The relation between bird diversity and hedge density in the agriculture area Maasheggen, the Netherlands

figure 1: Hedges in the Maasheggen (Vos, n.d.)

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Abstract

Biodiversity in the Netherlands has decreased 85% since 1900. The main reason for this rapid deterioration of biodiversity has been the intensification of agriculture. In this period of intensification, hedges have been removed from most agricultural field margins. Meanwhile, hedges offer a great variety of ecosystem services, amongst other things, the provision of habitat for birds, insects and small mammals. Bird species that prefer thicket and small-scale farmland as breeding habitat have faced a decrease of 60% in one century. The Maasheggen is one of the only remaining hedge areas in the Netherlands and is home to 43 bird species that are threatened in the Netherlands.The research question of this thesis is: to what extent does density of hedges per square kilometers influence bird diversity in the agricultural area Maasheggen? Bird diversity was measured by the abundance of birds and species richness in the Maasheggen. The proportions of hedges were calculated per cell in ArcGIS Pro. Rstudio was used for the analysis of the bird and hedge data. Based on the Pearson correlation test, there was a significant correlation between bird abundance and hedge density (0.620) and species richness and hedge density (0.592). The p-value of both regressions was far below the significance level of 0.05. The regression of bird diversity steadily increases with hedge density. The R squared of both models was not high and the data was slightly heteroscedastic. The curve of species richness seemed to bend after reaching a maximum around middle hedge densities, slightly decreasing around high hedge densities. To a certain extent, a similar pattern could be recognized in the residuals of the bird abundance regression, but less significant. Further research is needed to determine whether the relation is linear or at some point nonlinear. It can be stated that there is a positive relation between bird diversity and hedge density. Therefore, reintroducing hedges in the agricultural floodplains of the grand rivers would increase bird diversity in the Netherlands.

Keywords: Hedges; Birds; Biodiversity; Maasheggen; Species Richness; Abundance; Density; Correlation; Regression

Content

Introduction

The current rate at which biodiversity is decreasing forms a sixth major extinction since the beginning of life on earth (Rockstrom et al, 2009). The loss of species diminishes the resilience of ecosystems to changes of biotic and physical conditions. The system is reaching its boundaries having irreversible consequences for global ecosystems (Rockstrom et al., 2009). The Netherlands has one of the highest rates (85%) of biodiversity loss worldwide (Planbureau voor de Leefomgeving, 2014). The most important causes for this trend are land use change, environmental pressure and habitat fragmentation (Planbureau voor de Leefomgeving, 2014).

Since the 1960's, agricultural landscapes in the Netherlands have changed from small-scale farmland to large-scale bio-industries. Bird species that depend on small-scale agricultural and half open land, so-called "yard and thicket" birds, have decreased 60% since 1900 (CBS, 2020, 6 February). Harms, Stortelder and Vos stated in 1987, that due to the intensification of agriculture the Netherlands was coping with a stressed environment. The use of fertilizers, pesticides and the removal of landscape elements have increased pressures on Dutch ecosystems (Harms, Stortelder & Vos, 1987). Farmers have removed woodbanks, ditches, lines of trees and hedges to enlarge their parcels and create space for the use of large machinery (Montgomery, Caruso & Reid, 2020). Hedges are rows of woody plants, often containing other plant species and features. There is a great variety of hedges around the world and "the only consistent hedge feature is its linear structure that is elevated above the surrounding ground level" (Montgomery et al., 2020). Hedges deliver provisioning, regulating, cultural and supporting ecosystem services (Montgomery et al., 2020). One of the only remaining hedge areas in the Netherlands, the Maasheggen, is located in the floodplains of the river Maas (Visser, 1979). The hedges in this agricultural area mainly consist of hawthorn, buckthorn and blackthorn (Visser, 1979). The dense thorny plant species offer protection in the winter and the complexity of thicket decreases the risk of predation (Hinsley & Bellamy, 2000). Furthermore, thicket and other plant species in the hedges provide fruits in the winter and seeds in the summer (Hinsley & Bellamy, 2000). Breeding species that are attracted by the hawthorn hedges of the Maasheggen are amongst others the common linnet, the yellow barley and the blackbird (Visser, 1979). Moreover, the hedges of the Maasheggen contain oaks and pollard willows which are used by cavity nesters such as the little owl and the common redstart (De Vrieze, 1979). According to the Province of Noord-Brabant, 22% of the bird species that breed in the Maasheggen are on the red list (Braam & Lansing, 2008).

Despite the ecological values of hedges, Dutch farmers don't receive subsidies from the government for remaining or maintaining hedges and other landscape elements on their parcels (Smit, 2018). Several Dutch nature conservation organisations and agricultural organisations expressed their concerns in a letter to Carola Schouten, the Dutch minister of Agriculture, claiming that farmers should have a financial motivation to maintain hedges on their land (VNC, Landschappen NL, Natuur- en Landschapsontwikkeling LTO Nederland & Boerennatuur, 2018). Carola Schouten, minister, responded that the proposal would be taken into consideration during the conversations about the EU agriculture policies (Smit, 2018). Latest research in the Maasheggen by the Province of Noord-Brabant has shown that there is a positive relation between hedge height and bird diversity (Braam & Lansing, 2008). In California, Heath, Soykan, Velas, Kelsey and Kross (2017) have shown that field margins with hedges had a significantly higher bird diversity than field margins with bare vegetation. In the Netherlands, it has yet not been shown if there is a positive relation between the density of hedges in an area and bird diversity. Therefore, the research question of this thesis is: to what extent does hedge density influence bird diversity in the agricultural area Maasheggen?

Theoretical Framework and Study Area

This research focuses on the diversity and abundance of breeding birds in the Maasheggen. Bird species breed in the Netherlands roughly between 15 March and 15 July (Vogelbescherming, n.d.). Bird diversity will in this case be measured by bird abundance, meaning the number of individuals, and the number of species, which is called the species richness (Sadava, Hillis, Heller & Hacker, 2016). The study area is the Maasheggen (Fig. 1) since it is one of the only remaining hedge areas in the Netherlands. The area is named after the river *Maas,* that flows through the region, and the *heggen*, which is Dutch for hedges.

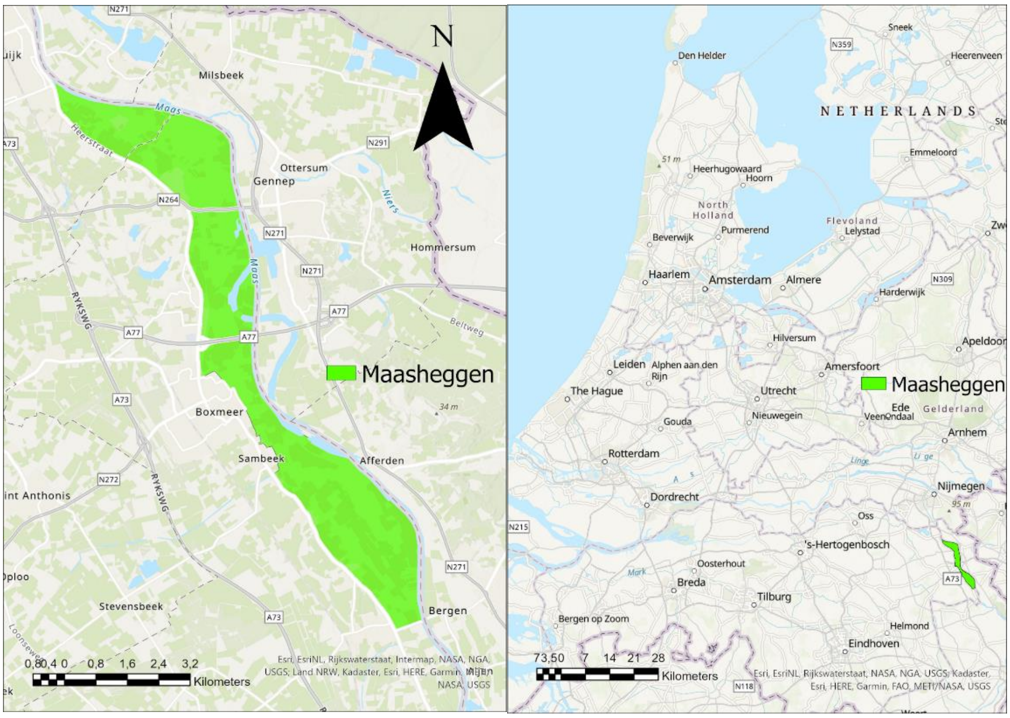

Figure 2: left, closeup of the Maasheggen area; right, Maasheggen on the Dutch map

It is a floodplain of the river Maas (or Meuse in French) that flows from France, through Belgium and the Netherlands, into the North Sea (Visser,1979). The hedges functioned as fences preventing cattle from moving to other parcels. Furthermore, the hedges decreased soil erosion while surviving the regular overflow of the river Maas. Before the intensification of agriculture, hawthorn hedges were abundant along the grand rivers of the Netherlands (De Vrieze, 1979). Most of the hedges have been replaced by barbed wire (De Vrieze, 1979). It is estimated that the hedges in Maasheggen have existed since the Middle Ages (Visser, 1979). Hence, the Maasheggen is a historical reminder of what the floodplains in the Netherlands looked like. Nowadays, the area still is mainly agriculture, where agricultural grass, beets, grain, potatoes and corn are the most present crops (Wageningen Univeristy & Research, n.d.). According to the “Wet Natuurbescherming”, provinces are responsible for regulating the natural areas. Momentarily, the Maasheggen is being monitored by the Province of Noord-Brabant, Staatsbosbeheer, Brabants Landschap and Waterschap Aa en Maas. In 2008, Braam & Lansing, ecologists of the Province of Noord Brabant, did research on the relation between bird diversity, hedge height and hedge management in Maasheggen. According to the researchers, the Maasheggen have a high ornithological value, because 43 out of 89 breeding species in the Maasheggen are uncommon, rare or on the red list (Braam & Lansing, 2008). Twenty species are characteristic for the area based on their above-average presence in comparison with their abundance in the rest of the Netherlands.

Most of the species in the Maasheggen prefer small agricultural landscapes with shrubs and thickets (Braam & Lansing, 2008). Research by Braam & Lansing (2008) and Visser (1979), have shown that there are many birds in the Maasheggen depending on the area as a breeding ground in the Netherlands. Researching the relation between bird diversity and hedge density might seem like stating the obvious, but in the Netherlands it has not been proved that there is a relationship between the density of hedges per surface and bird diversity. Hence, this study will focus on the number of hedges as predictor of bird diversity.

First, in the method section, the data preparation, the workflow in ArcGIS and analysis in Rstudio are described. Thereafter, the results of the research shown. The results will be explained and elaborated on in the discussion. Furthermore, limitations of the research are discussed and further research and policy recommendations are described. Finally, a conclusion of the research is given.

Methods

Data Preparation

Table 1: collected data in order to start research

Map layer	Name in Project	Type of data	Source
Satellite Images (0.5)	Group Layer: Satelite_Images	Raster	https://www.satellietdataportaal.nl/
Bird Observations	Broedvogelterritoria	Point data	Sovon
Study Areas	WSN_Plots_Maasheggen	Polygon Feature Classes	Sovon
Land Use Map	Not in Project	Raster	https://bit.ly/3oGHzRK

The necessary data (table 1) was partially collected online and partially received from Sovon, a non-profit research organisation that monitors birds in the Netherlands (Sovon, 2020). Henk Sierdsema, researcher at Sovon, counted breeding birds by doing a Broedvogel Monitoring Project (BMP) in Maasheggen between 2013 and 2019. The extensive territory method was used to collect data, which means that all birds were counted that behave territorially or seem to behave as if they are breeding in the area (Vergeer, van Dijk, Boele, van Bruggen & Hustings, 2016). This method has the following guidelines:

- The study area is larger than 10 ha and smaller than 250 ha
- 7-12 visits per study area
- Divide the visits between the period of February-June
- Visit the area during sunrise
- 1 or 2 visits at night
- The counting needs to be executed at least two years in a row

Eventually, this resulted in a large dataset of 7025 individual bird observations. The observations were loaded into ArcGIS as point data (Fig. 4). Furthermore, when using the extensive territory method, the project is conducted within the same study area repeatedly (Vergeer et al., 2016). These bounded study areas were drawn by Sierdsema as polygons in

ArcGIS. As this research focuses on hedges in agricultural areas, it was of importance to determine which of the study areas functioned as agriculture and nature. Therefore, the LGN Viewer (2019) of the University of Wageningen was used (Wageningen Univeristy & Research, n.d.). Veerhuis, Overbiest, Zurepasweiden and Groeningsche Veld (Fig. 3) were chosen as study areas for this research since the areas were used for agriculture and outlined by Sierdsema as study areas. The types of land use were agricultural grass, corn, potatoes, beets and grain (Wageningen Univeristy & Research, n.d.). In order to identifiy the number of hedges per area, satellite images have been downloaded from the satellite data portal (Satellietdataportaal, n.d.). This is a portal from the Dutch government that provides satellite data of the Netherlands to the general public (Netherlands Space Office, n.d.). The satellite images have a resolution of 0.5 metres and date from 23-04-2020 and 07-05-2020.

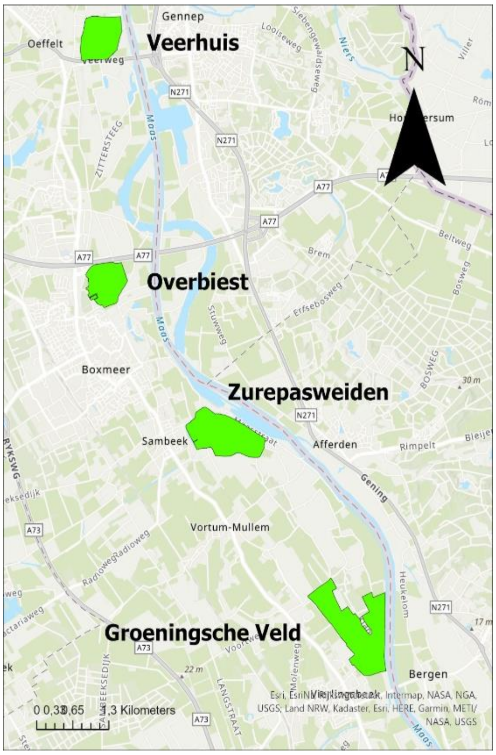

Fig 3: the study areas

Data Utilisation

For each study area, new feature classes have been created in the geodatabase. Veerhuis Overbiest, Zurepasweiden and Groeningsche Veld have been selected as study areas and therefore these areas were clipped from the shapefile WSN_plots_Maasheggen (Appendices 1.1, 1.2, 1.3, 1.4). First, the outlines were used to create cells of each 125-meter width and 125-meter length with the tool “Create Fishnet”. These dimensions were chosen to capture enough bird data per cell while having a large n size as well. The tools “Intersect” and “Select by Attributes” were used to remain solely the cells with 125 width and 125 length within the outlines (Fig. 4). Eventually, this led to a sample of 100 cells with exactly the same dimensions. In ArcGIS these shapefiles are called Fish_Inter_1, etc. The outlines of the area were clipped again to create a new feature class for each main area. The hedges were mapped by using the analysis tool “Split”. A field was added in the attribute table of each layer. Each polygon was labelled 0 (other) or 1 (hedge). In order to obtain data of the hedges per cell of the fishnet, the feature classes were converted into rasters (Fig. 4) by the tool “Polygon to Raster”. Subsequently, the rasters were divided into squares by intersecting it with the fishnet cells. By using the tool “Tabulate Area”, a table was created that shows the number of pixels with the value “hedge” or “other” per cell. Thereafter, the tool “Calculate Field” was used to calculate the proportion of both values.

The next step was to calculate the bird abundance and species richness per cell. First, the number of individuals were calculated with the tool “Spatial Join”. Thereafter, the proportion of hedge area was added to the table by using the tool “Add Join”.

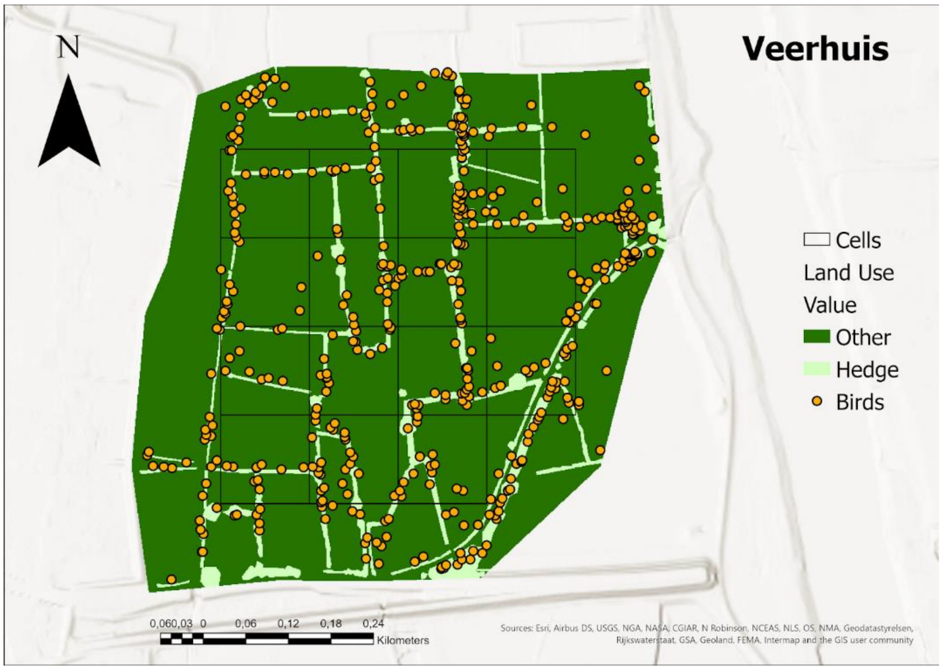

Fig 4: One of the study areas, Veerhuis.

The point data was converted into raster data based on the field “naam”, which is Dutch for name. The tool “Zonal Histogram” created a table with the amount of all the 114 species per cell. These tables, called “Zonal_Hi_1” etc. were exported to excel where each species that had more than 1 number of individuals per cell was altered into 1. The function AutoSum in Excel summed the amount of species per cell.

Data Analysis

Both tables were exported from excel to Rstudio where a Pearson Correlation test and a linear regression were executed. The assumptions for the correlation and linear regression are (STHTDA, n.d.-a):

1. the variables are normally distributed
2. there is a linear relationship
3. the data is homoscedastic
4. the observations are independent

The Central Limit Theorem says that when a sample size is large enough (n > 30), the sampling distribution tends to be normal no matter what distribution the vector has (STHTDA, n.d.-a). Since the sample size of this research is 100, it can be assumed that the data is normally distributed. It is assumed that on this scale, a cell size of 125 x 125, the relationship is linear for both the number of individuals as species richness. The regression for species richness would not be linear rather logistic with a larger study area, since there is a limited amount of species. The Spearman correlation test can be used if the data are not linear, since this test works with monotonic relations as well. It can be checked if the data is homoscedastic by plotting the standardized residuals with the fitted values. A horizontal line with equally spread points reflects homoscedasticity (STHTDA, n.d.-b).

When comparing two vectors, the function cor() shows the strength of a correlation with a value between -1 and 1. When the correlation is -1, there is a very strong negative correlation. When the correlation is 0 there is no correlation and 1 symbolises very strong positive correlation (STHDA, n.d.-a). The function lm() creates a linear regression model. By using the code summary(lm()), a summary is given of the linear regression model containing extensive information about the model. This function shows amongst other things the p-value, the residuals, R squared and the coefficients of the slope. A p-value of below 0.05 implies that there is a significant relation between two vectors. The coefficients can be used to create the formula of a linear regression: x = a + b * y where x is the dependent variable, a is the intercept, b is the slope and y is the independent variable. When the linear regression model is plotted, Rstudio shows diagnostic plots that can be used to analyse the residuals.

Results

There is a positive relation between the proportion of hedges and bird abundance (Fig 5). The Pearson correlation coefficient was 0.620. The p-value of the regression was 7.614e-12, which is far below the significance level 0.05. The regression had an intercept (a) of 1.167 and a slope (b) of 58.804, which gives the following formula: bird abundance = 1.1667 + 58.804 * Proportion Hedge (Fig 5). The results of the Spearman correlation were more significant and stronger than the Pearson correlation. The rho was 0.688 and the p-value was 3.86e-15.

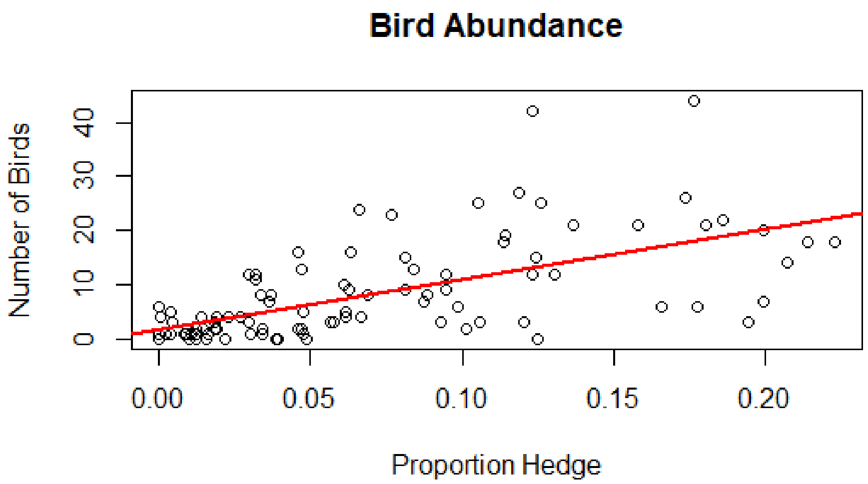

Fig 5: the red line in the figure is the regression of bird abundance, the points are the values for each cell.

The Pearson correlation coefficient for species richness and hedge density was 0.596, thus a positive relation as well. The regression of species richness had a p-value of 7.423e-11, meaning that the relation was significant. The formula of the regression was the following: Species Richness per ha = 1.310 + 31.161 * Proportion Hedge. Again, the results of the Spearman test were more significant and stronger than the correlation of the Pearson test: a rho of 0.646. and a p-value of 5.374e-13.

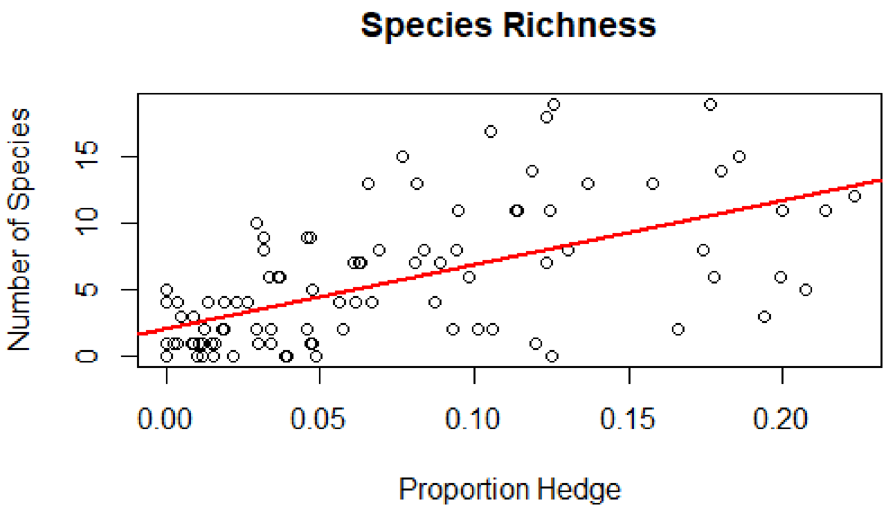

Fig 6: the red line in the figure is the regression species richness, the points are the values for the cells.

The R squared for the bird abundance regression was 0,385, meaning that 38,5% of the variation is explained by the model. The R squared for the species richness regression was 0,365. The standardized residuals show that the highest residuals occurred with high predicted values (Appendix S2.3 & S2.4). The Cook's distance () function, shows the cells with influential values for the regression. Cells 51, 10 and 66 have the highest cook's distance for bird abundance (Appendix S2.1) and cells number 84, 10 and 66 have the highest cook's distance for species richness (Appendix S2.2).

Discussion

There is a significant positive relation between the hedge density and bird diversity. The p-values of both regressions were far below the significance level of 0.05. The correlation between proportion of hedges within the cells and number of individuals was 0.620 and species richness was 0.596. These results confirm the hypothesis that there is a positive relation between bird diversity and hedge density in agricultural areas in the Maasheggen. Montgomery et al. (2020) stated that hedges have a supporting ecosystem function as habitat and food source for birds. The positive relation between breeding birds and hedges in these results show that hedges indeed function as habitat for bird species. According to Heath, Soykan, Velas, Kelsey, and Kross (2017), who have conducted research in the Central Valley of California, agricultural field margins with hedges contain about 2 to 3 times as many bird species as bare or weedy field margins. Furthermore, the total abundance of birds was 3 to 6 times higher in field margins with hedges. In England, O'Connor (1984) showed that there was a significant positive relation between the density of hedges on farms and the density of breeding birds. The abundance of birds steadily increases with the abundance of hedges around farms (Fig 7). The graph is similar to the results of this research (Fig. 5)

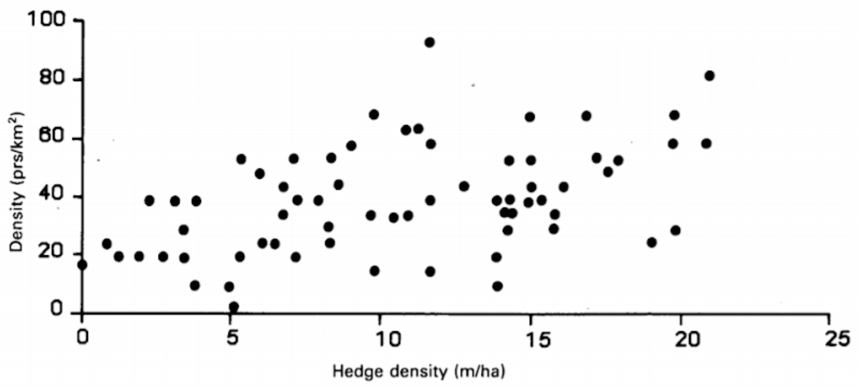

Figure 6: bird abundance steadily increases with the density of hedges on farms in England O'Connor (1984)

Meanwhile, O'Connor (1984) stated that species richness "increases non-linearly with hedgerow, rising to a peak at densities of around 13-18 km/ha and declining slowly thereafter". According to O'Connor (1984), areas with low hedge density are dominated by field species. As hedge density increases, different types of bird species, mostly passerine birds, are dominating the hedges and field species are more or less disappearing. Therefore, the highest species richness is found in areas with middle hedge density where different types of species are present (O'Connor, 1984). For species richness, the Spearman test had a higher correlation coefficient Pearson test, 0.646 instead of 0.596. Considering the research of O'Connor (1984), it can be doubted if the assumption that there is a linear relation between species richness and hedge density was right. Moreover, bird abundance also had a higher spearman coefficient than a Pearson correlation coefficient. This would not be in line with the research of O'Connor (1984) who states that there is a linear relationship between bird abundance and hedge density.

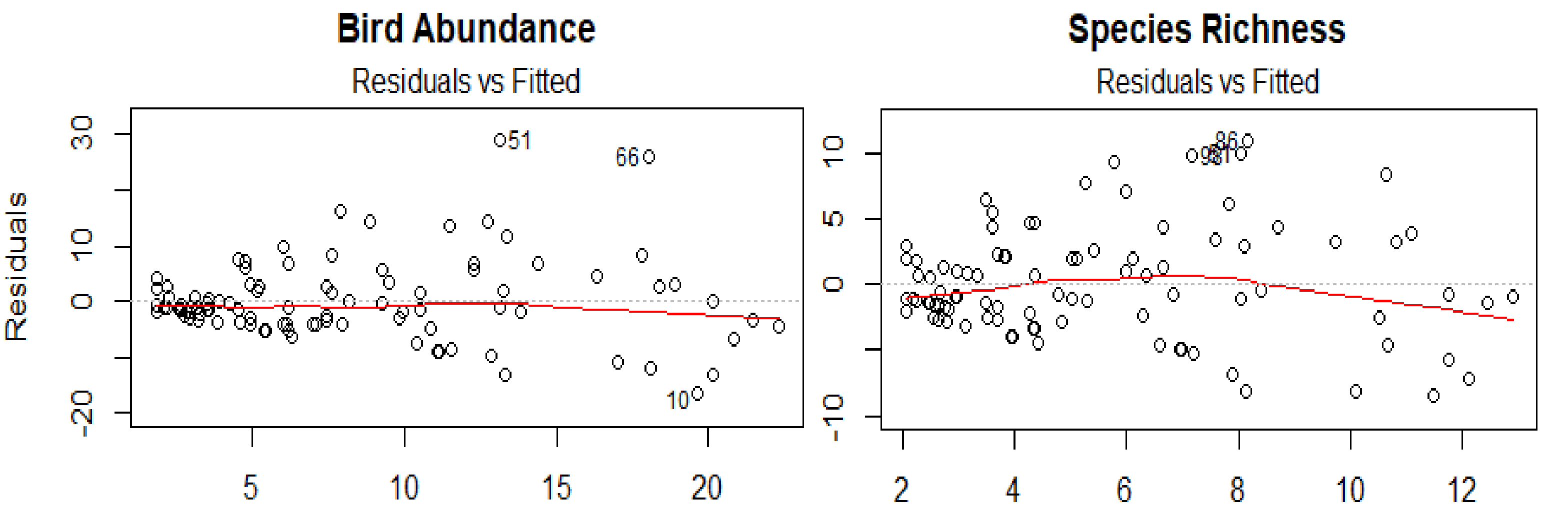

Figure 7: The residuals plotted vs the predicted values for bird abundance with bird abundance on the left and species richness on the right.

When analysing the residuals and the fitted values of species richness (Fig. 7), it is visible that the residuals are higher than expected around the middle-fitted values while the residuals are lower than expected around the high fitted values. This could mean that the actual curve of the relation between species richness and hedge density indeed starts decreasing after reaching a maximum around the proportion of 0.14 hedge density. The same pattern can be seen in the residuals of bird abundance, but much less strong (Appendix). Shortly, both models for bird abundance and species richness show signs of nonlinearity, but the signs are stronger for species richness. What would be another explanation for the high residuals that are mainly found at the cells with higher proportion of hedges?

The R squared statistic shows that only 0.385 of the variation in the bird abundance model is explained by the regression and only 0.365 for the species richness. A score of 1 would mean that the regression perfectly explained all the variation in the variables. Meanwhile, an R squared of 1 would be a quite unexpected and unrealistic result. For instance, an R squared of 0,5 for the relation between the age of kids and the length of kids would be a good result. Since it is not realistic that each kid has exactly the same length based on its age. Comparably, it cannot be expected that each cell would have a perfectly predicted species richness or number of individuals by the proportion of hedges. Still, 0.385 and 0.356 are relatively low. The scale location graph (Appendix 2.3) shows that the line is slightly increasing for both the regressions. The standardized residuals are higher with higher predicted values. Therefore, the data is slightly heteroscedastic. This decreases the accuracy of the regression. For example, cell number 10 had 19,8% hedges while containing only 3 birds. This cell is one of the influential points in the dataset (Appendix 2.1 & 2.2), meaning that the value of the cell influences the regression a lot.

Outliers like this can appear due to an error in the data, a mistake by the researcher or randomly. The highest outliers that are present in both models, have occurred by coincidence and not by an error or mistake of the researcher. Therefore, the outliers have not been removed from the table. The cause of these large residuals and heteroscedasticity could be due to the cell size of 125 width and 125 length. Increasing the dimensions of the cells would decrease the chance of capturing these types of errors. Then, in order to keep a large sample size, the study area should be bigger. Apart from that, it can be doubted if 125 x 125 was the right cell size since it created cells with proportion of hedges of over 0.20. A field with more than 20% hedges does not reflect reality. Increasing the cell size would create cells with more realistic proportions of hedges.

Research Recommendations

This linear regression model can be used to create a multiple regression model for more predictors of bird diversity in the Maasheggen. Firstly, it is recommended to include the type of agricultural use in the multiple regression since the type of crop adjacent to hedges can influence the presence of bird species in the hedges (Green, Osborne & Sears, 1994). The types of agriculture in the study area were agricultural grass, corn, potatoes, beets and grain. Furthermore, according to Green, Obsorne and Sears (1994), several bird species occur less in the hedges adjacent to fields sprayed with pesticides. Hence, it would be valuable to add a component of pesticides and fertilizers to a multiple regression. The components hedge height and hedge management, which have been researched by Braam and Lansing (2008) and Visser (1979), could also be added to a multiple regression in combination with hedge density.

Policy Recommendations

In 1992, the first Convention on Biological Diversity (CBD) treaty was signed by a number of countries, the Netherlands being one of them. The countries that have signed the treaty are obliged to conserve biodiversity by international standards. Based on the CBD, the European Commission creates a strategy every ten years (European Commission, 2020). 2020's strategy aims to restore, protect and make all of the world's ecosystems resilient by the year of 2050. The commission stated that in 2030: "Europe's biodiversity will be on the path to recovery" (European Commission, 2020, pp. 3). The Dutch government is obliged to follow bird and habitat guidelines since it has signed the CBD (Planbureau voor de Leefomgeving, 2014). Within the guidelines it is stated that "the conservation of all bird species requires the protection, maintenance or restoration of habitats that are sufficiently diversified and of adequate surface area" (Richtlijn (EU) 2009/147). The Maasheggen is one of the only remaining hedge areas in the Netherlands and this research has shown that the presence of hedges in agricultural field margins increases bird diversity. Reintroducing hedges to agricultural areas would thus, partially, restore breeding habitat for birds and increase the surface area of habitat in the Netherlands. It is recommended to reintroduce hawthorn hedges in agricultural areas along the big rivers of the Netherlands where they were once so abundant (De Vrieze, 1979). The North and the West are dominated by a different type of farmland, mainly low wetlands which attracts waders. These species have faced a 85% decrease in population (CBS, 2020, 6 february). Visser (1979) has observed that waders, such as the black-tailed godwit and the lapwing, were less present in the areas with more abundance of hedges in the Maasheggen. Therefore, placing hedges in the North and the West might counteract the efforts of the Dutch to restore waders' populations.

Conclusion

The aim of this research was to answer the following research question: to what extent does density of hedges influence bird species diversity in the agricultural area Maasheggen? Bird diversity was measured in two ways: 1. bird abundance, 2. species richness. Hedge density was calculated by the proportion of hedges per cell of 125 x 125 meters. Based on a Pearson correlation, both bird abundance and species richness had a positive correlation of 0.620 and 0.592 with hedge density, while the p-values were far below the significance level. Therefore, the hypothesis that hedge density positively influences bird diversity was confirmed. This is in line with earlier research of Heath, Soykan, Velas, Kelsey, & Kross (2017) who found that field margins with hedges had 2-3 times as many species and 3-6 times as many individuals as field margins with bare vegetation. O'Connor (1984) found a similar positive and steadily increasing relation between hedge density and bird abundance. Meanwhile, according to O'Connor (1984), species richness follows a non-linear relation that reaches a maximum and then starts decreasing. The same pattern of non-linearity was found in this research, since species richness was higher than predicted by the regression around middle hedge densities and lower than predicted at higher hedge densities. Also, the bird abundance residuals showed such pattern, but less significant.

Further research is needed to determine whether the relation of species richness and bird abundance are linear or nonlinear. Due to the small cell size of 125 x 125 meters it occurred that some cells had a very high proportion of hedges while containing few birds. This led to high residuals and a low R squared. A larger cell size would decrease the chance that these types of outliers occur. Hence, it is recommended that the same research will be executed with a larger cell size.

In conclusion, it can be said that there is a significant positive relation between density and bird diversity in Maasheggen. The hedges in the Maasheggen form an important habitat for 43 species that are rare or on the red list in the Netherlands (Braam & Lansing, 2008). Returning hedges to agricultural areas around the grand rivers, would increase the habitat for breeding birds in the Netherlands.

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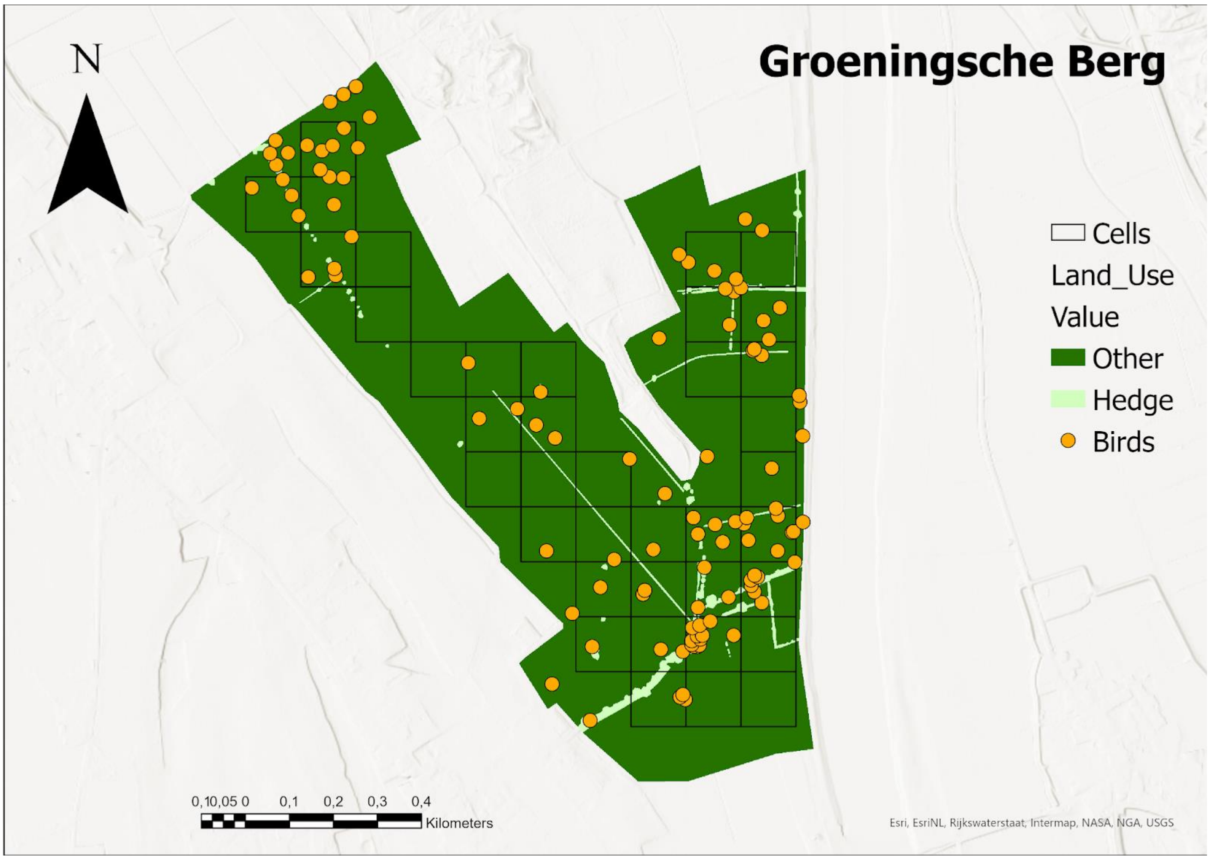
Appendices

This appendix shows the layers that were created in ArcGIS, the script of Rstudio and the graphs that resulted from the analysis in Rstudio.

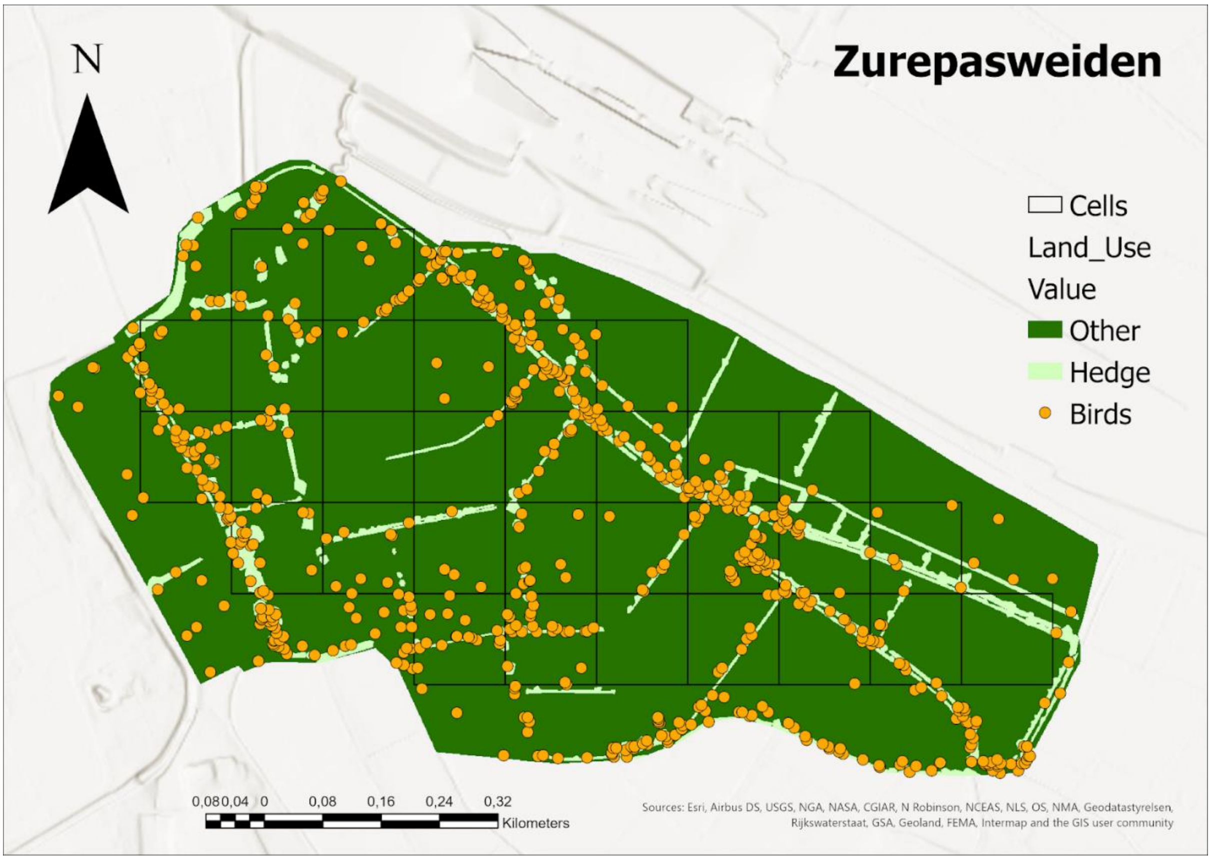
ArcGIS Layers

All the layers have the same coordinate system of RD New. The linear units are meters. Credits for Henk Sierdsema from Sovon who provided bird data in point data and feature classes.

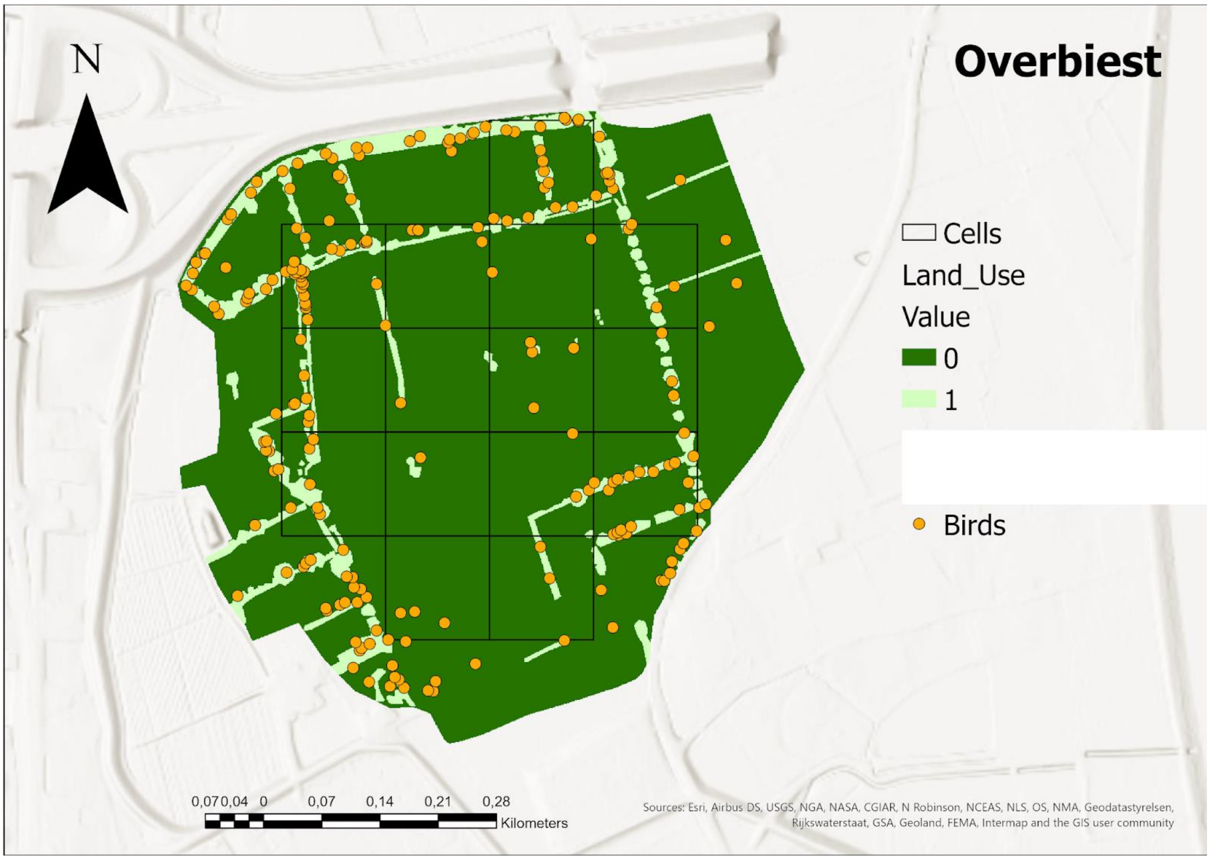
1.1: This layout shows the data in ArcGIS for the Groeningsche Berg



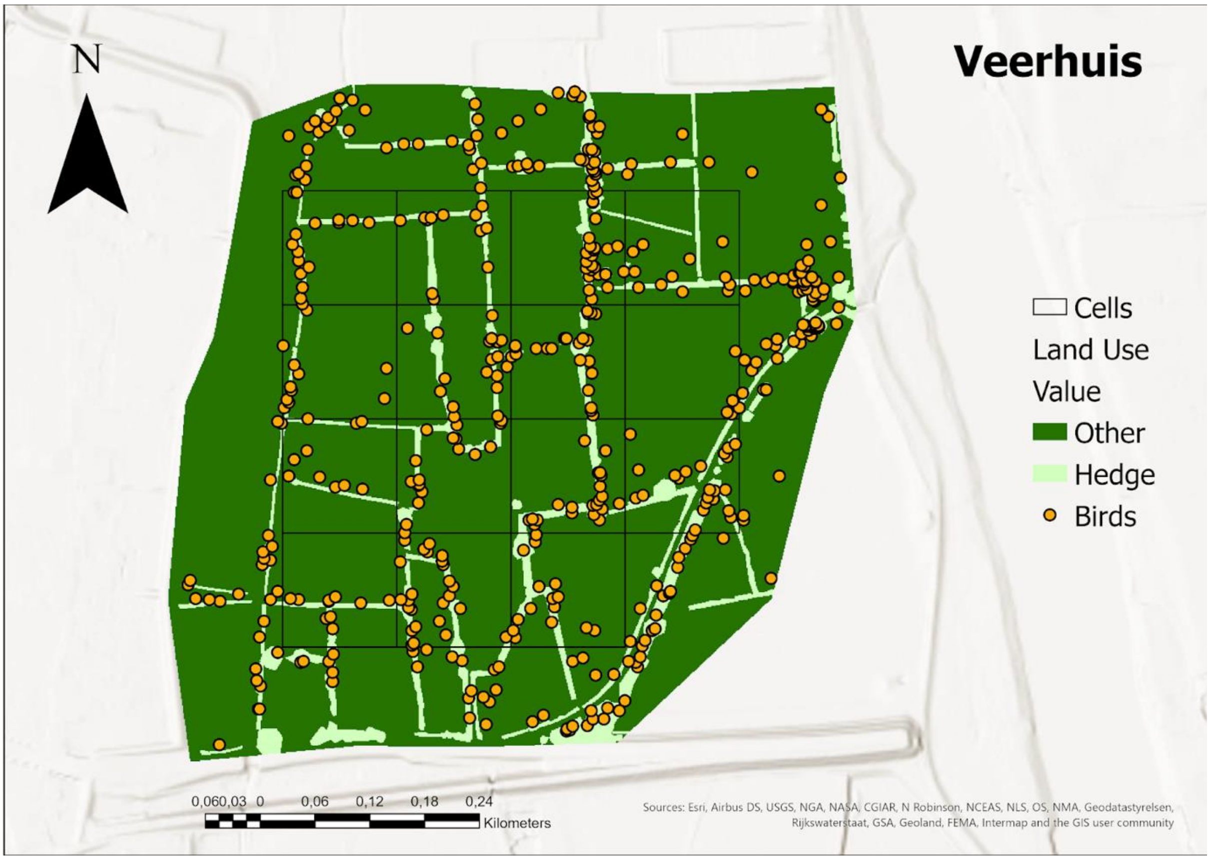
1.2: This layout shows the data in ArcGIS for the Zurepasweiden



1.3: This layout shows the data in ArcGIS for Overbiest

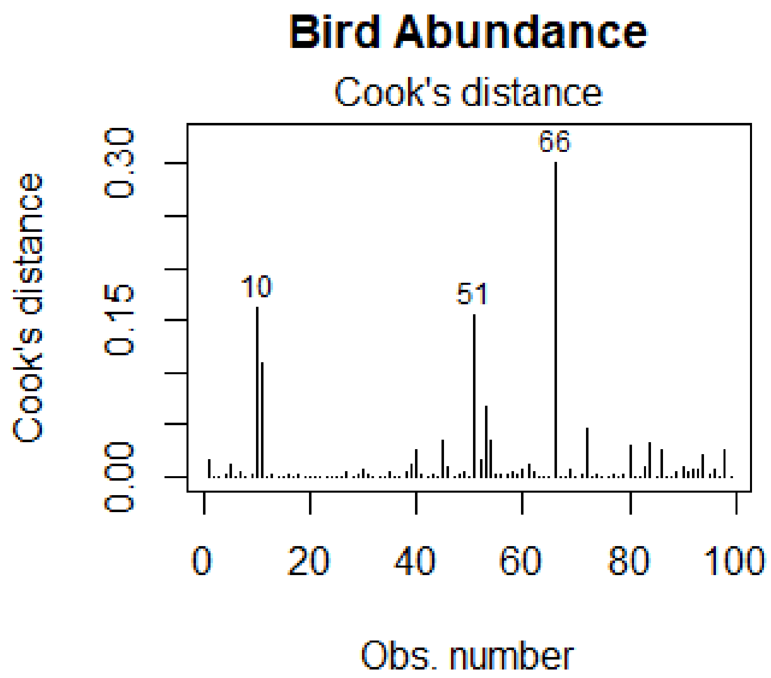


1.4: This layout shows the data in ArcGIS for Veerhuis

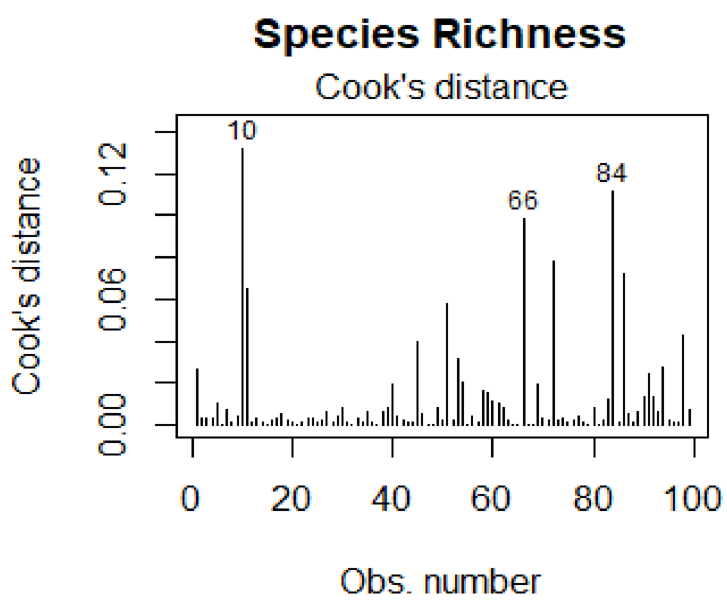


Graphs from Rstudio Analysis

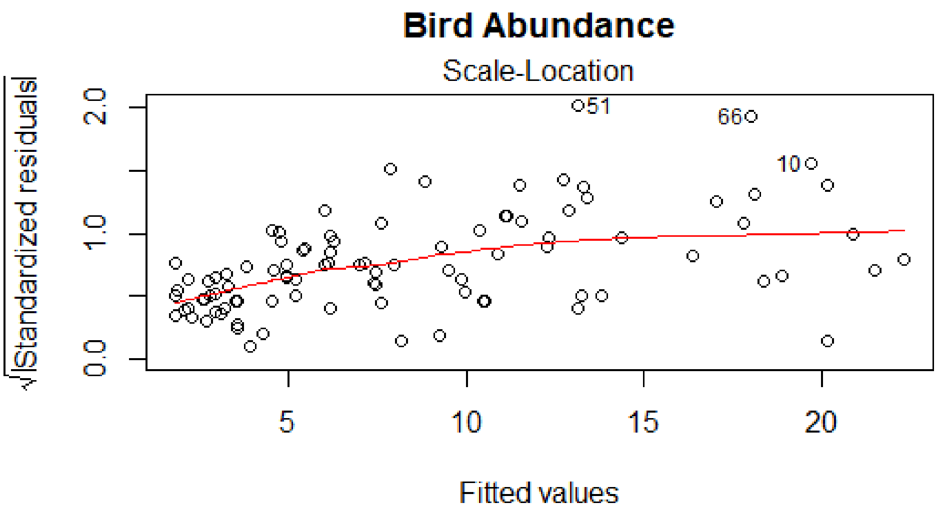
2.1: Cook's Distance Bird Abundance



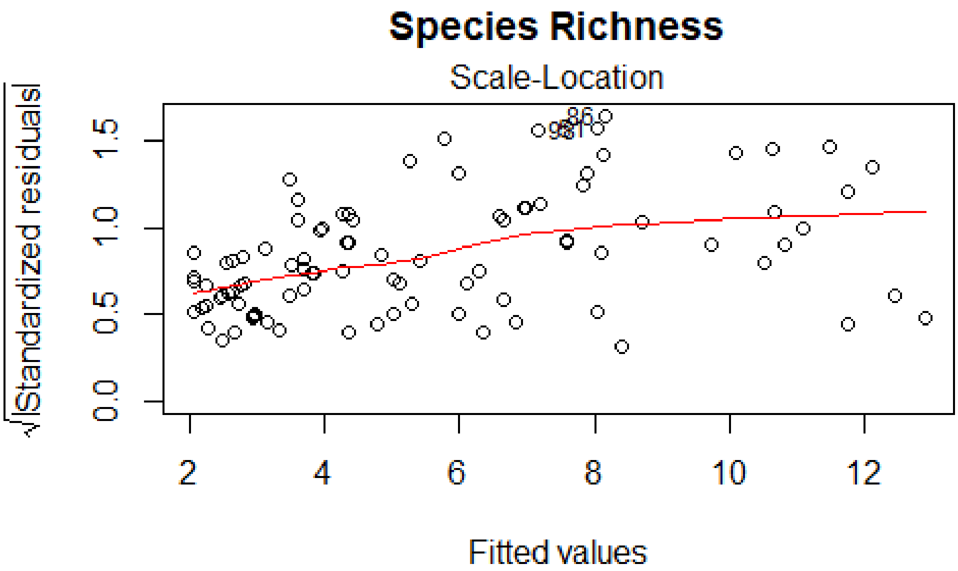
2.2: Cook's Distance Species Richness



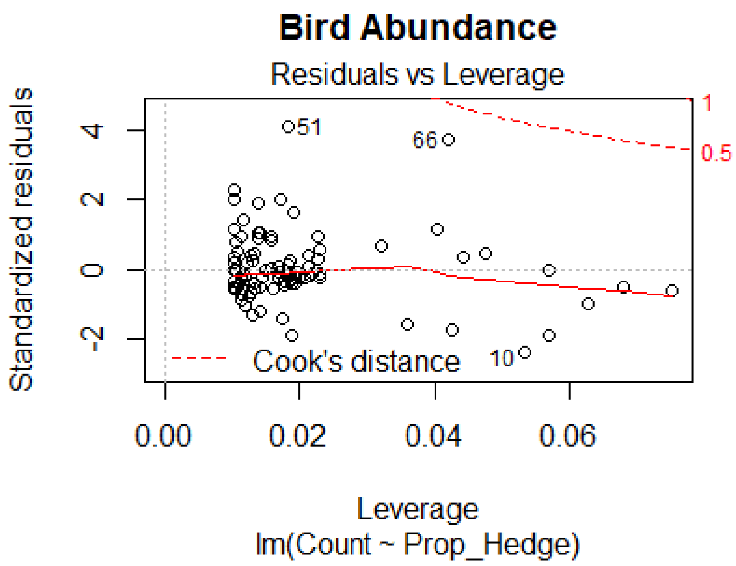
2.3: Scale Location Graph Bird Abundance



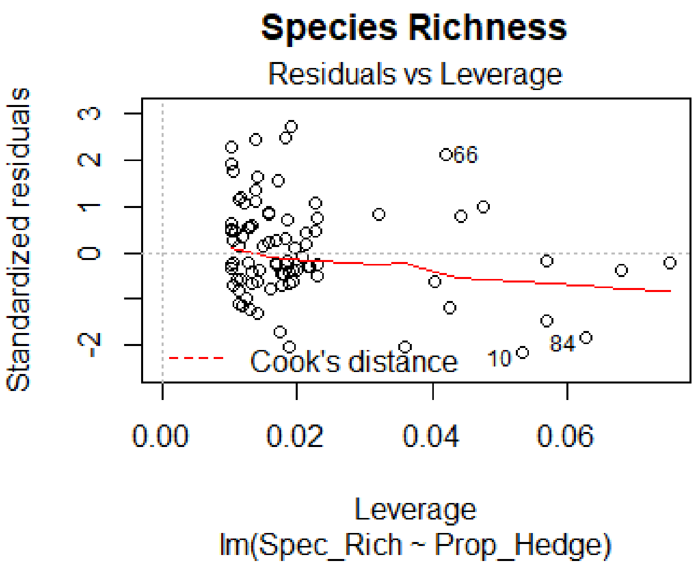
2.4: Scale Location Graph Species Richness



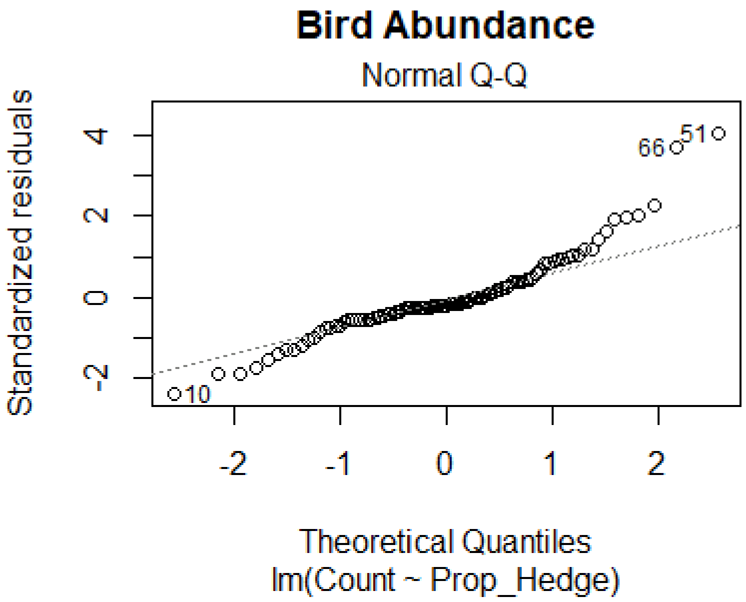
2.5: Residuals vs Leverage Bird Abundance



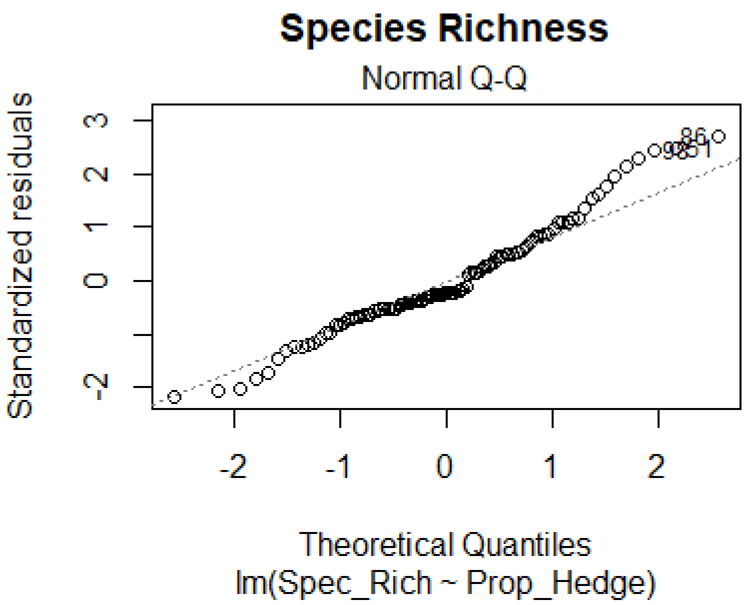
2.6: Residuals vs Leverage Species Richness



2.7: Normal Q-Q Bird Abundance



2.8: Normal Q-Q Species Richness



Rstudio script

This jpg file shows the script in Rstudio

3. R script

```r
library(readxl)
Final_Broed_2 <- read_excel("~/ArcGIS/Projects/MyProject2/Excel bestanden/Final_Broed_2.xlsx")
Species_Richness <- read_excel("~/ArcGIS/Projects/MyProject2/Species_Richness.xlsx")

Count <- Final_Broed_2$New_Broed_1and2_Join.Join_Count
Prop_Hedge <- Final_Broed_2$Tabulat_New_1and2.Prop_Hedge
Spec_Rich <- Species_Richness$Sum

cor.test(Count,Prop_Hedge, method = "pearson")
cor.test(Count,Prop_Hedge,method = "spearman")
lmSA <- lm(Count  ~ Prop_Hedge)
summary(lmSA)
plot(Prop_Hedge,Count, xlab = "Proportion Hedge",ylab = "Number of Birds", main = "Bird Abundance")
abline(lmSA, col = 2, lwd = 2)
plot(lmSA, main = "Bird Abundance")

cor.test(Spec_Rich,Prop_Hedge, method = "pearson")
cor.test(Spec_Rich,Prop_Hedge,method = "spearman")
lmSR <- lm(Spec_Rich ~ Prop_Hedge)
summary(lmSR)
plot(Prop_Hedge, Spec_Rich,  xlab = "Proportion Hedge",ylab = "Number of Species", main = "Species Richness")
abline(lmSR, col = 2, lwd = 2)
plot(lmSR, main = "Species Richness")
```