Problem Chosen	2023 MCM/ICM Summary Sheet	Team Control Number
B		Void

A differential equation-based prediction model for cyclists

Summary

Keywords:

Contents

1 Introduction

1.1 Problem Background

”According to the International Union for Conservation of Nature (IUCN), more than 28,000 species are currently considered to be endangered”. Increasing population growth and human activities of urbanisation, industrialisation and agriculture are gradually eating into and crowding out wildlife's habitat. The decline in numbers can be seen in Figure 1 below. In order to counteract the decreasing species diversity, nature reserves have been established. In recent years, however, some ecological reserves have been affected, including the Masai Mara National Reserve in Kenya.

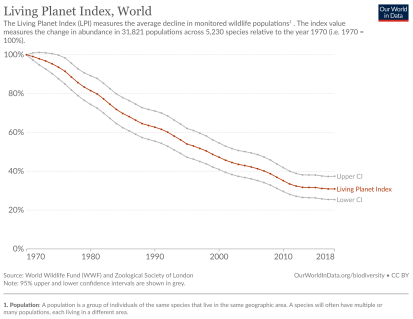

Figure 1.1: Decline of wildlife species in the word [https://ourworldindata.org/biodiversity]

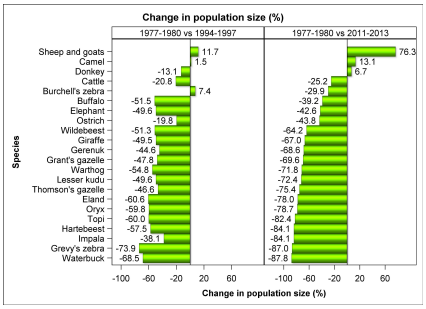

Figure 1.2: Decline of wildlife biomass [https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0163249]

Figure 2 shows the change in wildlife in Kenya from 1977 to 2013, and it is distressing to note the rapid decline in wildlife biomass in this area, and the trend in Masai Mara National Reserve, an important area for wildlife in Kenya, is clearly in line with this. In response to this fact, it is imperative and urgent that a policy is put in place to reduce the impact of human activities around the nature reserve and to pursue a balance between humans and nature.

1.2 Restatement of the problem

An analysis of the background to the problem and a review of the actual situation in Masai Mara National Reserve with regard to the balance between man and nature, the restate of the problem can be expressed as follows:

- ➔ The protected areas are divided according to the characteristics of the different areas in the reserve and modelled for their regional characteristics to predict the optimal combination of human and wildlife populations, balancing human development and nature conservation. And based on this result different specific policies are developed for different areas.
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- ➔

1.3 Literature Review

The main issue in this situation is how to achieve a balance between people and nature around nature reserves. In recent years, with the growing interest in nature reserves, there has been a growing number of

surveys on nature reserves, including the Masai Mara National Reserve.

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1.4 Our Work

This issue required us to identify and evaluate policies for different areas following zoning and to demonstrate that the policies could be applied to other nature reserves. The main points of our work include the following:

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4.

2 Assumption and Explanations

Due to the complexity of the actual problem, it is not possible to consider the full range of factors of the problem in the model. Therefore, the model developed below is based on the following assumptions:

- Assumption 1: The extent of the nature reserve is the area drawn in Figure 4.1.
  Explanation: Because the situation at the edge of the nature reserve is more complex and the boundary itself is not clear. Using the quadrilateral in the figure as the extent of the nature reserve facilitates subsequent modelling and has little impact on the size of the area.
- Assumption 2: Animal populations in protected areas are influenced only by water distribution and human activity.
  Explanation: The results of the Nina survey show that these two factors are the main ones and that considering only water distribution and human activity helps to simplify the model and has a smaller impact on the results.
- Assumption 3: The value of latitude and longitude is used as the only measure of distance. The meaning of all coordinates below is (latitude, longitude).
  Explanation: As previously mentioned in section 1.3, it is possible to convert space into a two-dimensional plane. On this basis, a change in the value of latitude and longitude can be an accurate representation of distance.
- Assumption 4: All information collected during the problem solving process is accurate and available.
  Explanation: All data can be found in specific sources that prove their availability.

3 Notations

4 Model Preparation

4.1 Data Overview

The problem was solved for Masai Mara National Reserve and Masai Mara National park, but no information was given about these two areas. The analysis of the problem shows that it is inevitable to collect geographical and faunal information about the area in order to solve subsequent problems, and that visualisation can make this data more readable.

4.1.1 Data Collection

4.1.2 Data Summary

The search resulted in the collection of maps of Masai Mara National Reserve and Masai Mara National park (F4.1), and also revealed that the human settlements adjacent to the nature reserve are pastoral areas. The conflict between pastoral areas and nature reserves is therefore the main issue to be discussed.

This is because the boundary line of the nature reserve is unclear and too irregular. As mentioned in Part II, in order to simplify the model, the conservation was subsequently modelled and analysed as a quadrilateral area by taking and fitting the latitude and longitude to the edge portion of the reserve. The images were fitted in Matlab by calculating the latitude and longitude of four points, A (-1.2644, 35.0457), B (-1.6068, 35.3913), C (-1.4108, 34.7604) and D (-1.7233, 35.3298), and visualised and labelled with key locations using maps, the results of which are shown in Figure F4.2. The procedure for fitting the calculations can be found in Appendix 1.

According to the Google Map it can be seen that there are several human towns near the line AB, therefore defining the right side of the line as an area of human activity. Point E (the confluence of the three rivers) within the protected area is also defined as the water source.

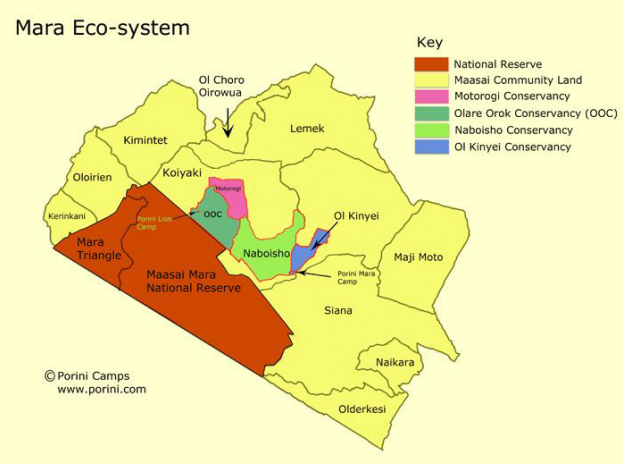

Figure 4.1: The National park map [https://www.maasaimarakenyapark.com/information/location/]

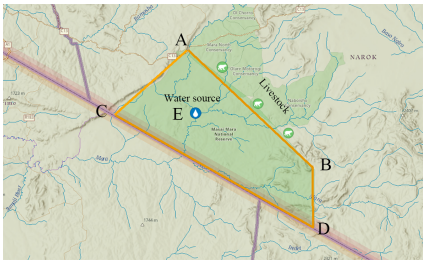

Figure 4.2: Masai Mara National Reserve in Matlab

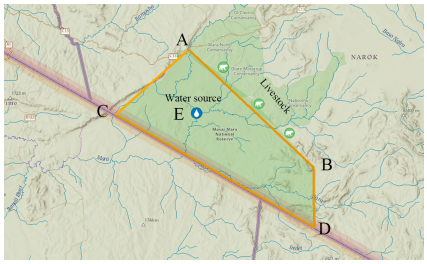

Figure 4.3: Masai Mara National Reserve in Map

5 Model A

5.1 Grid-Method based zoning

Nature reserves are large, and the distribution of natural resources and fauna varies somewhat between different areas of the reserve. In order to develop policies for the characteristics of the different areas, it is necessary first to divide the nature reserves into zones. Previous articles mentioned that areas could be divided into rasters, and each small raster can be analyzed separately (article 1); ecological sensitivity coefficients can also be defined to quantify the differences between different areas (article Guangxi).
To explore the balance between wildlife, natural resources and human activities: human activities and water sources are used to influence ecological sensitivity. The response to environmental influences is through the distance from wildlife to the water source (point E), and the response to influences by human activities is through the distance from wildlife to AB.

5.1.1 Anthropogenic impact factors and Water impact factors

The livestock area is defined as an area of human activity, and the human activity factor K_H is discussed according to the distance from AB. The three equivalents of the lines AC and BD are found and connected. The protected area is divided into three parts, representing different levels of human activity, with the further away from the livestock area, the less human activity is affected. The results of the classification are shown in Figure 5.1.
The water source is defined as the confluence of three rivers, E (-1.43280, 35.06375), and the water impact factor K_W is discussed around point E. The area is divided into three parts according to the size of the protected area. The three parts represent the different levels of impact on the water source, with the farther away from the water, the less impact it has. This is shown in Figure 5.2.
The following weighting analysis was carried out on the anthropogenic and water impact factors, with Bhola mentioning that the human impact had reduced the number of animals moving in the area by 50% between 1970 and 2000. The K_H for the three areas was therefore specified to be [1, 1.25, 1.5] from near to far. The article also refers to the biological density of the area during the wet and dry seasons, and it can be seen that the animal density in the wet season is twice as high as in the dry season. Therefore, the K_H for the three areas are [2, 1.5, 1] from near to far.
The environmental sensitivity K can be calculated by equation 5.1.

$$K = K_{water} * K_{human} \tag{5.1}$$

References

Appendices

Appendix A Pictures which is Data source