Behavioral differences in urban and rural owls

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Abstract

Light pollution, noise and man-made structures can have an influence on the behaviour of different animals, for example like the European owl (lat. bubo bubo). In this project we compared the urban and rural owl to conclude if these mentioned factors can have an influence on these animals. For analysis we examined the factors hunting time, duration and the hunting area to answer this question. As a result of our research we can conclude that the hunting time has no big differences between both types, as well as the hunting duration. But the analysis of the hunting area shows that the rural owl covers a larger hunting surface than the urban owl. For future research more owls should be included into the analysis.

1 Introduction

Human activities are a major force in shaping the biosphere. Scientists have become aware that not natural forces but rather human actions are the source for most contemporary change or obstruction of biogeochemical cycles [1]. In addition, humans have a major influence on animal behaviour due to light pollution, noise or man-made structures in the natural environment of animals among others [2][3][4]. Understanding these human-animal dynamics is essential if both are to coexist. Therefore it is important to document and analyse the current situation. GPS tracking devices are often used to monitor animals. With these, spatio-temporal data can be recorded for the individual animals. This allows new insights into the behaviour of animals to be discovered, as it allows for monitoring of the animal and its activities.

1.1 Research Question

This GPS-enabled anaysis allows us to direct our research at the behaviour analysis of individual owls. The question this research poses is the following:

To what extent does the behaviour of owls in urban environments differ from that in rural areas?

To answer this as a whole, three supplementary questions are asked to specify the subject.

- How do nocturnal activities differ in both categories?
- To what extent does the hunting radius differ?
- How do hunting times differ in both categories?

1.2 The eagle owl

The eagle owl (lat. Bubo bubo) is a nocturnal bird which can mostly be found in Europe. Typically of this owl is that it is often habituated in richly structured landscapes. When hunting the eagle owl usually requires spots with good observation and hiding capabilities. When choosing a location to hunt or breed these factors are more important, than the direct availability of food in the area, making the eagle owl a location-loyal animal. Location-loyal animals tend to stay in one place and typically will not leave their hunting grounds. The eagle owl's habitat can come in three forms:

- Forests
- Wetlands
- Populated areas

This wide arrange of different habitats emphasises the point that the eagle owl is a highly adaptive animal and that it can survive in various conditions [5].

2 Methodology

2.1 Data set

The data set available to us consists of GPS coordinates of 21 different owls. The pattern according to which measurements were taken varies from owl to owl. GPS coordinates are recorded at intervals depending on the owl. The largest interval we have is 30 minutes while the smallest interval is 30 seconds. Additionally, each owls does have an individual measurement starting point and end points. So while for some owls in the data set, measurements always start at 5pm and end at 4am, others will start at 8pm and finish at 5am.
The data set contains information about the position (latitude and longitude), time of measurement and general information about the owl in question. Since this research work deals exclusively with the time and position data of the owls, unneeded columns like gender were removed.

2.2 General

2.2.1 Pre-Processing

First, we classified the owls in urban and rural. For the number of inhabitants of the areas we have estimated the possible number of inhabitants with google research. After that the decision was to classify all owls as rural were the number of inhabitants is under 1000. Above 1000 inhabitants per area was classified as urban (see figure 2, "Inhabitants"). Afterwards we checked whether the area in question was more likely to be forest, roads or residential areas. For supporting our decisions we matched our classification with the VIIRS 2015 and the World atlas SQM light pollution data [6]. The VIIRS data shows the radiance coming from the earth surface (0 – <75 radiance 10^{-9} W/cm^2 * sr), influenced by different light sources, while the World Atlas shows the brightness of the sky (<17.5 – 20.0 magnitude/arc second^2), that means how dark the zenith is [7], [6]. For the data of the World Atlas and the VIIRS we looked at the mean values of the two sensors per area. The World Atlas classified all owls with values above 21.02 mag./arc sec.^{2} as rural and below that as urban (see figure 2 "World Atlas SQM). Based on this information, we have decided to classify the owls as shown in figure 3.

2.2.2 Analysis

To examine the time component of the owls, the data set must first be divided into individual days. With the knowledge that the owl usually hunts from dusk to dawn, this subdivision can be done programmatically. The next step is to find the exact start and end point of the hunt. For this purpose a condition for the start and end of the hunt has been defined.

- *An owl starts to hunt from the point where it first moves for more than 20m*
- *An owl will stop hunting if it does not move more than 20m for a period of 20 minutes*

After the individual days have been adjusted using these criteria, statistics can be calculated. A flowchart describing the proposed method can be seen in 1.

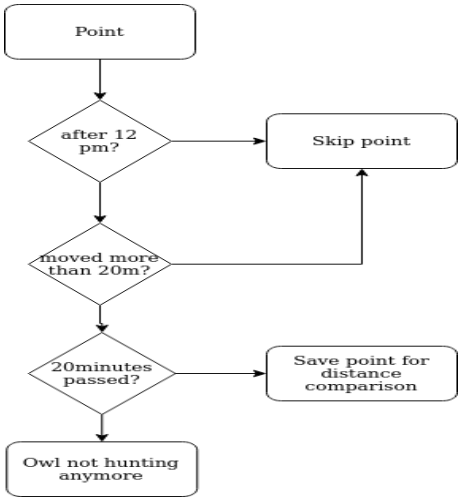

Figure 1: Flowchart time analysis

Additionally, the approximate area that each eagle owl covers is considered as well. The reason why we want to calculate it is to compare both rural and urban area and relate them with time analysis to further proceed with our conclusions.

We apply a method to calculate the convex hull to the points that each eagle owl contain. What the convex hull method does, is that it generates a polygon whose side lines are built from most peripheral points of all points of each owl individually. So, the polygon from the convex hull contains all points from which it was calculated, inside it. We do this in order to get the area that each eagle owl covers when they are moving during the time provided. Before applying the mentioned method, we identified each owl. Our eagle owls are distinguished from each other by their id number. From the convex hull we calculated retrieved the size of the hunting areas

2.2.3 Post-Processing

To visualize our results and to compare the two types of owls directly, we have presented them in boxplots to identify the mean values and possible outliers.

2.3 Implementation in Python

The whole project was implemented in Python, version 3.7. Since QGIS (3.8.2+) offers a wide range of libraries, we used its extension.
In our first step we analysed the respective hunting grounds in detail and gave them a rough allocation to towns or villages. After that the owl types were added to the attribute table as a new column, named ”owl types” and we categorised them into the owl-types ”rural” and ”urban”. Since we had data for the VIIRS-2015 for all areas available as GeoTiff, we combined them with the convex hull shape. Therefore we cut the raster data into the size of the respective area and then visualised it with the right coordinates and the values for the light pollution (see figure 2). For this step the common libraries GDAL, OSR, OGR[1] an Numpy[2] were used and for the visualisation also the matplotlib library. In order to analyse the time component of the dataset first, a shapefile for each owl was created. This was done because the intial shapefile contains well over 100.000 features and calculating on such a big file is more prone to crashes and overall takes more time. Afterwards, the GDAL/OGR library is used to extract information from the shapefile. After extracting the shapefile information the time analysis according to 2.2.2 is performed. For this mostly native python libraries are used. The dateparser [3] library is used in order to correctly parse the date information. When performing calculations on the data set, the date information is converted to total amount of seconds. After calculation is done, it is converted back into hours. Moreover, three native python libraries are used. These include: csv, math, os.

[1] https://www.pypi.org/project/GDAL/
[2] https://pypi.org/project/numpy/
[3] https://pypi.org/project/dateparser/

As a preprocessing part of calculating the area would be to transform the coordinate reference system from geographic to a projected one in order to get the area in square meters rather than in square degrees. The new projection chosen was "Europe Albers Equal Area Conic" as it is the kind of projection that preserves the area when transformed. To calculate the area of polygons that represent each owl we first use the method "ConvexHull()" and than the method "GetArea()". We add the area that we calculated in a new field in the layer. We use OGR library to get the method for the convex hull to build polygons from the points. The same library is also used for calculating the area of those polygons. Another library imported is OS library, which is used to define input and output shapefiles.

For the visualization of all our results we used the boxplot method from the Matplotlib library. From the final CSV file we ordered the data by the "owl-types" and picked the respective values (duration, start-end-time, area), for each visualisation. To do the statistical analysis we used the statistic-library [4].

[4] www.github.com

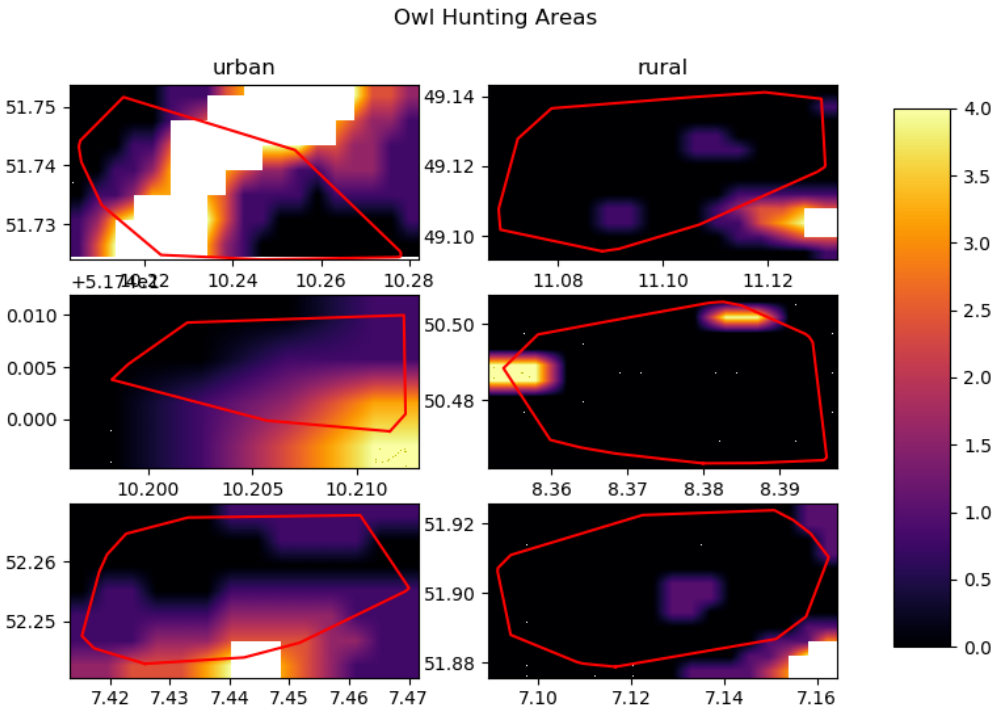

Figure 2: VIIRS-2015 light-pollution map under convexhull - left side shows the as urban classified owls and the right side the rural owls. The colors correspond to the values of the light pollution data from the light pollution map

Owl ID	Area Name	Inhabitans	VIIRS 2015	World atlas SQM	Typ
3897	Haag - Schloßberg	<1000	1,42	21,48	Rural
3898	Haag - Schloßberg	<1000	1,42	21,48	Rural
4846	Phillipstein	1001	0,91	21,34	Rural
4848	Förste - Osterode am Harz	1789	5,875	21,35	Urban
4046	Förste - Osterode am Harz	1789	5,875	21,35	Urban
4043	Förste - Osterode am Harz	1789	5,875	21,35	Urban
5158	Förste - Osterode am Harz	1789	5,875	21,35	Urban
3892	Rheine	76530	2,24	21,00	Urban
3893	Rheine	76530	2,24	21,00	Urban
3894	Baumberbe Nottuln	11.979	0,28	21,28	Rural
1292	Buldern	5800	0,15	21,20	Rural
3896	Flamschen	<100	0,58	21.17	Rural
3895	Flamschen	<100	0,58	21.17	Rural
1750	Nöllenhammerweg Wuppertal	354.382	5,71	20,50	Urban
1751	Nöllenhammerweg Wuppertal	354.382	5,71	20,50	Urban
3899	Mettmann - Vohwinkel	30.740	10,53	19.88	Urban
1753	Rohdenhaus - Neviges	18.858	7,99	19,99	Urban
1754	Rohdenhaus - Neviges	18.858	7,99	19,99	Urban
5159	Ibbenbüren	51522	0,87	21,02	Urban
4044	Ibbenbüren	51522	0,87	21,02	Urban
4045	Ibbenbüren	51522	0,87	21,02	Urban

Figure 3: Owl classification in urban and rural - based on the factors inhabitants and light pollution

3 Results

3.1 Hunting Area

In figure 4 can be seen clear differences in the hunting area of both owl types. The rural owls have a bigger hunting area (average $\approx$ 15.807 km^2) as the urban ones (average $\approx$ 7.208 km^2). Thus the average hunting grounds of the rural owls are almost twice as large as those of the urban owl. Particularly noticeable is an outlier of a rural owl with a hunting area of over 50.95 km^2. The smallest hunting grounds are similar in both types and have a size of under one km^2 (see figure 4, table 1).

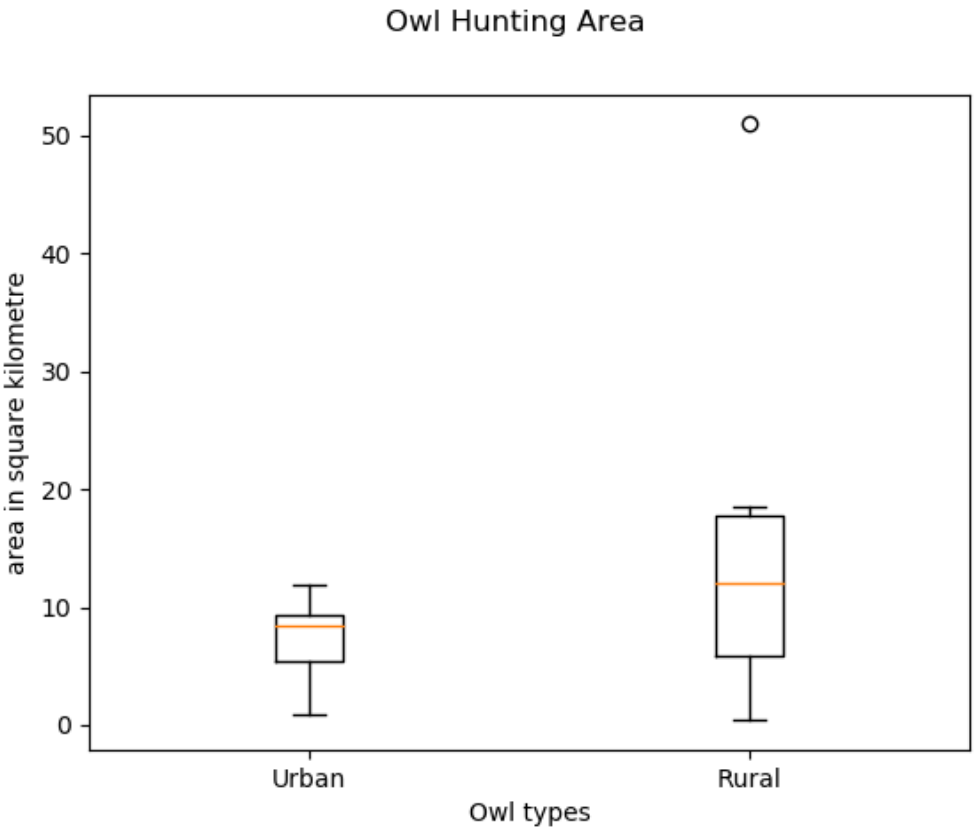

Figure 4: Calculated owl hunting area in km^2

Table 1: Statistics of Hunting Area

	Urban	Rural
median	8.421	11.994
mean	7.208	15.807
standard deviation	3.902	17.058

3.2 Hunting Duration

Figure 5 shows the difference in the hunting duration between both owl types. The rural owl has a mean value by 522 minutes while the urban ones has 523 minutes. There is a small difference in the values whereas higher differences can be seen in the standard deviation. Furthermore it can be seen that the interquartile range of the urban owl duration is bigger then the rural owl (see figure 5, table 2).

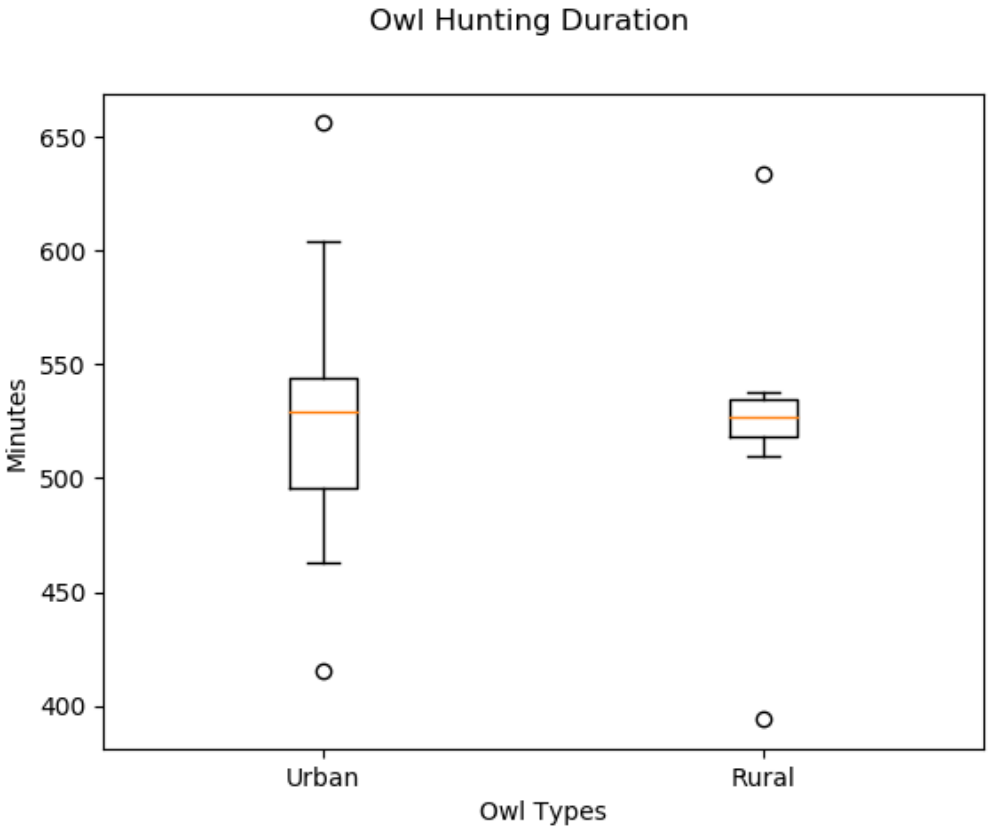

Figure 5: Calculate owl hunting duration

Table 2: Statistics of Hunting Duration

	Urban	Rural
median	529	527
mean	523,333	522,857
standard deviation	58,576	70,053

3.3 Hunting Times

In figure 6 the start and end time of the hunting of the owls are shown. The urban ones start a little bit earlier (average $\approx 6:45pm$) as the rural owls (average $\approx 7pm$). But in the end time they are nearly the same (average ≈ 9 minutes difference). Two particularly conspicuous outliers can be seen: start time (rural) $\approx 5:45pm$ and end time (urban) $\approx 5:30am$ (see figure 6, table 3).

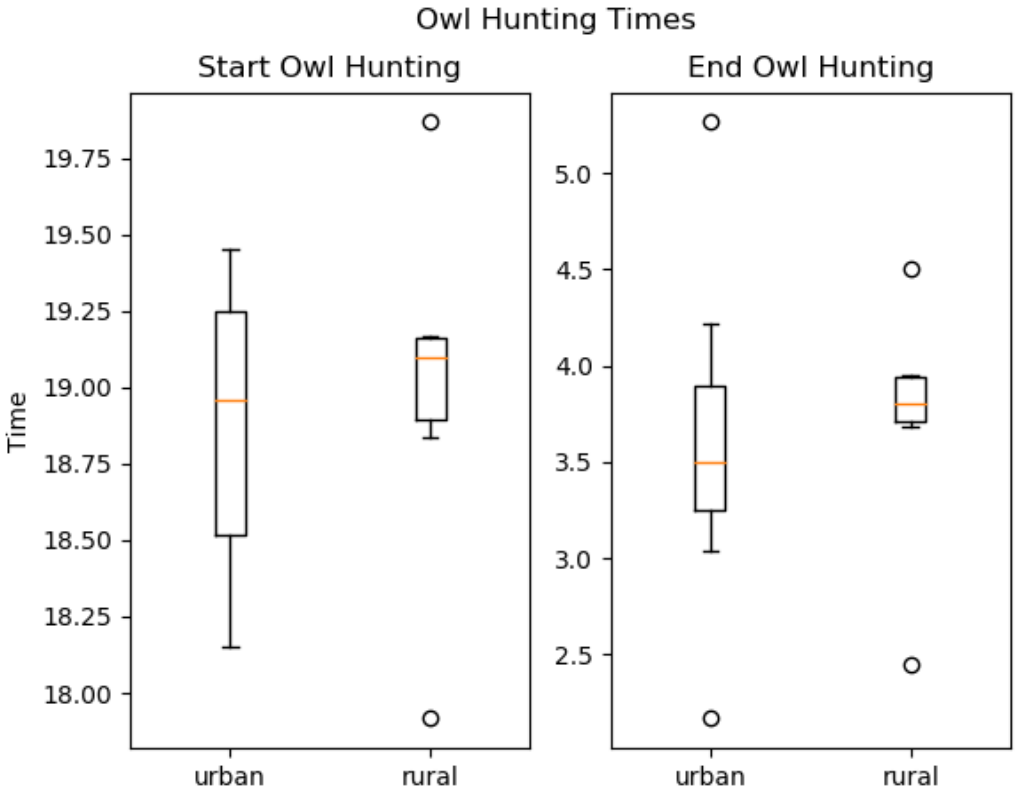

Figure 6: Calculated owl hunting start and end

Table 3: Statistics of Hunting Times

start time	Urban	Rural
median	18,95	19,1
mean	18,86	18,99
standard deviation	0,444	0,58

end time	Urban	Rural
median	3,5	3,8
mean	3,58	3,72
standard deviation	0,7	0,62

4 Discussion

After assessing the results, one notices that that while there seem to be little to no differences in start and end time, as well as the hunting duration, urban and rural owls show significant differences in their respective hunting area. In the following, the results are discussed and possible explanations are given. Further, future research and knowledge gaps within the domain of animal behaviour analysis are given. Lastly, limitations of this research are discussed.

When comparing the hunting areas from the results, rural owls have a noticeable higher hunting surface. The reason for this can be that the rural owls have to fly more to find spoils. Small animals like mice can easily hide in bushes or undergrounds, which make it more difficult for the owl. In urban areas the owls have better chances, because most of the mice for example are located in the trash and have not many hiding places like the others which are living at rural places [5]. DeCandido et. al [8] also suggest that birds in urban spaces can use hideouts in buildings to observe possible prey. Additionally, they propose that animals which live in an urban environment can get disoriented more quickly due to light pollution for instance, making them more vulnerable as prey to hunting birds. Further research into the observation and hiding places of these owls would be necessary to deduct further insight from that.

Hunting times for the two categories of owls do not seem to differ greatly. This could be a first hint that the biorhythm of the owls is not significantly influenced by humans. However, in order to finally determine this, more owls, especially rural owls, would have to be observed. Furthermore, other factors such as the fertility of the owls would have to be recorded. In summary, our results indicate that the two groups have similar hunting seasons. Dominoni et. al. [9] analyse the influence light pollution can have on the biorhythm of animals and also gives indications as to how to measure this influence. Other research also suggests that birds are influenced by light pollution [10][11]. For this reason, this finding of our work should be treated with caution.

Additionally, analysing the time component of our research proofed to be more challenging than initially thought because of faulty or missing documentation of the data set. Moreover, the seemingly arbitrary pattern of measurement across the different owls, makes comparing of for example the starting time of the hunting increasingly hard. Although we used the threshold value to determine whether the owls hunt, this threshold value lacks a sound scientific basis. Overall, with only seven rural owls and 14 urban owls, it would be necessary to conduct further research with more owls, ideally with rural owls.

5 Conclusion

The conducted research shows major differences in the area urban and rural owls cover each night. However, little to no differences were being detected for the hunting times of the owls. This emphasizes the influence humans have on urban wildlife and furhter illustrates the adaptibility of some animals to their habitat conditions.

However, these results must be viewed critically, as the underlying data set suffers from inconsistencies and an incomplete documentation.

6 Project Code

The python code can be retrieved of the following GitHub Repository: https://github.com/carobro/PyGIS

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7 Task division

Which group member has done what

Caro

- Pre-processing with Aysel
- Post-processing - Visualisation with Aysel
- Presentation collaboration
- Report collaboration with Aysel
- Support for problem solving to calculate the convex hull
- transformation of the projection

Aysel

- Pre-processing and Post-Processing with Carolin
- Presentation collaboration
- Report collaboration with Carolin for each task which we done

Mirjeta

- Create polygons
- Calculate the area
- Check for the transformation of shapefile

Eric

- Coming up with a research question(s) and sub questions
- Analysis - time component (an in depth overview of my work on this can be looked at https://github.com/carobro/PyGIS/commits?author=Thiemann96)
- Preparation of the presentation
- Discussion of results