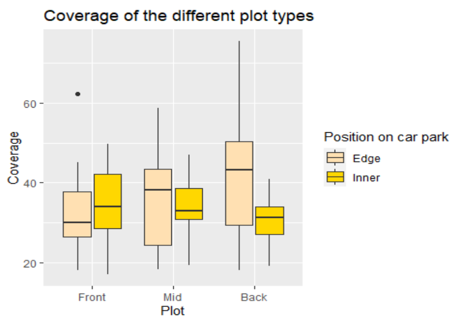
```
# grouped boxplot
ggplot(PlotsAll, aes(x=Plot, y=Coverage)) +
  labs(title="Total coverage vegetation of the different plot types",y="Total coverage (%)")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```




```
ggplot(data = PlotsAll, mapping= aes(Coverage, Species_richness))+
  geom_point()+
  geom_smooth(method=lm)

## `geom_smooth()` using formula 'y ~ x'
```




```
# grouped boxplot
ggplot(PlotsAll, aes(x=Plot, y=Coverage, fill=Position)) +
  labs(title="Coverage of the different plot types",y="Coverage", fill="Position on car park")+
    geom_boxplot()+
  scale_fill_manual(values=c("#FFE0B2", "gold"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```



#Testing differences between plot type in Coverage

```
summary(aov(PlotsAll$Coverage~PlotsAll$Plot))

##                  Df Sum Sq Mean Sq F value Pr(>F)
## PlotsAll$Plot     2    181   90.41   0.776  0.462
## Residuals       135  15727  116.50

TukeyHSD(aov(PlotsAll$Coverage~PlotsAll$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
```

```
## Fit: aov(formula = PlotsAll$Coverage ~ PlotsAll$Plot)
##
## $`PlotsAll$Plot`
##         diff       lwr      upr     p adj
## B-A 1.907391 -3.426179 7.240962 0.6741889
## C-A 2.733478 -2.600092 8.067049 0.4466564
## C-B 0.826087 -4.507484 6.159658 0.9284703
```

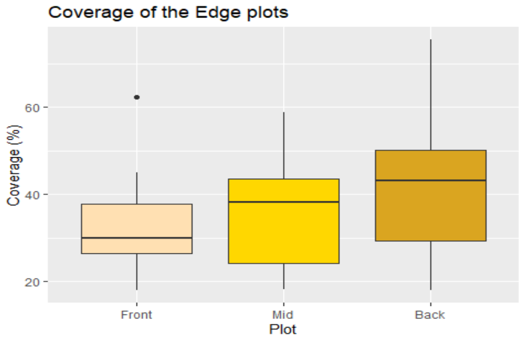
#Check for difference Inner/Edge per plot type

```
library(readxl)
PlotsC <- read_xlsx("/Users/birgi/OneDrive/Documenten/Msc Stage 2/Statistiek uitwerking/PlotsC.xlsx")
PlotsB <- read_xlsx("/Users/birgi/OneDrive/Documenten/Msc Stage 2/Statistiek uitwerking/PlotsB.xlsx")

summary(aov(PlotsC$Coverage~PlotsC$Position))

##                 Df Sum Sq Mean Sq F value  Pr(>F)
## PlotsC$Position  1   1530  1529.5   11.97 0.00121 **
## Residuals       44   5623   127.8
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

TukeyHSD(aov(PlotsC$Coverage~PlotsC$Position))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = PlotsC$Coverage ~ PlotsC$Position)
##
## $`PlotsC$Position`
##                 diff       lwr       upr     p adj
## Inner-Edge -11.53261 -18.25099 -4.814229 0.0012139

summary(aov(PlotsB$Coverage~PlotsB$Position))

##                 Df Sum Sq Mean Sq F value Pr(>F)
## PlotsB$Position  1     65   65.16   0.667  0.418
## Residuals       44   4296   97.64

TukeyHSD(aov(PlotsB$Coverage~PlotsB$Position))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = PlotsB$Coverage ~ PlotsB$Position)
##
## $`PlotsB$Position`
##                 diff       lwr      upr     p adj
## Inner-Edge -2.380435 -8.252778 3.491908 0.4183547
```

#Coverage in edge plots

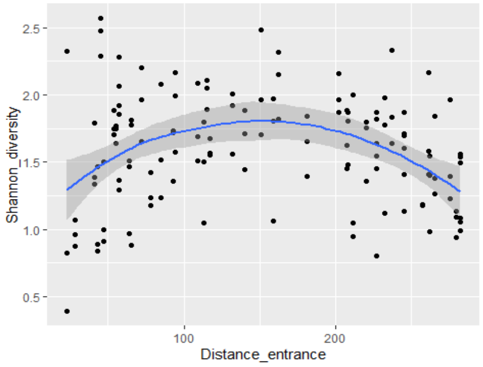
```
summary(aov(EdgeData$`Coverage (%)`~EdgeData$Plot))

##               Df Sum Sq Mean Sq F value Pr(>F)
## EdgeData$Plot  2   1124   561.8   3.537 0.0347 *
## Residuals     66  10483   158.8
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

TukeyHSD(aov(EdgeData$`Coverage (%)`~EdgeData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = EdgeData$`Coverage (%)` ~ EdgeData$Plot)
##
## $`EdgeData$Plot`
##         diff        lwr      upr     p adj
## B-A 4.467391 -4.4435583 13.37834 0.4561973
## C-A 9.869565  0.9586156 18.78051 0.0264657
## C-B 5.402174 -3.5087757 14.31312 0.3198348
```

```r
library(ggplot2)
ggplot(EdgeData, aes(x=Plot, y=`Coverage (%)`)) +
  labs(title="Coverage of the Edge plots",y="Coverage (%)")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                    labels=c("Front", "Mid", "Back"))
```

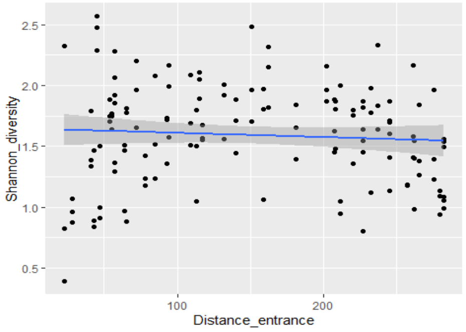


#DISTANCE FROM ENTRANCE

```r
ggplot(data = PlotsAll, mapping= aes(Distance_entrance, Shannon_diversity))+
  geom_point()+
  geom_smooth()

## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```



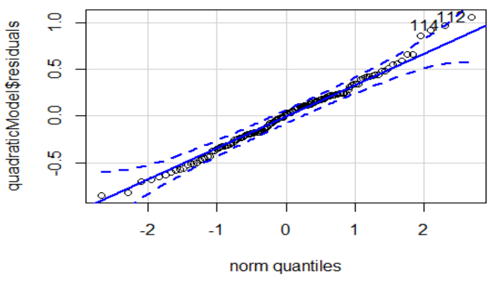

```r
ggplot(data = PlotsAll, mapping= aes(Distance_entrance, Shannon_diversity))+
  geom_point()+
  geom_smooth(method=lm)

## `geom_smooth()` using formula 'y ~ x'
```



#Quadratic model distance

```r
PlotsAll$Distance2<- PlotsAll$Distance_entrance^2

quadraticModel <- lm(Shannon_diversity~Plot+Coverage+Distance_entrance+Distance2+Position, data=PlotsA
ll)
```

```
library(car)
qqPlot(quadraticModel$residuals)
```

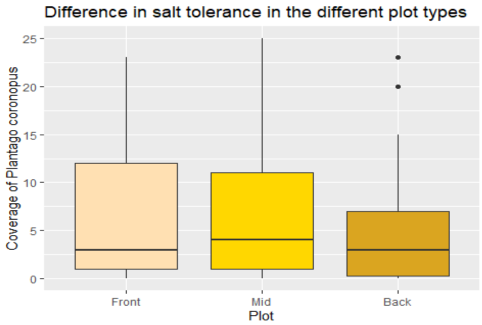



```
## [1] 112 114

summary(quadraticModel)

##
## Call:
## lm(formula = Shannon_diversity ~ Plot + Coverage + Distance_entrance +
##     Distance2 + Position, data = PlotsAll)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.85188 -0.23536  0.01933  0.21989  1.06124
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)        9.120e-01  1.480e-01   6.164 8.14e-09 ***
## PlotB              7.297e-02  7.821e-02   0.933 0.352524
## PlotC              2.092e-01  7.850e-02   2.665 0.008672 **
## Coverage           6.851e-03  3.456e-03   1.982 0.049538 *
## Distance_entrance  7.225e-03  2.195e-03   3.292 0.001278 **
## Distance2         -2.519e-05  6.793e-06  -3.708 0.000308 ***
## PositionInner      2.128e-02  6.464e-02   0.329 0.742494
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3737 on 131 degrees of freedom
## Multiple R-squared:  0.2243, Adjusted R-squared:  0.1887
## F-statistic: 6.312 on 6 and 131 DF,  p-value: 7.476e-06

quadraticModel2 <- lm(Shannon_diversity~Plot+Coverage+Position+Distance2, data=PlotsAll)
summary(quadraticModel2)

##
## Call:
## lm(formula = Shannon_diversity ~ Plot + Coverage + Position +
##     Distance2, data = PlotsAll)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.0875 -0.2721  0.0456  0.2420  0.9267
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1.171e+00  1.300e-01   9.009 2.04e-15 ***
## PlotB          6.332e-02  8.101e-02   0.782 0.435829
## PlotC          1.954e-01  8.126e-02   2.404 0.017593 *
## Coverage       1.191e-02  3.209e-03   3.711 0.000303 ***
## PositionInner  2.597e-02  6.699e-02   0.388 0.698901
## Distance2     -3.180e-06  1.253e-06  -2.538 0.012310 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3874 on 132 degrees of freedom
## Multiple R-squared:  0.1601, Adjusted R-squared:  0.1283
## F-statistic: 5.032 on 5 and 132 DF,  p-value: 0.0002975
```

```
quadraticModel3 <- lm(Shannon_diversity~Plot+Coverage+Distance_entrance+Position, data=PlotsAll)

summary(quadraticModel3)

##
## Call:
## lm(formula = Shannon_diversity ~ Plot + Coverage + Distance_entrance +
##     Position, data = PlotsAll)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.0926 -0.2576  0.0290  0.2441  0.9335
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)        1.1890879  0.1337198   8.892 3.93e-15 ***
## PlotB              0.0630981  0.0818487   0.771 0.442137
## PlotC              0.1950399  0.0821051   2.375 0.018964 *
## Coverage           0.0120263  0.0033111   3.632 0.000401 ***
## Distance_entrance -0.0007824  0.0004090  -1.913 0.057939 .
## PositionInner      0.0260214  0.0676745   0.385 0.701221
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3914 on 132 degrees of freedom
## Multiple R-squared:  0.1429, Adjusted R-squared:  0.1104
## F-statistic:   4.4 on 5 and 132 DF,  p-value: 0.0009736
```

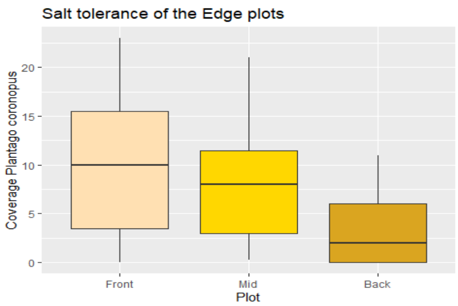
#Subquestion 3 Can a difference be found in morphological characteristics between area with different intensity usages?
##Salt tolerance

```
summary(aov(AllData$Salt~ AllData$Plot))

##               Df Sum Sq Mean Sq F value Pr(>F)
## AllData$Plot   2    103   51.69   1.277  0.282
## Residuals    135   5466   40.49

TukeyHSD(aov(AllData$Salt~ AllData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = AllData$Salt ~ AllData$Plot)
##
## $`AllData$Plot`
##           diff       lwr      upr     p adj
## B-A -0.0923913 -3.236629 3.051846 0.9973301
## C-A -1.8804348 -5.024672 1.263803 0.3348761
## C-B -1.7880435 -4.932281 1.356194 0.3714749

ggplot(AllData, aes(x=Plot, y=Salt)) +
  labs(title="Difference in salt tolerance in the different plot types",y="Coverage of Plantago corono
pus")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                    labels=c("Front", "Mid", "Back"))
```



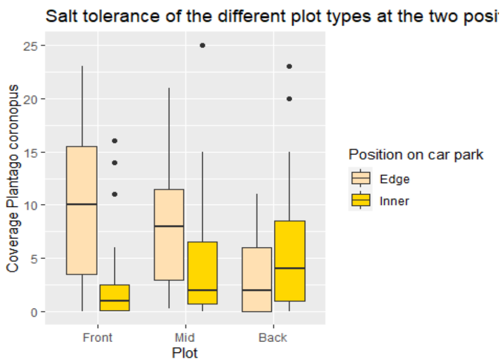
#Inner and edge data seperately

```r
EdgeData <- read_xlsx("/Users/birgi/OneDrive/Documenten/Msc Stage 2/Statistiek uitwerking/EdgeData.xls
x")
InnerData <- read_xlsx("/Users/birgi/OneDrive/Documenten/Msc Stage 2/Statistiek uitwerking/InnerData.x
lsx")

summary(aov(EdgeData$Salt~EdgeData$Plot))

##                 Df Sum Sq Mean Sq F value   Pr(>F)
## EdgeData$Plot  2  555.9   277.9    8.15 0.000687 ***
## Residuals      66 2250.8    34.1
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

TukeyHSD(aov(EdgeData$Salt~EdgeData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = EdgeData$Salt ~ EdgeData$Plot)
##
## $`EdgeData$Plot`
##          diff        lwr        upr     p adj
## B-A -1.847826  -5.976831  2.2811789 0.5340550
## C-A -6.728261 -10.857266 -2.5992559 0.0006444
## C-B -4.880435  -9.009440 -0.7514298 0.0165607

summary(aov(InnerData$Salt~InnerData$Plot))

##                  Df Sum Sq Mean Sq F value Pr(>F)
## InnerData$Plot  2  101.8   50.88   1.379  0.259
## Residuals       66 2435.6   36.90

TukeyHSD(aov(InnerData$Salt~InnerData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = InnerData$Salt ~ InnerData$Plot)
##
## $`InnerData$Plot`
##         diff       lwr      upr     p adj
## B-A 1.663043 -2.632110 5.958197 0.6244232
## C-A 2.967391 -1.327762 7.262545 0.2296467
## C-B 1.304348 -2.990806 5.599501 0.7477510

library(ggplot2)
ggplot(EdgeData, aes(x=Plot, y=Salt)) +
  labs(title="Salt tolerance of the Edge plots",y="Coverage Plantago coronopus")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                    labels=c("Front", "Mid", "Back"))
```



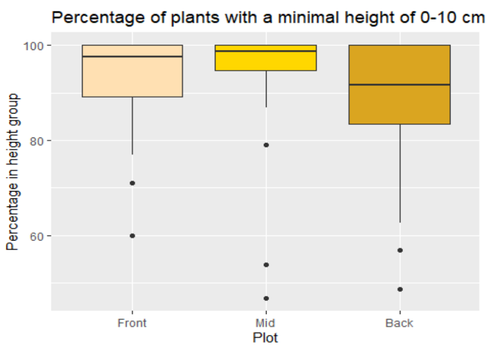

```r
# library
library(ggplot2)

# grouped boxplot
ggplot(AllData, aes(x=Plot, y=Salt, fill=Position)) +
  labs(title="Salt tolerance of the different plot types at the two positions",y="Coverage Plantago co
ronopus", fill="Position on car park")+
    geom_boxplot()+
```

```
  scale_fill_manual(values=c("#FFE0B2", "gold"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                   labels=c("Front", "Mid", "Back"))
```



##Height 0-10cm

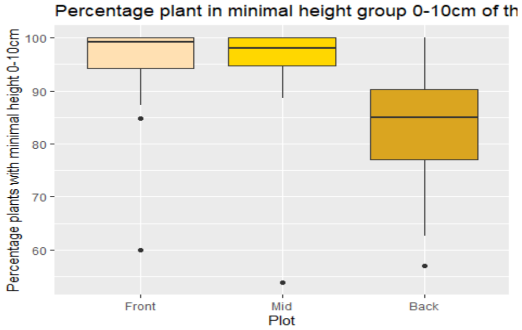
```
summary(aov(AllData$`Perc_0-0.1`~ AllData$Plot))

##                 Df Sum Sq Mean Sq F value Pr(>F)
## AllData$Plot     2    983   491.5   4.172 0.0175 *
## Residuals      135  15905   117.8
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

TukeyHSD(aov(AllData$`Perc_0-0.1`~ AllData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = AllData$`Perc_0-0.1` ~ AllData$Plot)
##
## $`AllData$Plot`
##            diff        lwr        upr     p adj
## B-A   0.8336537  -4.529913  6.1972209 0.9279855
## C-A  -5.1987721 -10.562339  0.1647951 0.0596172
## C-B  -6.0324258 -11.395993 -0.6688587 0.0233138

library(ggplot2)
ggplot(AllData, aes(x=Plot, y=`Perc_0-0.1`)) +
  labs(title="Percentage of plants with a minimal height of 0-10 cm in the different plot types",y="Pe
rcentage in height group")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                   labels=c("Front", "Mid", "Back"))
```



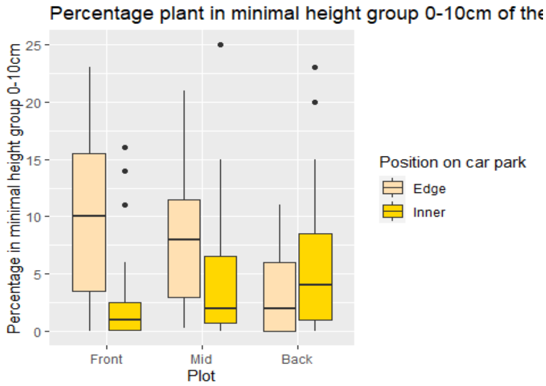
#Inner and edge data seperately

```
summary(aov(EdgeData$`Perc_0-0.1`~EdgeData$Plot))

##                 Df Sum Sq Mean Sq F value   Pr(>F)
## EdgeData$Plot  2    2256  1127.8   10.38 0.000121 ***
## Residuals      66    7172   108.7
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

TukeyHSD(aov(EdgeData$`Perc_0-0.1`~EdgeData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = EdgeData$`Perc_0-0.1` ~ EdgeData$Plot)
##
## $`EdgeData$Plot`
##             diff        lwr       upr     p adj
## B-A  -0.09024821  -7.460828  7.280331 0.9995249
## C-A -12.17334458 -19.543924 -4.802765 0.0005400
## C-B -12.08309637 -19.453676 -4.712517 0.0005957

summary(aov(InnerData$`Perc_0-0,1`~InnerData$Plot))

##                Df Sum Sq Mean Sq F value Pr(>F)
## InnerData$Plot  2     48   23.93    0.22  0.803
## Residuals      66   7195  109.01

TukeyHSD(aov(InnerData$`Perc_0-0,1`~InnerData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = InnerData$`Perc_0-0,1` ~ InnerData$Plot)
##
## $`InnerData$Plot`
##           diff       lwr      upr     p adj
## B-A 1.75755570 -5.624678 9.139789 0.8360690
## C-A 1.77580046 -5.606433 9.158034 0.8329617
## C-B 0.01824476 -7.363989 7.400478 0.9999806

library(ggplot2)
ggplot(EdgeData, aes(x=Plot, y=`Perc_0-0.1`)) +
  labs(title="Percentage plant in minimal height group 0-10cm of the Edge plots",y="Percentage plants
with minimal height 0-10cm")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```

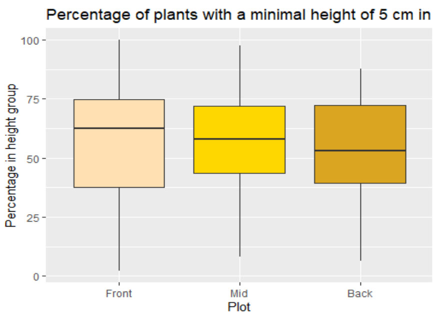



```
# library
library(ggplot2)

# grouped boxplot
ggplot(AllData, aes(x=Plot, y=Salt, fill=Position)) +
  labs(title="Percentage plant in minimal height group 0-10cm of the different plot types",y="Percenta
ge in minimal height group 0-10cm", fill="Position on car park")+
    geom_boxplot()+
  scale_fill_manual(values=c("#FFE0B2", "gold"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```



##Height 0-5cm

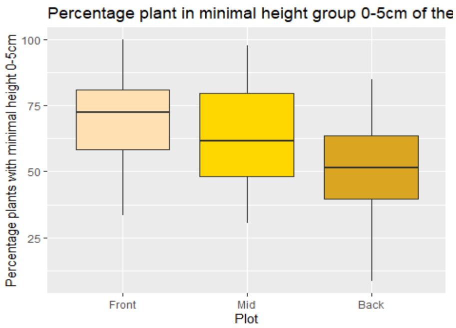
```
summary(aov(AllData$`Perc_0-0.05`~AllData$Plot))

##               Df Sum Sq Mean Sq F value Pr(>F)
## AllData$Plot   2    278   138.8    0.27  0.764
## Residuals    135  69373   513.9

TukeyHSD(aov(AllData$`Perc_0-0.05`~AllData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = AllData$`Perc_0-0.05` ~ AllData$Plot)
##
## $`AllData$Plot`
##          diff       lwr       upr     p adj
## B-A  1.108547 -10.09314 12.310232 0.9701408
## C-A -2.296844 -13.49853  8.904841 0.8781042
## C-B -3.405391 -14.60708  7.796294 0.7518282

library(ggplot2)
ggplot(AllData, aes(x=Plot, y=`Perc_0-0.05`)) +
  labs(title="Percentage of plants with a minimal height of 5 cm in the different plot types",y="Perce
ntage in height group")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                    labels=c("Front", "Mid", "Back"))
```



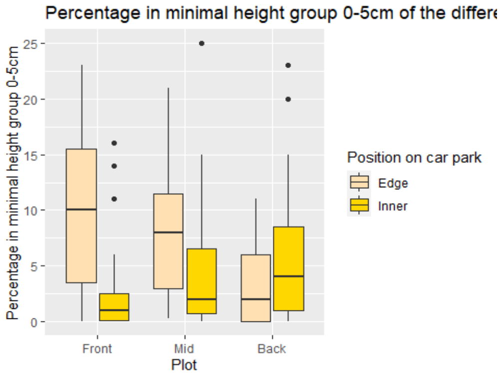
#Inner and edge data seperately

```
summary(aov(EdgeData$`Perc_0-0.05`~EdgeData$Plot))

##               Df Sum Sq Mean Sq F value  Pr(>F)
## EdgeData$Plot  2   3777  1888.7   5.263 0.00757 **
## Residuals     66  23686   358.9
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

TukeyHSD(aov(EdgeData$`Perc_0-0.05`~EdgeData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
```

```
##
## Fit: aov(formula = EdgeData$`Perc_0-0.05` ~ EdgeData$Plot)
##
## $`EdgeData$Plot`
##            diff       lwr        upr     p adj
## B-A  -5.137374 -18.53166  8.2569149 0.6299037
## C-A -17.620620 -31.01491 -4.2263303 0.0067587
## C-B -12.483245 -25.87753  0.9110441 0.0727808

summary(aov(InnerData$`Perc_0-0,05`~InnerData$Plot))

##                 Df Sum Sq Mean Sq F value Pr(>F)
## InnerData$Plot  2   1962   981.2   1.821   0.17
## Residuals      66  35568   538.9

TukeyHSD(aov(InnerData$`Perc_0-0,05`~InnerData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = InnerData$`Perc_0-0,05` ~ InnerData$Plot)
##
## $`InnerData$Plot`
##           diff        lwr      upr     p adj
## B-A  7.354468  -9.059033 23.76797 0.5332400
## C-A 13.026931  -3.386570 29.44043 0.1458564
## C-B  5.672463 -10.741038 22.08596 0.6866961

library(ggplot2)
ggplot(EdgeData, aes(x=Plot, y=`Perc_0-0.05`)) +
  labs(title="Percentage plant in minimal height group 0-5cm of the Edge plots",y="Percentage plants w
ith minimal height 0-5cm")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```

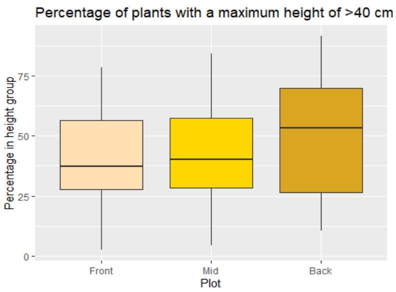



```
# library
library(ggplot2)

# grouped boxplot
ggplot(AllData, aes(x=Plot, y=Salt, fill=Position)) +
  labs(title="Percentage in minimal height group 0-5cm of the different plot types",y="Percentage in m
inimal height group 0-5cm", fill="Position on car park")+
    geom_boxplot()+
  scale_fill_manual(values=c("#FFE0B2", "gold"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```



##Height >40cm

```
summary(aov(AllData$`Perc)>0.4`~AllData$Plot))

##               Df Sum Sq Mean Sq F value Pr(>F)
## AllData$Plot   2   3451  1725.4   3.887 0.0228 *
## Residuals    135  59931   443.9
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

TukeyHSD(aov(AllData$`Perc)>0.4`~AllData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = AllData$`Perc)>0.4` ~ AllData$Plot)
##
## $`AllData$Plot`
##          diff        lwr      upr     p adj
## B-A  1.525545 -8.8859903 11.93708 0.9357310
## C-A 11.288051  0.8765158 21.69959 0.0301275
## C-B  9.762506 -0.6490296 20.17404 0.0710838

library(ggplot2)
ggplot(AllData, aes(x=Plot, y=`Perc)>0.4`)) +
  labs(title="Percentage of plants with a maximum height of >40 cm in the different plot types",y="Per
centage in height group")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                   labels=c("Front", "Mid", "Back"))
```

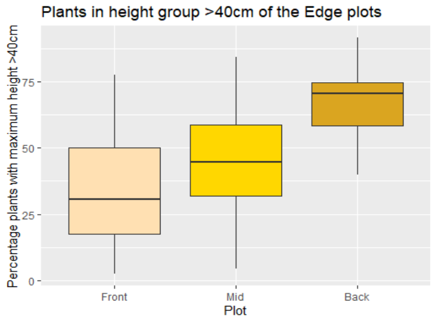



```
library(readxl)
InnerData <- read_xlsx("/Users/birgi/OneDrive/Documenten/Msc Stage 2/Statistiek uitwerking/InnerData.x
lsx")
```

#Inner and Edge data seperately

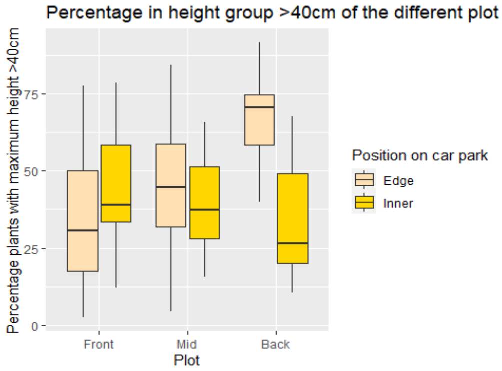
```
summary(aov(EdgeData$`Perc)>0.4`~EdgeData$Plot))

##               Df Sum Sq Mean Sq F value   Pr(>F)
## EdgeData$Plot  2  12718    6359   16.47 1.58e-06 ***
## Residuals     66  25484     386
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
TukeyHSD(aov(EdgeData$`Perc)>0.4`~EdgeData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = EdgeData$`Perc)>0.4` ~ EdgeData$Plot)
##
## $`EdgeData$Plot`
##          diff        lwr      upr     p adj
## B-A  8.792829 -5.100694 22.68635 0.2893945
## C-A 32.171627 18.278103 46.06515 0.0000016
## C-B 23.378798  9.485275 37.27232 0.0004202

summary(aov(InnerData$`Perc)>0,4`~InnerData$Plot))

##                 Df Sum Sq Mean Sq F value Pr(>F)
## InnerData$Plot  2   1073   536.3   1.697  0.191
## Residuals      66  20855   316.0

TukeyHSD(aov(InnerData$`Perc)>0,4`~InnerData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = InnerData$`Perc)>0,4` ~ InnerData$Plot)
##
## $`InnerData$Plot`
##          diff       lwr      upr     p adj
## B-A -5.741738 -18.31004 6.826563 0.5203104
## C-A -9.595524 -22.16382 2.972777 0.1676190
## C-B -3.853786 -16.42209 8.714515 0.7435455

library(ggplot2)
ggplot(EdgeData, aes(x=Plot, y=`Perc)>0.4`)) +
  labs(title="Plants in height group >40cm of the Edge plots",y="Percentage plants with maximum height
>40cm")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```




```r
# Library
library(ggplot2)

# grouped boxplot
ggplot(AllData, aes(x=Plot, y=`Perc)>0.4`, fill=Position)) +
  labs(title="Percentage in height group >40cm of the different plot types at the two positions",y="Pe
rcentage plants with maximum height >40cm", fill="Position on car park")+
    geom_boxplot()+
  scale_fill_manual(values=c("#FFE0B2", "gold"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```



##Rosettes

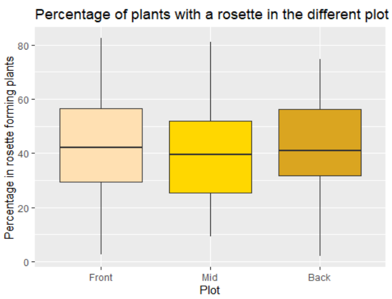
```
summary(aov(AllData$Perc_rosette~AllData$Plot))

##                Df Sum Sq Mean Sq F value Pr(>F)
## AllData$Plot    2    159    79.4   0.226  0.798
## Residuals     135  47378   351.0

TukeyHSD(aov(AllData$Perc_rosette~AllData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = AllData$Perc_rosette ~ AllData$Plot)
##
## $`AllData$Plot`
##           diff        lwr       upr     p adj
## B-A -2.4908043 -11.747988  6.766380 0.7996327
## C-A -0.5210425  -9.778227  8.736142 0.9902397
## C-B  1.9697618  -7.287422 11.226946 0.8693844

library(ggplot2)
ggplot(AllData, aes(x=Plot, y=Perc_rosette)) +
  labs(title="Percentage of plants with a rosette in the different plot types",y="Percentage in rosett
e forming plants")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```



#Inner and edge data seperately

```
summary(aov(EdgeData$Perc_rosette~EdgeData$Plot))

##                Df Sum Sq Mean Sq F value Pr(>F)
## EdgeData$Plot  2    194    96.8   0.266  0.767
## Residuals     66  23996   363.6

TukeyHSD(aov(EdgeData$Perc_rosette~EdgeData$Plot))

##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = EdgeData$Perc_rosette ~ EdgeData$Plot)
##
```

```
## $`EdgeData$Plot`
##           diff       lwr       upr     p adj
## B-A -3.9415698 -17.42334  9.540202 0.7637356
## C-A -0.9808904 -14.46266 12.500882 0.9833669
## C-B  2.9606794 -10.52109 16.442452 0.8586321

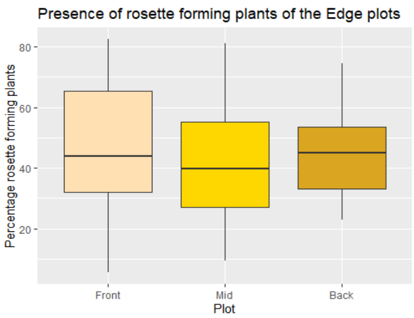
summary(aov(InnerData$Perc_rosette~InnerData$Plot))

##                 Df Sum Sq Mean Sq F value Pr(>F)
## InnerData$Plot   2     16     7.8   0.023  0.977
## Residuals       66  22308   338.0

TukeyHSD(aov(InnerData$Perc_rosette~InnerData$Plot))

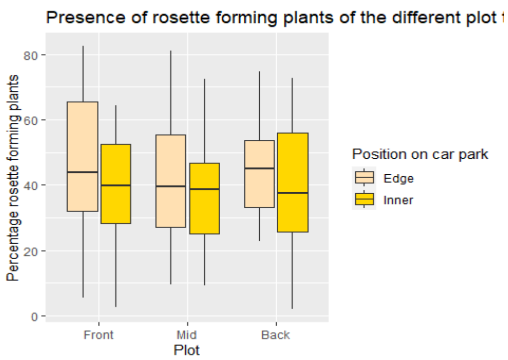
##   Tukey multiple comparisons of means
##     95% family-wise confidence level
##
## Fit: aov(formula = InnerData$Perc_rosette ~ InnerData$Plot)
##
## $`InnerData$Plot`
##            diff       lwr      upr     p adj
## B-A -1.04003881 -14.03887 11.95879 0.9799217
## C-A -0.06119457 -13.06003 12.93764 0.9999298
## C-B  0.97884424 -12.01999 13.97768 0.9821936

library(ggplot2)
ggplot(EdgeData, aes(x=Plot, y=Perc_rosette)) +
  labs(title="Presence of rosette forming plants of the Edge plots",y="Percentage rosette forming plan
ts")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```




```
# library
library(ggplot2)

# grouped boxplot
ggplot(AllData, aes(x=Plot, y=Perc_rosette, fill=Position)) +
  labs(title="Presence of rosette forming plants of the different plot types at the two positions",y="
Percentage rosette forming plants", fill="Position on car park")+
    geom_boxplot()+
  scale_fill_manual(values=c("#FFE0B2", "gold"))+
  scale_x_discrete(breaks=c("A", "B", "C"),
                      labels=c("Front", "Mid", "Back"))
```



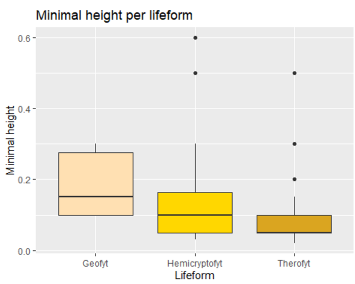
#Lifeform

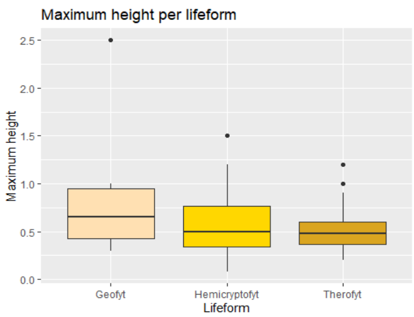
```
library(readxl)
MatrixR <- read_xlsx("/Users/birgi/OneDrive/Documenten/Msc Stage 2/Statistiek uitwerking/MatrixR.xlsx"
)

MatrixR$Lifeform <- as.factor(MatrixR$Lifeform)
MatrixR$`Root type` <- as.factor(MatrixR$`Root type`)
MatrixR$Rozet <- as.factor(MatrixR$Rozet)
summary(MatrixR)

##  Species (Dutch)      Max hoogte       MinHoogte      Species (Scientific)
##  Length:60          Min.   :0.0800   Min.   :0.0200   Length:60
##  Class :character   1st Qu.:0.3500   1st Qu.:0.0500   Class :character
##  Mode  :character   Median :0.5000   Median :0.1000   Mode  :character
##                     Mean   :0.5747   Mean   :0.1328
##                     3rd Qu.:0.7125   3rd Qu.:0.1500
##                     Max.   :2.5000   Max.   :0.6000
##
##  Life cycle (P/A)            Lifeform  Biotoopvoorkeur
##  Length:60          Geophyte       : 6   Length:60
##  Class :character   Hemicryptophyte:28   Class :character
##  Mode  :character   Therophyte     :26   Mode  :character
##
##
##
##
##  Ellenberg Zout mean (SynBioSys)                Root type    Plantvorm
##  Length:60                        Hoofd-en bijwortels:16   Length:60
##  Class :character                 Penwortel          :11   Class :character
##  Mode  :character                 Bijwortelstelsel   : 7   Mode  :character
##                                   Rhizoom/Wortelstok : 5
##                                   rhizoom/wortelstok : 4
##                                   Rhizoom/wortelstok : 3
##                                   (Other)            :14
##  Plantgrootte        Bladstand          Rozet
##  Length:60          Length:60          Ja :14
##  Class :character   Class :character   Nee:46
##  Mode  :character   Mode  :character
##
##
##
##

library(ggplot2)
ggplot(MatrixR, aes(x=Lifeform, y=MinHoogte))+
  labs(title="Minimal height per lifeform",y="Minimal height")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))
```






```
library(ggplot2)
ggplot(MatrixR, aes(x=Lifeform, y=`Max hoogte`))+
  labs(title="Maximum height per lifeform",y="Maximum height")+
  geom_boxplot(fill=c("#FFE0B2", "gold", "goldenrod"))
```

Quadratic model distance entrance^2

```
#Quadratic model distance
```{r}
PlotsAll$Distance2<- PlotsAll$Distance_entrance^2
```
```{r}
quadraticModel <- lm(Shannon_diversity~Plot+Coverage+Distance_entrance+Distance2+Position,
data=PlotsAll)
```
```{r}
summary(quadraticModel)
```
```

```
Call:
lm(formula = Shannon_diversity ~ Plot + Coverage + Distance_entrance +
    Distance2 + Position, data = PlotsAll)

Residuals:
     Min       1Q   Median       3Q      Max
-0.85188 -0.23536  0.01933  0.21989  1.06124

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)        9.120e-01  1.480e-01   6.164 8.14e-09 ***
PlotB              7.297e-02  7.821e-02   0.933 0.352524
PlotC              2.092e-01  7.850e-02   2.665 0.008672 **
Coverage           6.851e-03  3.456e-03   1.982 0.049538 *
Distance_entrance  7.225e-03  2.195e-03   3.292 0.001278 **
Distance2         -2.519e-05  6.793e-06  -3.708 0.000308 ***
PositionInner      2.128e-02  6.464e-02   0.329 0.742494
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3737 on 131 degrees of freedom
Multiple R-squared:  0.2243,	Adjusted R-squared:  0.1887
F-statistic: 6.312 on 6 and 131 DF,  p-value: 7.476e-06
```

Appendix 7

Matrix

Species (Dutch)	Species (Scientific)	Plant Family	Max height	Min height	Lifeform	Ellenberg Salt mean	Rosette	Vegetation-structure
Grote brandnetel	*Urtica dioica*	Urticaceae	2,5	0,3	Geophyte	0,25	No	P
Teunisbloem onbekend		Onagraceae	1,5	0,5	Hemicryptophyte	?	No	P
Ijle dravik	*Anisantha sterilis*	Poaceae	1,2	0,15	Therophyte	0,25	No	P
Speerdistel	*Cirsium vulgare*	Asteraceae	1,2	0,6	Hemicryptophyte	0,5	No	P
Akkerwinde	*Convolvulus arvensis*	Convulvulaceae	1	0,2	Geophyte	0	No	G
Zachte dravik	*Bromus hordeaceus*	Poaceae	1	0,5	Therophyte	0,5	No	P
Engels raaigras	*Lolium perenne*	Poaceae	0,9	0,1	Hemicryptophyte	0,5	No	G
Gestreepte witbol	*Holcus lanatus*	Poaceae	0,9	0,3	Hemicryptophyte	0,5	No	P
Jakobskruiskruid	*Jacobaea vulgaris*	Asteraceae	0,9	0,3	Hemicryptophyte	0,5	Yes	G
Klein streepzaad	*Crepis capillaris*	Asteraceae	0,9	0,3	Therophyte	0,5	No	P
Veldbeemdgras	*Poa pratensis*	Poaceae	0,9	0,1	Hemicryptophyte	0,5	No	P
Heermoes	*Equisetum arvense*	Equisetaceae	0,8	0,1	Geophyte	0,5	No	H
Viltige basterdwederik	*Epilobium parviflorum*	Onagraceae	0,8	0,2	Hemicryptophyte	?	No	G
Canadese fijnstraal	*Erigeron canadensis*	Asteraceae	0,75	0,2	Therophyte	?	No	P
Heelblaadjes	*Pulicaria dysenterica*	Asteraceae	0,75	0,5	Hemicryptophyte	0,5	No	G
Langbaardgras	*Vulpia myuros*	Poaceae	0,7	0,1	Therophyte	0,5	No	P
Duinreigersbek	*Erodium cicutarium subsp. Dunense*	Geraniaceae	0,6	0,05	Therophyte	0,25	No	P
Gewone reigersbek	*Erodium cicutarium*	Geraniaceae	0,6	0,05	Therophyte	0,5	Yes	P
Gewoon biggenkruid	*Hypochaeris radicata*	Asteraceae	0,6	0,15	Hemicryptophyte	0,5	Yes	P
Gras onbekend	*Poa sp*	Poaceae	0,6	0,1	Therophyte	?	No	R
Herderstasje	*Capsella bursa-pastoris*	Brassicaceae	0,6	0,05	Therophyte	0,5	Yes	G
Kruipertje	*Hordeum murinum*	Poaceae	0,6	0,15	Therophyte	0,25	No	G
Robertskruid	*Geranium robertianum*	Geraniaceae	0,6	0,1	Hemicryptophyte	0	No	G
Zomprus	*Juncus articulatus*	Juncaceae	0,6	0,2	Hemicryptophyte	0,5	No	?
Moeraskers	*Rorippa palustris*	Brassicaceae	0,55	0,15	Therophyte	0,5	No	P
Duizendblad	*Achillea millefolium*	Asteraceae	0,5	0,15	Hemicryptophyte	0,5	No	?
Grote weegbree	*Plantago major*	Plantaginaceae	0,5	0,1	Hemicryptophyte	0,5	Yes	P
Hopklaver	*Medicago lupulina*	Fabaceae	0,5	0,07	Therophyte	0,25	No	G
Kruipende boterbloem	*Ranunculus repens*	Ranunculaceae	0,5	0,1	Hemicryptophyte	0,5	No	P
Reukeloze kamille	*Tripleurospermum maritumum*	Asteraceae	0,5	0,1	Therophyte	?	No	P
Rode klaver	*Trifolium pratense*	Fabaceae	0,5	0,15	Hemicryptophyte	0,5	No	P
Rood guichelheil	*Anagallis arvensis*	Primulaceae	0,5	0,05	Therophyte	0,25	No	P
Ruige zegge	*Carex hirta*	Cyperaceae	0,5	0,3	Geophyte	0,5	No	?
Gewone brunel	*Prunella vulgaris*	Lamiaceae	0,45	0,07	Hemicryptophyte	0,5	No	G
Kluwenhoornbloem	*Cerastium glomeratum*	Caryophyllaceae	0,45	0,05	Therophyte	0,5	No	G
Smalle weegbree	*Plantago lanceolata*	Plantaginaceae	0,45	0,05	Hemicryptophyte	0,5	Yes	G
Vertakte leeuwentand	*Scorzoneroides autumnalis*	Asteraceae	0,45	0,1	Hemicryptophyte	0,5	Yes	G
Zachte ooievaarsbek	*Geranium molle*	Geraniaceae	0,45	0,05	Therophyte	0,25	Yes	P

Gewone paardenbloem	*Taraxacum officinale*	Asteraceae	0,4	0,05	Hemicryptophyte	?	Yes	P
Gewoon varkensgras	*Polygonum aviculare*	Polygonaceae	0,4	0,02	Therophyte	0,5	No	G
Kleine ooievaarsbek	*Geranium pusillum*	Geraniaceae	0,4	0,05	Therophyte	0,5	Yes	G
Platte rus	*Juncus compressus*	Juncaceae	0,4	0,1	Geophyte	0,5	No	P
Straatgras	*Poa annua*	Poaceae	0,4	0,05	Therophyte	0,5	No	P
Vogelmuur	*Stellaria media*	Caryophyllaceae	0,4	0,1	Therophyte	0,5	No	P
Zilverschoon	*Potentilla anserina*	Rosaceae	0,4	0,05	Hemicryptophyte	0,5	No	?
Greppelrus	*Juncus bufonius*	Juncaceae	0,35	0,03	Therophyte	0,5	No	P
Hertshoornweegbree	*Plantago coronopus*	Plantaginaceae	0,35	0,05	Hemicryptophyte	2,5	Yes	H
Kleine klaver	*Trifolium dubium*	Fabaceae	0,3	0,05	Therophyte	0,5	No	P
Schapenzuring	*Rumex acetosella*	Polygonaceae	0,3	0,1	Hemicryptophyte	0,5	No	P
Schijfkamille	*Matricaria discoidea*	Asteraceae	0,3	0,05	Therophyte	0,5	No	G
Stijve klaverzuring	*Oxalis stricta*	Oxalidaceae	0,3	0,1	Geophyte	0,5	No	P
Veldereprijs	*Veronica arvensis*	Plantaginaceae	0,3	0,05	Therophyte	0	No	?
Gehoornde klaverzuring	*Oxalis corniculata*	Oxalidaceae	0,25	0,05	Therophyte	0	No	G
Gewone zandmuur	*Arenaria serpyllifolia*	Caryophyllaceae	0,25	0,05	Therophyte	0,5	No	P
Kleine leeuwentand	*Leontodon saxatilis*	Asteraceae	0,25	0,05	Hemicryptophyte	0,5	Yes	G
Witte klaver	*Trifolium repens*	Fabaceae	0,25	0,05	Hemicryptophyte	0,5	No	R
Kleine varkenskers	*Coronopus didymus*	Brassicaceae	0,2	0,05	Therophyte	0,25	No	G
Schijnaardbei	*Potentilla indica*	Rosaceae	0,2	0,05	Hemicryptophyte	0,25	No	G
Madeliefje	*Bellis perennis*	Asteraceae	0,15	0,05	Hemicryptophyte	0,5	Yes	P
Vijfvingerkruid	*Potentilla reptans*	Rosaceae	0,15	0,05	Hemicryptophyte	0,25	No	G
Liggende vetmuur	*Sagina procumbens*	Caryophyllaceae	0,08	0,03	Hemicryptophyte	0,5	Yes	P

Appendix 8

Spatial maps per characteristic

Figure 22 Spatial distribution of the coverage of Plantago coronopus *for each plot.*

Figure 23 Spatial distribution of the percentage of plants in the minimal height group 0-10cm for each plot.

Figure 24 Spatial distribution of the percentage of plants in the minimal height group 0-5m for each plot.

Figure 25 Spatial distribution of the percentage of plants in the maximal height group >40cm for each plot.

Figure 26 Spatial distribution of the percentage rosette forming plants at each plot.

Appendix 9

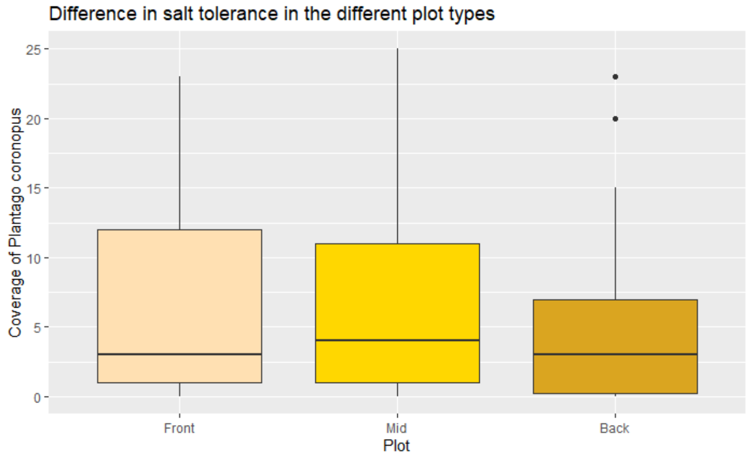


Figure 27 Boxplot of the salt tolerance per plot type, by looking at the coverage of Plantago coronopus. No significant difference is present.

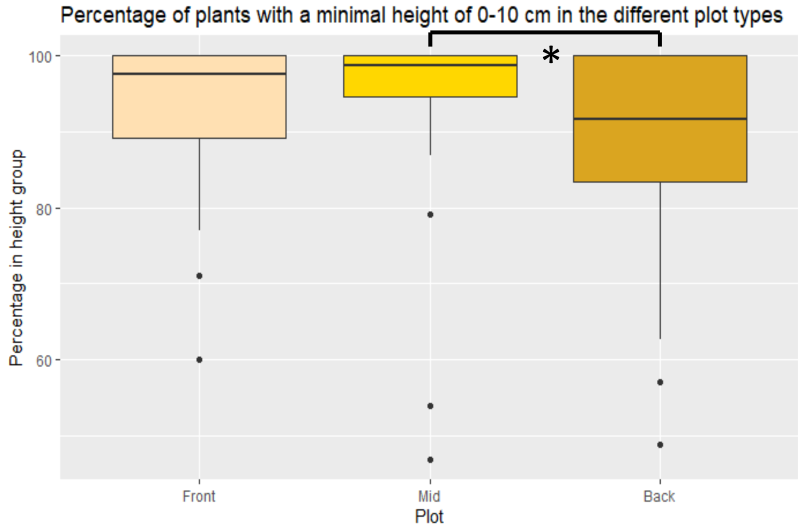


Figure 28 Boxplot of the percentage of plant in the height group 'minimal height of 0-10cm' in the different plot types. A significant difference is present between the Mid and Back plots. (p=0.0233138)

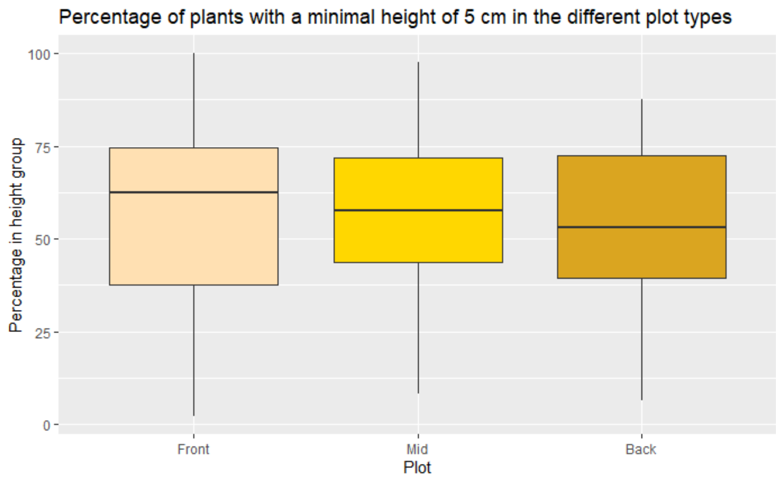


Figure 29 Boxplot of the percentage of plant in the height group 'minimal height of 0-5 cm' in the different plot types. No significant difference is present.

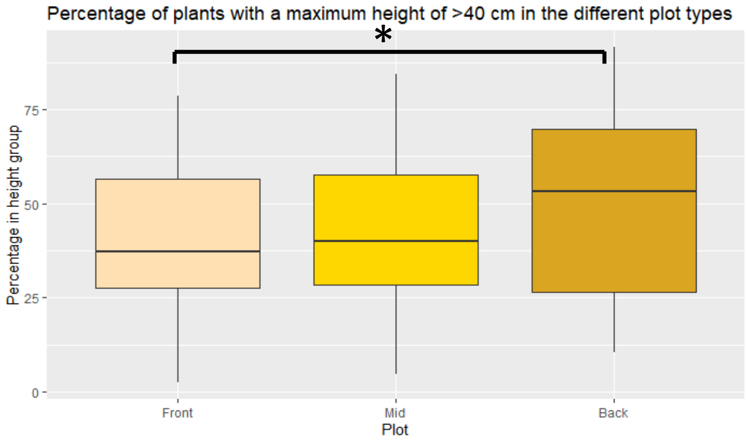


Figure 30 Boxplot of the percentage of plant in the height group 'maximum height of >40 cm' in the different plot types. A significant difference is present between the Front and Back plot type. (p=0.0301275)

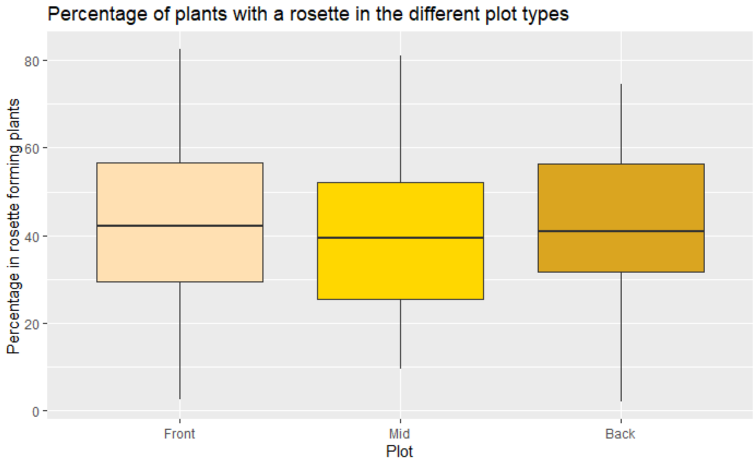


Figure 31 Boxplot of the percentage of rosette forming plants in the different plot types. No significant difference is present.