University of Zurich[UZH]

Faculty of Science: Geography

Computational Movement Analysis (Geo 880): Semester Project

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1 Introduction

The team roles and responsibilities were evenly distributed over the team.

1.1 Research question

In this project we will address a way of defining interaction between biker and roe deer in the Sihlwald in Zürich. We will further aim at detecting a daily behavior of roe deer. The goal of this computational movement analysis project is to answer the following research question: "How does the normal daily behavior of roe deer in the 'Wildnispark Zürich' look like and do humans influence or change this behavior patterns."

For this purpose, we determine the daily behavior of roe deer by looking at data within a time span of two weeks and establish interaction between the visitors counted at five counter stations.

We would like to thank Ronald Schmidt for providing us the visitor data from the Wildnispark Zürich 2014 and other additional information. A special thanks also to Prof. Dr. Roland Graf from the Animal Management Group who provided the tracked roe deer data in the area of the Wildnispark Zürich.

1.2 Data and conceptual models

The following data used to answer the research question:

Behavior

- Roe deer data 2014
- SwissTLM3D
- Visitor data Sihlwald 2014

Interaction

- DHM 2014 from the canton of Zurich
- Roe deer data 2014
- Visitor data Sihlwald 2014
- Counter stations (#201-205)

Conceptual models for trace and space are both used. The roe deer data are data of the Langrange perspective because they are recorded with GPS whereas the visitor data are Euler perspective data due to measuring at the counter locations. Concerning space, the roe deer data are continuous and the visitor data are discrete since they are limited to the path ways and the counter stations of the Wildnispark Zürich (Laube 2014).

2 Investigation

2.1 Behavior

To distinguish the daily behavior of roe deer, we use the roe deer GPS data from the animals RE02, RE07 and RE12 between the 11.07.14 and 24.7.14 and the Swiss TLM3D ground cover data. We chose these dates because we have many 5 min interval measurements in this time span. Since the aim is to find a characteristic daily behavior of roe deer we decided to analyse two weeks. If there is a clear pattern in the behavior it will appear in those data. The Swiss TLM3D covers 7 classes (rock, lotic waterbody, shrubbery, unconsolidated rock, lentic waterbody, wetland and forest). Unfortunately there is no class for grass. We cover this gap by plotting the results also on OpenStreetMap and get the land cover classes from there and Google Earth.

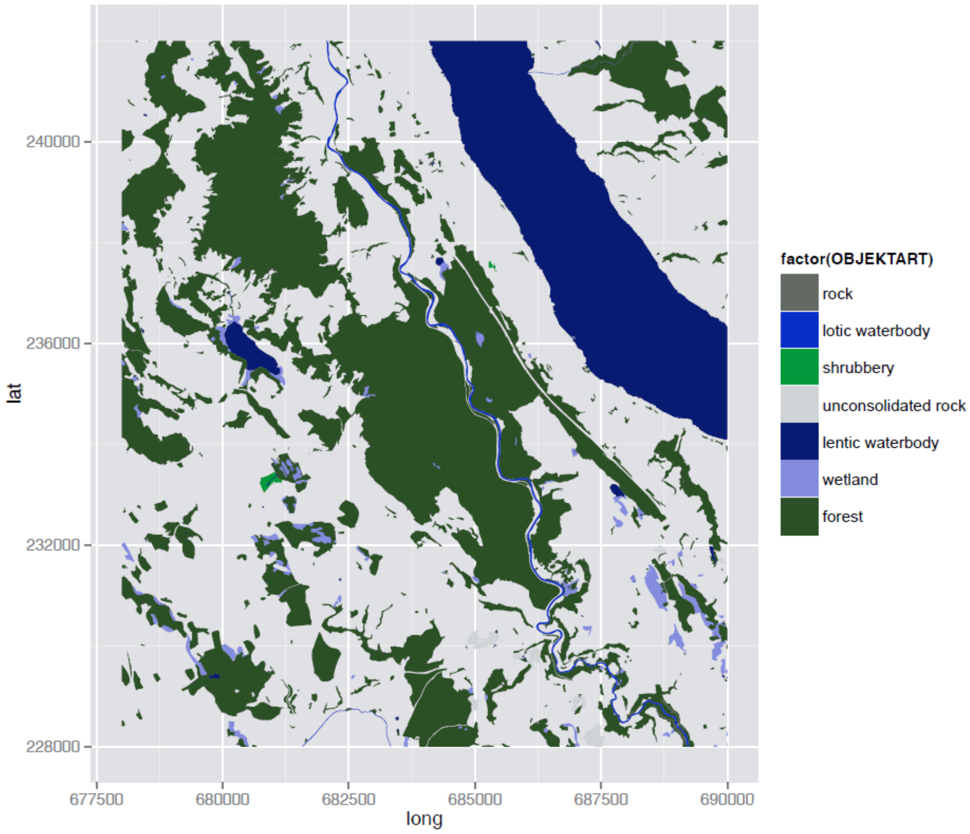

Figure 1: TLM3D ground cover data

First, the data was prepared. A column was added to every measurement defining whether the roe deer has moved or not. Therefore, the step length between two measurements was calculated. By testing different threshold, we defined 10 meters as threshold for whether a roe deer has moved or not. Then only measurements with time intervals smaller than 10 minutes were selected since time intervals of 180 min are very difficult or even impossible to interpret. The movement data are then plotted on to the ground cover classes and a count is made for each ground cover type. A combination of daytime, ground cover class and movement is used to identify the behavior.

From the literature we expect roe deer to be active mostly in dawn, around midday and in twilight. Roe deer have a 6 to 8 hour digestion rhythm. Their behaviors include move, escape, graze, ruminate and sleep. When a roe deer is disturbed it first keeps down and then escapes. The escape route is rather short. Roe deer are expected to be more in the forest during the day. They sleep in the forest as well as on the open field in the night (Stiftung Unternehmen Wald n.d. / MountainWilderness n.d.).
In July dawn is around 4:00-6:00 and twilight between 21:00-23:00 in summer here in Switzerland (Jura Sternwarte n.d.).

2.2 Meeting

The approach of meeting between human and roe deer is a viewshed analysis in ArcGIS. We are interested in the interaction between roe deer and human. We use this approach because we do not only have an interaction between human and roe deer when they physically meet each other, but also when they can see each other. This is independent of the distance between them. We assume that a roe deer is only disturbed by human when it can see them. Whether a person can also see the roe deer is irrelevant. Thus we have an interaction when people (counted at the counter stations in the park) can be seen from the place where the roe deer is located within the same time span. As time span we define full hours (0:00 - 23:00) because the visitors passing a counter are summed up per hour. The viewshed analysis was calculated in ArcGIS using the DHM25 elevation with 200m resolution of Swisstopo. This data was provided by GIUZ. We decided to ignore the surface (vegetation) because an animal can also observe a counter station when it is located in the forest.

Since ArcGIS cannot handle more than 16 points per viewshed analysis, we used each counter station and determined all locations (raster) from where this station can be observed. We are interested in locations from where human at the counter stations can be observed. In Switzerland, the average male height is 1.75m and the average female height is 1.65m (Wikipedia n.d.), thus in the viewshed analysis we set 1.65m as observer height. We converted the roe deer locations in a raster with cell size 1m (as value we us a unique key which is the id of each roe deer measurement) and multiplied it with the viewshed. Now we know for each measurement if the animal could observe the counter stations (1) or not (0). When a roe deer can observe human at a counter, we call it visibility. To compare the visibility with the visitors, we decided to look in detail at RE12 between the 11.07.14 and 24.7.14 due to the high visibility at the counter station 201 and 205 during the measurement period. Since we only have visitor counts per hour, we had to summarize the roe deer measurements and their visibility per counter. We calculated a percentage value for the visibility. If we have for example five measurements in an hour and from four of these measurements the counter can be seen, the percentage value of this counter in this hour is 0.8. We multiplied this value with the visitors per hour for each counter station and summarized them. As a result, we have the interaction between roe deer RE12 and the visitors per hour.

2.3 Results

The results consist of maps showing the coordinates of a roe deer and whether it has moved or not. Additionally a plot is produced to illustrate the counts of coordinates on each ground cover class for each movement category. The histogram shows the speeds a roe deer has per time span.

All three roe deer (RE02, RE 07 and RE 12) were analysed. Similar behaviors are found for roe deer 02 (classes 09:00-14:00, 19:00-23:00 and 23:00-03:00), roe deer

07(classes 07:00-12:00, 19:00-23:00 and 23:00-02:00) and roe deer 12 (classes 06:00-11:00, 18:00-22:00).

Representative plots for the behavior are shown in this section. We chose on a data driven approach to distinguish the classes 06:00-11:00, 09:00-14:00, 19:00-23:00 and 23:00-03:00. There are no 5min interval data available in this time span for the after-noon.

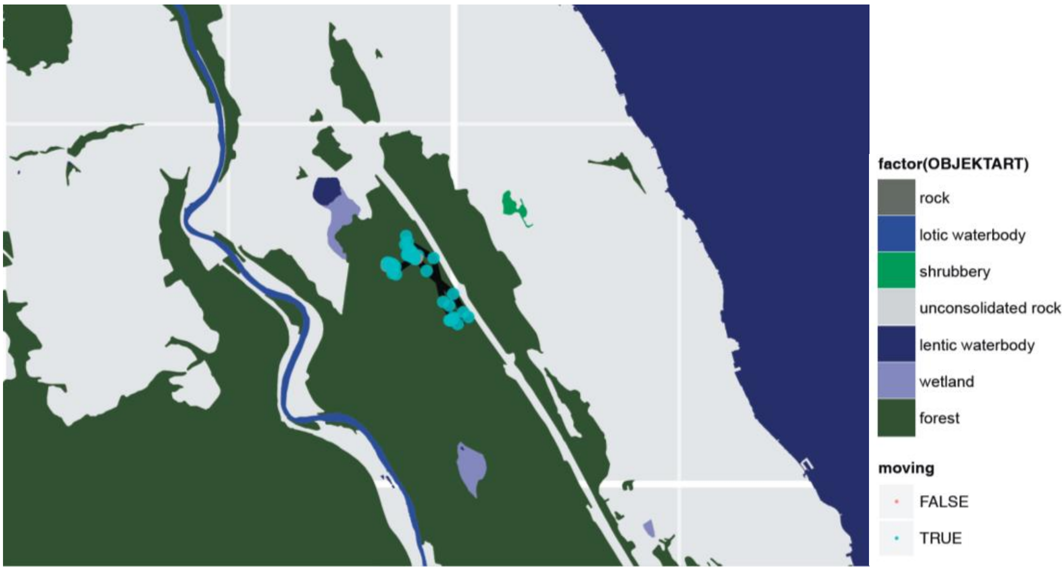

Figure 2: RE12 06:00-11:00/ 11.07.16

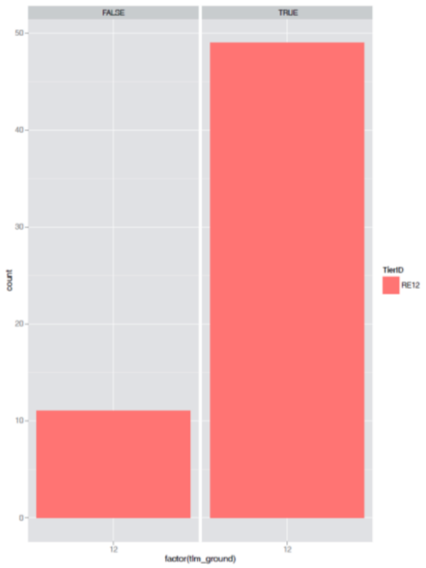

Figure 3: ground cover per movement category

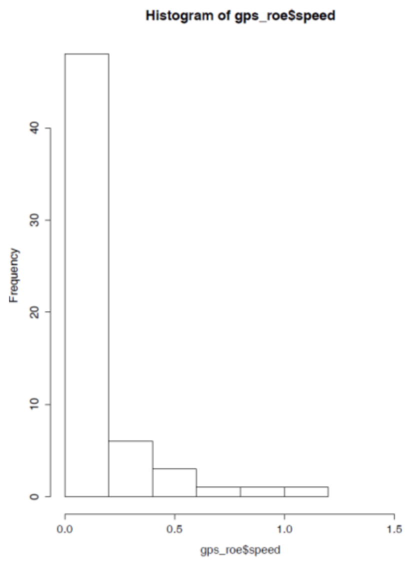

Figure 4: speed

The roe deer is quite active in the morning. The dots in figure 2 represent the places the roe deer was in the morning of the 11.07.14. It spent the whole time in the forest moving very slowly. But also reaching speeds up to 1.2ms^{-1} a few times.

Figure 5: RE02 from 09:00-14:00

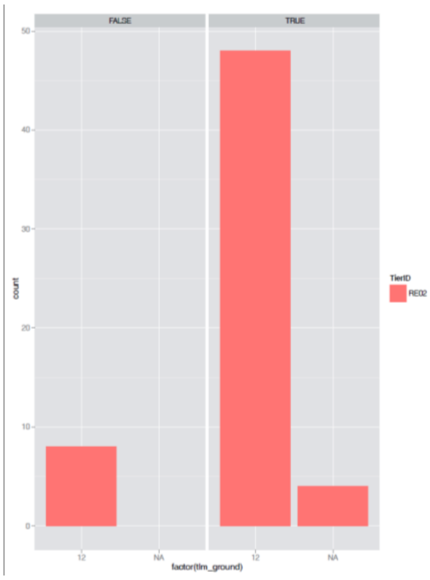

Figure 6: ground cover per movement category

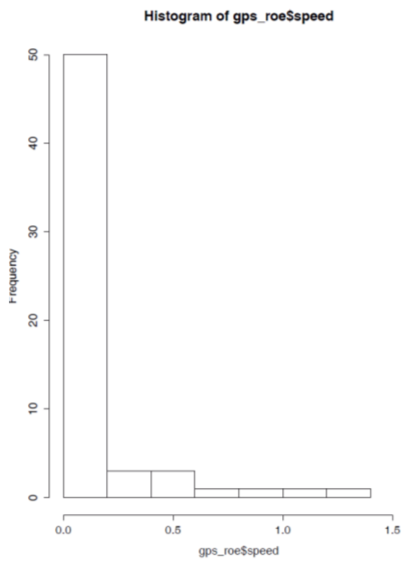

Figure 7: speed

Figure 5 and 6 show that the roe deer was active most of the time between 09:00 and 14:00. It was mainly in the forest, only a few points lay outside the forest on the field. The roe deer was moving at low pace but had to run a few times reaching speeds up to 1.4 ms^{-1}. The data shown above are all from one date since these are the only 5min interval coordinates we have in the defined time span. So it can be seen that the roe deer has moved a lot during 09:00 and 14:00.

Figure 8: RE02 from 19:00-23:00

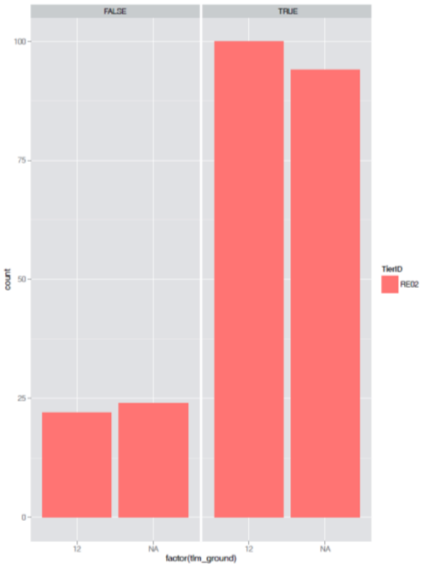

Figure 9: ground cover per movement category

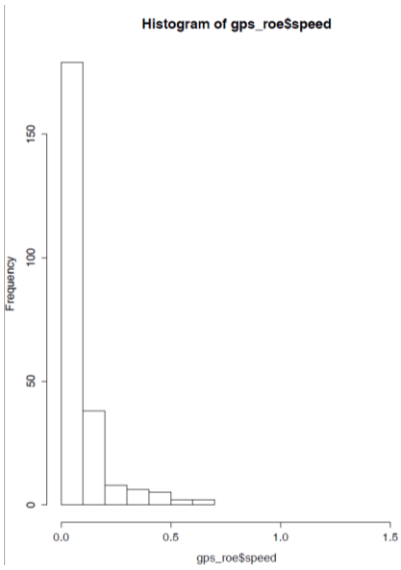

Figure 10: speed

The data in figures 8 and 9 show that the roe deer was active most of the time. For the time moving as well as for the time not moving it spent equal amounts in the forest and on the field. The speed maximum is $0.7ms^{-1}$.

To illustrate how much the roe deer moves in one evening the 13.07.14 was chosen to plot the coordinates on the map.

Figure 11: RE02 19:00-23:00/ 13.07.14

Figures 8 and 11 show that the roe deer choose different spots but then stay close to it during the whole evening.

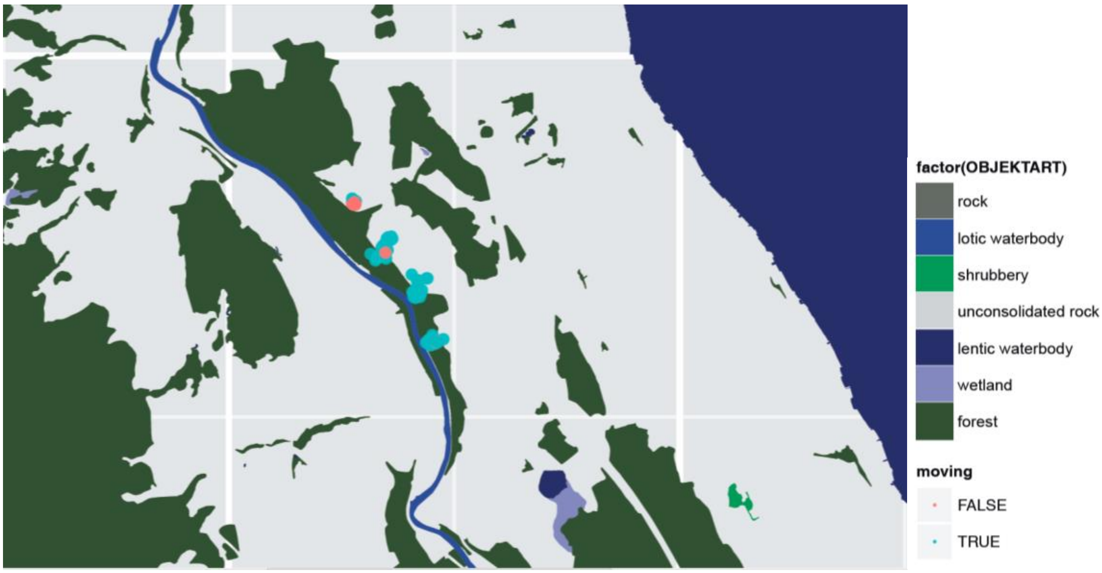

Figure 12: RE02 23:00-03:00

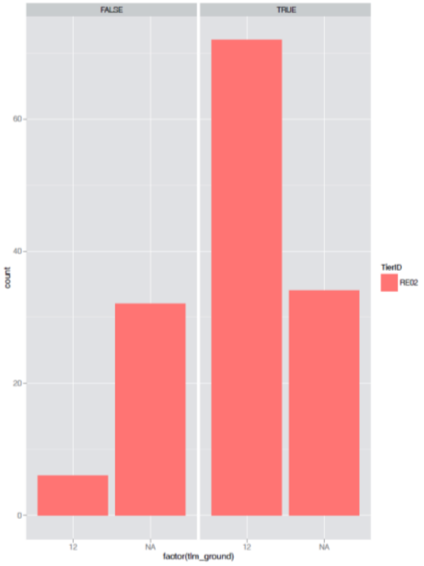

Figure 13: ground cover per movement category

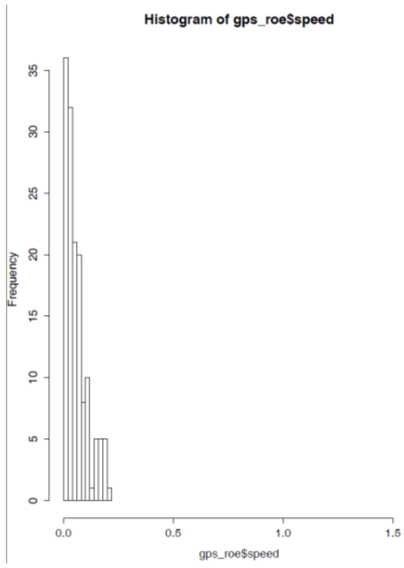

Figure 14: speed

Clear spots where the roe deer spends its night can be distinguished. Also during this time period the roe deer is active. It is moving mainly in the forest but also on the field. When it is not moving it is mostly on the field. This relates to the fact that roe deer sleep on the open fields in the night.

Figure 12 and 15 illustrate again that roe deer choose one spot for the night and then move around close to it. The spot changes from night to night.

Figure 15: RE02 23:00-03:00/ 17.07.14

The roe deer data show that roe deer are very active in general. In the morning as well as during the day they move around 5 times more than they stay on the same spot. When not moving we expect roe deer to either sleep or ruminate. During the day roe deer are mostly in the forest. Only a few times they are spotted on a field. In the evening they move far less distances but still moves 4 times more than they do not. During the evening they spend about equal time in the forest and on the field. In the night they are the least active. But still they move about 3 times more than they do not. The time not moving they spend mostly on the open field.

The speed histograms show a clear trend. Highest speeds are encountered during the day and lowest speeds during the night. This could be an indication for disturbance since roe deer are not expected to move fast by themselves because of their week circulation. Speeds in the morning are a bit higher than in the evening. This correlates nicely with the counts of visitors of the 'Wildnispark Zürich' shown in figure 16. Most visitors visited the park in July 2014 between 8:00 and 20:00 with a peak between 11:00 and 15:00.

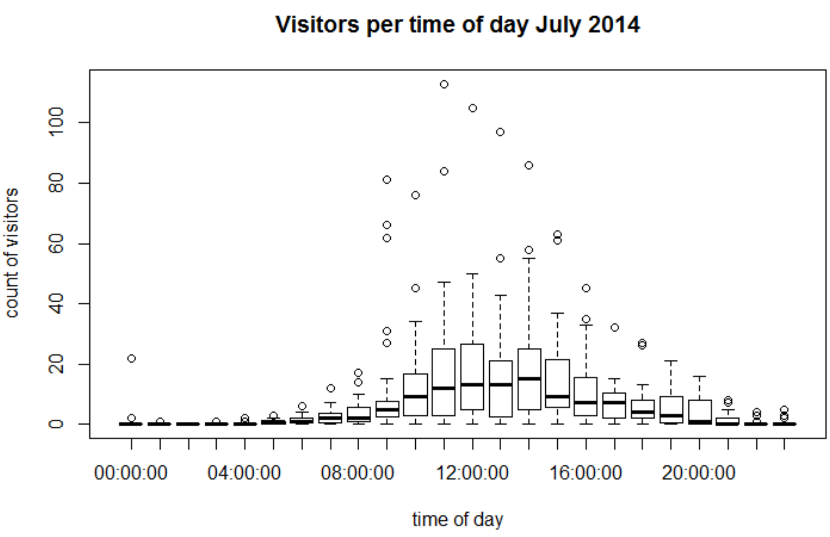

Figure 16: visitors per time of day in July 2014

Visibility

Figure 17 illustrates the visibility from the five counter stations in the Sihlwald Zürich. The lighter the blue the more counter stations can see this location. The roe deer are most of the time in areas where they are either not visible or visible from two counter stations.

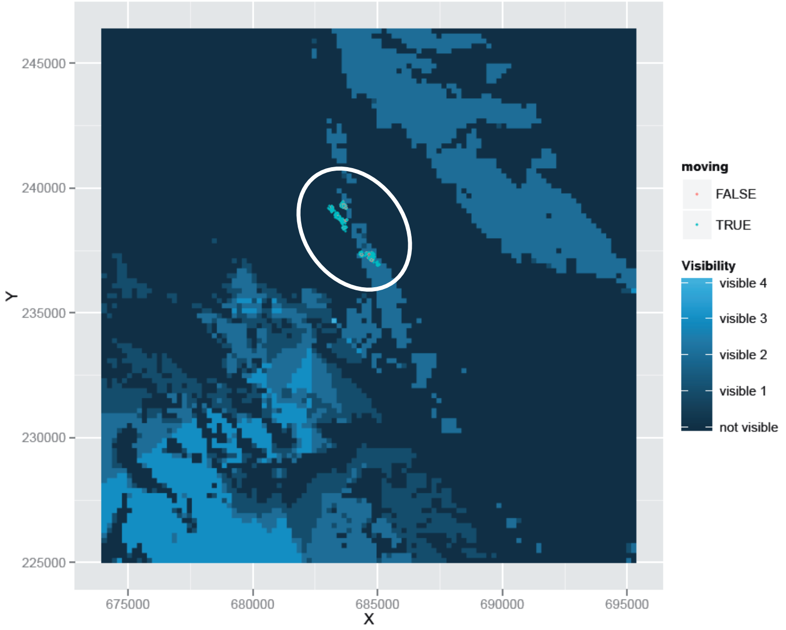

Figure 17: visibility from counter stations

Figure 18 shows the mean visible interactions of RE12 with the 5 counter stations in the two weeks in July 2014. Interactions take place mostly around 9am and between 6-8 pm. There are more meetings in the evening than in the morning. These interactions relate to the fact that high speeds are encountered during the day and not at night.

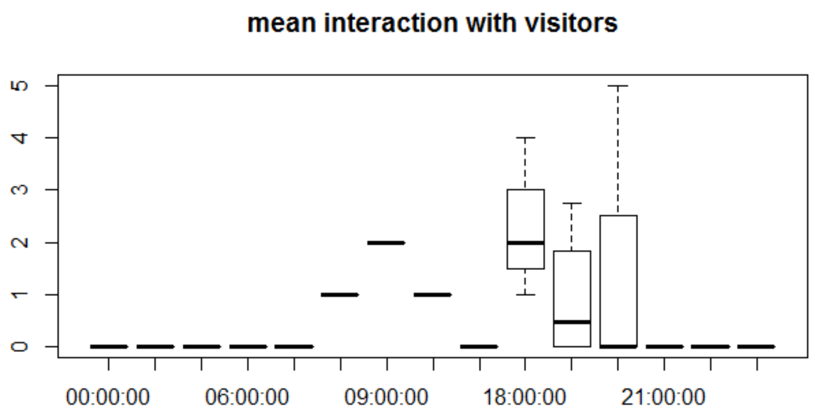

Figure 18: mean interaction with visitors July 2014

3 Discussion

Problems and limitations with software

At the beginning the aim was to calculate the viewshed analysis in R with functions of the package GRASS7. Unfortunately, the installation of the package in R Studio did not work on the remote desktop. Since the DHM25 data is only available on the remote desktop, we decided to work with ArcGIS. The usage of DHM25 is not very good, because the resolution is with 200m too low. However, ArcGIS could not deal with the "big data" of the DHM2014 with a resolution of 0.5m provided by the canton of Zurich (GIS-ZH). We did also not look at meetings with bikers because the data set is too big to analyse the visibility in ArcGIS.

Discussion of approaches

We defined meeting in a way that meeting takes place when a visitor and a roe deer can see each other. We argue that disturbance can take place even when the visitor and the roe deer are not at the same spot but interfere through eye contact. This approach could even be more specific to roe deer through including smell and sound since roe deer have a very good sense of smell and a good acoustic understanding. Therefore, the diffusing of smell and sound could be analysed and included into the model.

In order to define the behavior of roe deer we distinguished between moving and not moving. A simple criterion of less than 10m per 5min was used. This criterion was empirically found through looking at the data and trying out different values. This factor could be set more precisely through observation of roe deer. These observations could then also help in distinguishing between sleeping and ruminating which could not be separated in this approach.

Discussion of data

The ground cover data provided by SwissTLM3D are of good resolution. The accuracy for land cover classes is between 1-3 meters. The main restriction of the data is that it consists only of 7 ground cover classes for the area of the Sihlwald. The class field/ grass which is one of the main classes for roe deer analysis is not present. Therefore OSM and GoogleMap data were used to fill the gaps. Concerning the roe deer data one of the main challenges was to deal with the different time intervals. We decided to use only time intervals smaller than 10min for our analysis, which then leaves us with incomplete time spans. So the classes to group morning, midday, evening and night were chosen according to the data available. Also due to this incompleteness of 5min interval data we were not able to distinguish the supposed 6-8 hour digestion rhythm.

An extension of this work would be to find sequences in the behavior of roe deer. Those sequences could also be related to the ground cover class. In order to identify sequences more continuous measurements of 5 min interval data would be needed.

Since we worked with data of different conceptual models and time resolutions the comparison of them is difficult. It would be interesting to compare the daily behaviour of roe deer with tracking data of visitors.

4 Conclusion

We managed to do an analysis of the daily behavior of roe deer and to identify interactions depending on visibility. When looking at the speed of the roe deer the plots clearly showed a relation to the counts of visitors. During midday when there were most visitors counted the speeds were highest. Concerning our research question it can be said that the humans influence the behavior of roe deer in the 'Wildnispark Zürich'. We were not able to analyse whether the behavior patterns change because of the interactions since behavior patterns could not be identified in form of sequences.

Further research could be addressed to finding sequence patterns and then analyses whether they change when a meeting occurs or not. If the sequence does not change it would mean that the visitors influence the roe deer temporarily but not with lasting effect as to say they stop sleeping during a longer period.

Literature

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https://en.wikipedia.org/wiki/List_of_average_human_height_worldwide, Access: 17.06.16

Appendix 1 – Code description

The complete R file is uploaded separately on OLAT since it is more readable in R than it is copying it into a pdf.

The code starts with loading the libraries and the functions written in the course. Then the section for the visibility analysis starts. The data are prepared in R and also the result is plotted in R. The calculations were done in ArcGIS.

Then the section with the code needed for the behaviour analysis begins. First, the raw data are imported and adjusted for the calculations. Then the calculations for steplength and speed are done and the spatial information about elevation and ground cover type was added.

The section called "Date&Time" is very important. In the variables "a" and "b" the start and end time of the analysis can be specified. Those variables can be adjusted in every run and are independent from the analysis and can be used to group the hours into the classes morning, midday, evening and night. Then the specified hours are extracted from the dataset for the 11.07.14-24.7.14.

Now the roe deer you are interested in can be selected by running one of the three provided lines. If you are interested in all three roe deer you can skip this part. The line: gps_roe <- gps_roe[(gps_roe$timediff < 10),] selects all time measurements with an interval smaller than 10 min.

In the last section all plots and visualizations are produced.