research report ver 17

PROJECT APPLICATION DEVELOPMENT - Inholland University of Applied Science

Abstract

This research report explores the development of an application that results from a possible solution, to a problem taken from an existing ecological system, by using a mathematical model to show the predicted effects of the proposed measure on the ecosystem.

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# Introduction

Mathematical engineering is based on developing application models for making predictions and find desirable solutions to real-life problematic situations. While working towards the development of an application, one comes across several challenges which fluctuates the approach of development. Challenges can be encountered when determining the model of the application, due to the observation and collection of data which is relevant to use as variables in a mathematical formula. Thus, parameters are going to be divided into categories such as the essential and trivial factors, then later implemented to improve the model. Therefore, due to the level of complexity that the model may hold it is mandatory to not only implement an application which gives as an output statistical numbers but visuals as well, such as graphs.

# Context

Oostvaardersplassen, a persevered ecological system, which has many animals living there including the main three large herbivores: wild horses, wild cattle, and deer; and other foremost species such as geese and birds of prey. Conjecting that no major predators are present in the ecological system and the herbivores prohibited migration, unbalance has been settled in the Oostvaardersplassen preservation.

Complicating the situation is the fact that there are a lot of geese, particularly during winter, and they consume the same type of food as the large herbivores do. The competition and interact between the herbivores and the geese for food can be quite severe, leading some to extreme situations such as death.

# Purpose

The purpose of this project is to work towards a possible solution of a problem taken from an existing ecological system, Oostvaardersplassen. Based on a mathematical model for the system and an application doing the number crunching to graphically illustrate the predicted effects of the proposed measures on the ecosystem.

# Central research question and sub-questions

# Research question

Main Research Question of the project:

What will happen to the populations of deer, cattle, horse and geese if releasing a number of foxes in the preserve (with the number of foxes being the free variable)?

Main Research Question for this research paper:

How do the herbivores and the geese compete for the grass in an enclosed area?

# Research sub-questions

Sub-Research Questions for this research paper:

* + 1. What is the rate of grass consumption of each animal?
    2. How do animal populations change as a result of grass availability?
    3. What are the populations of each animal?
    4. How can the start data and historical data help shape existing mathematical models to an equation which fits the problem in Oostvaardersplassen?
    5. How can the application hold all the implementations what are being asked?

# Research Methodology

The methodology explored in this project reflects the competition for food, taking place between herbivores and geese, in an enclosed ecosystem, Oostvaardersplassen. By means of collecting data and modeling equation based on the data, the research will then attempt to provide an accurate prediction based on fluctuating data. The **Data collection** is based on the information found on the Website of Oostvaardersplassen1.1 (Startpagina Staatsbosbeheer. Het zit in onze natuur. n.d.), which is related to the numbers of herbivores and geese during different seasons, the amount of grass they eat, death rate and any other related data.

The **Equation research** is mostly focused on the equations of the grass growth. The research conducted to find equations is based on literature2.2 (Gotelli, N. J. 2008). Transforming grass amount into actual weight so comparison can be made to the amount of food the herbivores and geese are eating.

Once the data collection process and equation research will be finalized, the creation of the application model will begin. By creating class models of UML [[1]](#footnote-1)will help to visualize how the application will look like and what it should do. As soon as, the UML model for the application will be completed the focus then turns to the back-end work, implemented using Java. After having the engine and the whole map of the Oostvaardersplassen in program, the application will then display in a GUI[[2]](#footnote-2), by JavaFX[[3]](#footnote-3).

During the project development several limitations may occur, that could harm the final result of the application. Some of those **Limitations** for this research are the time frame which project needs to be finished. The information availability constraints which might be lacking data or not accurate at all. Another challenge is the interdependence on the other group that is investigating relating variable. This research is limited scope to Oostvaardersplassen.

The **first sub-question** is getting the information about the *grass consumption* of each animal. The way in which the answer to this question will be given, is by researching about the amount of grass each of the animals in Oostvaardersplassen needs in order to continue living. There is a lot of information about herbivores and geese grass consumption on the internet, however only the most similar specie of each animal of Oostvaardersplassen will be chosen, then take the figures found and implement it in the application.

In concordance to the website3.3 (Intake requirements n.d.), in regards to the data collection concerning with the food consumption of the *Red Deer*, it shows a distribution of a 50/50 rate of male/female dears. By means of data shown in a graph, it was deducted that the average deer weights about 110kg, and consumes about 2.5kg of Dry Matter each day.

According to the website*4.4* (Konik 2016), used to collect data about *Horse* food consumption, the average horse consume every day around 2.5% of DM[[4]](#footnote-4); depending on the horse‘s body weight. According to the source, the horses in Oostvaardersplassen weigh between 350kg-400kg, it was decided on taking an average body weight of a horse of 375kg, which consume 9.4kg of DM each day.

From the source5.5 (Cattle 2017), used to generate information about the food consumption of a *Cow*, can be deduced that the average cow consume 2.5% of its body weight in DM each day. The average weight of a cow in Oostvaardersplassen is 600kg, which means that each cow consume 15kg of DM every day.

Due to lacking information in the data collection in regards to the food consumption of a “wild *Goose*”, a farm goose was decided to be taken as source for indication. According to the sourc*6.6*, the average goose eats everyday around 0.15kg of DM.

In order to answer the **second sub-question**, research needs to be done about what is the formula that most fit the situation, in order to know how the availability of grass would affect the animals that are there. This information exists in the ecology book that was given as a reference.

The formula that was used in the application calculates the population growth rate of a specific species, given the specific species’ population, intrinsic rate of increase, carrying capacity, competing species’ population and their competition coefficients. The grass is a new variable that was introduced into the formula in order to test the effect of the grass on the herbivores living there. The improved formula now takes the grass consumption of the herbivores together with the available grass in Oostvaardersplassen. In order to test the effect of how do animal populations change as a result of grass availability, the application needs to confirm all the inputs given, then the system will use the formula in order to predict each year as long as there is available grass. The application will draw a graph of the effect of the grass availability on the herbivores, showing the effect on population over years as long as there is available grass to consume. Therefore, the application will not continue the prediction for the rest of the years where there is no available grass to consume by the herbivores. Which means that starvation will be reached by the animals.

In order to check the accuracy of the formula, the group made many tests that were successful, the test that were taken was taking the figures of 1992 of the historical data and put into the application in order to test the prediction of it. The figures that we used for it were 170 cows, 45 deer, 85 horses and the prediction was for 20 years, and as the group expected, the prediction came out very similar to the reality of the historical data; by the fact the deer population raised enormously and the cows are reaching to extinction. One of the only things the application itself can’t predict is the weather effects, such as cold winter/warm summer, on the herbivores. Therefore, the accuracy of this application is sufficient for this research’s purpose.

The way in which the **third sub-question** will be answered, is by getting the existing numbers of Oostvaardersplassen herbivores and geese from the given information that was received and the information that is on Oostvaardersplassen website. Afterwards the process of implementation of those figures in the application will begin, so that the outcome would be as accurate as it can be.

The amount of the herbivores according to 2015 was given as a reference, after some research with calculations and some small assumption, it is now known what the estimated herbivores numbers according to 2016 is. The figures are as follows:

According to May 2015, there were 250 Cattle (Cows), up to May 2016, 80 cows died, and the assumption is that 60 were born (average of the last few years), which means 230 cows.

In accordance with May 2015, there were 1250 Konik horses, up to May 2016, 380 horses died, and the assumption is that 250 were born (average of the last few years), which means 1120 horses.

According to May 2015, there were 3200 Red deer, up to May 2016, 970 deer died, and the assumption is that 700 were born (average of the last few years), which means 2930 deer.

In the **fourth sub-question**, historical data of Oostvaardersplassen, needs to be accessed, as well as what mathematical models would fit the problem.

The equation, used in the mathematical model, is a modified version of the competitive Lotka-Volterra model2.2 (Gotelli, Nicholas J. 2008). This model calculates the population growth rate of a specific species, given the specific species’ population, intrinsic rate of increase, carrying capacity, grass availability, competing species’ population and their competition coefficients.

The modification made to this model was the introduction of an extra variable, which measures the grass availability. The current grass amount was given as a source to add into the equation, adding it into the nominator and denominator of the equation in order to set the variable to 1, along with a full list of variables and explanations which can be found in the appendix.

As well an excel sheet was provided, with the population numbers and total births/deaths for each of the three herbivore species. From there, calculations based on the individual birth/death-rate for each species were involved. Using SPSS’ [[5]](#footnote-5)Curve Fit functionality, the correlation between the population and individual birth/death-rate, gave some of the variables needed to be used in the mathematical model. A full list of these variables can be found in the appendix.

To find the last variable, the competition coefficient, the formula used a separate equation7.7 (Schoener, T. 1974). This involved researching each species’ dietary distribution and comparing them against each other. Then multiplying these numbers by the species’ relative consumption amounts, so that it would account for the differences in consumption between species as well.

*Competition coefficient numbers*

Finally, a third equation was used to calculate the total grass consumption for each species. While the model did not need this data as a variable, but it was required to have in order to answer the main question of this project. The third equation that was introduced is a straight forward equation which takes the total available amount of grass in kilograms, after converting the area of dry grass into kilograms and deducting from it the amount being eaten by all herbivores in one year in kilograms. The equation of consumption for each animal looks like this:

Deducting the total amount of grass eaten by each herbivore on an amount for each year, from the total grass available, brings the total grass left after all the years calculated.

In order to convert the area of DM grass in Oostvaardersplassen it was needed to do a research of how to convert area to weight. One of the sources was of a company who sell grass for golf clubs, and they sell it in pallets which each pallet covers 450feet of area (137.16m) and weigh 2250lbs (1020.583kg); considering the fact that the grass height when being sold to the customer is at 0.3cm height. Taking into account that the area of DM grass in Oostvaardersplassen is 20,000 square meter, which means it is required to have 479 pallets of grass in order to cover all this area, which gives the following calculation:  
The grass at Oostvaardersplassen is at around 14cm according to 2015, which means the available amount of food at Oostvaardersplassen is:

Although confidence was to be found in the formulas and data as presented, there were some issues with the data collection that could not be solve; such as the lack of available data for certain species. As such, certain assumptions were made to account for these issues. A full list of issues and assumptions with regards to the data collection can be found in the appendix.

In order to implement all the information that is collected, for the **fifth sub-question** the use of both front end development and backend development, with Java and JavaFX. With the intention of showing graphs, which outcome is based on the input that will be inputted by the user.

In view of the fact that the application is built dynamically in the *front end development*, the best choice for creating the Graphical User Interface (GUI) was by utilizing Scene Builder[[6]](#footnote-6). Scene Builder was a shaped fit, in regards to the application’s needs, not only because of the affluent maintainability but also due to its support; as well as the trivial factor of previous work experience with this tool.

The GUI was designed with ease of use in mind, to be simple yet effective. It consists of Menu Bar, Text Fields, Buttons, Radio Buttons and Graph, which visually represent the data.

Inside the *Menu Bar* three main items can be found. A primary item is the close functionality, which allows the user to exit the application, and is found under “File >Close”. Another item is in “About us”, which opens a window with a brief introduction about the application creators.

“Cattle”, “Red Deer”, “Horses”, “Geese” and “Years” are the *Text Fields* which prompt the user to enter Custom Data, numerical values specifically, that will be used in the Prediction model. The fields are checked by application for correct entry; if user enters a word value instead of a numerical one, or leaves area empty – an error message will be displayed.

The predominant *buttons*, for the application, are the ones which influence the most the outcome of a prediction. “Predict” is one of the buttons, and its task to take entered data and sends it to Model to execute calculation, then display results in View. A second button is “Show Historical Data”, which draws the chart of historical data for cattle, horses and deer from 1982 to 2015. The next button resets the Text Fields and Graph view, so that the user can reenter data for a new prediction, entitled “Clear Data”. The last button, “Grass Left”, displays a message in console about the grass availability at the end of the calculation.

The main purpose of the *Radio Buttons* is to manipulate chart view. The user can select to display one or more preferred animal graphs, or use “Totals” button to show all graphs together.

Since the application displays its results visually, by drawing charts which then will be compared and analyzed by user, the *Graph View* takes up the largest part of application window. The chart will automatically adjust its scale to given timeframe and graphs. Each animal is assigned unique color for better readability.

In the *backend work*, the development of the software side, the language the code was written in is Java. By using classes and methods, which are referred to by name and invoked at any point in a program to get a functionality. Below can be found a brief description of the main methods that make the application functional, which have a more direct association /involvement towards the frontend work.

The core controller behind the *buttons* functionality found on the GUI, for this application, are the predominant methods. One of the methods, is *handleCompute,* which makes the prediction by taking all the text fields as input and puts them inside the formula. By way of using a for loop to predict each year, then showing the output on the graph. A second significant method is *handleHistoricalData*, which shows all the historical data of the nature preserve since 1983 up to 2015. Both of these methods have implemented a *disabling* option, which can be pressed to compute/show historical data buttons again after the first prediction has been made. A third considerable method used to control the buttons is *methodhandleClearData*, which clears the data of the prediction or the historical data which was shown in the graph; enables the show prediction/historical data after the clear data button was pressed. *calculateGrassLeft* is a fourth method for button control, which prints to the console the amount of grass left each year; by taking the text fields as input to deduce the amount of available grass each year.

A special type of buttons used in the application are *RadioButtons*, means that only one button at a time can be selected. The three radio buttons used are *handleAppearanceRedDeer*, which shows and removes the line of the dears on the graph, the *handleAppearanceHorses*, showing and removing the line of the horses from the graph, and lastly *handleAppearanceCows*, shows as well as removes from the graph the lines dedicated to cows.

Another aspect which stands out is the *TextFields* section. Which is a method that takes all of the text fields as input then changing them from text field property to a string. Following with a transition from a string to a double, to push it into the formula and make the prediction. This process is true for cattle input, horses input, deer input and years input.

The menu functionality has two main methods *handleExit*, found under file with its main task to exit the application, and *handleAbout,* which shows the creators names for this application in an Alert window and is located under the About us tab.

An important method which is conspicuous is the *isInputValid*, checking if all text fields are being filled correctly with inputs when the buttons have been pushed. Otherwise a warning message with information in regards to what field needs adjustments are needed, to proceed with the prediction.

The *communication* between the two applications is done via the use of sockets which send Json objects containing values used in calculating a prediction. The object will be sent, the application will wait until it receives a response from the other application, then the following year’s prediction will commence. The process of sending the Json object, waiting, calculating with the new data, sending a new Json object again will repeat until the last year that is predicted is reached. This process will be similar for both application.

# Results

After running several tests with the formula of the competitive Lotka-Volterra model together with new introduced variable G (Grass), the result were showing that cows are reaching close to extinction after about twenty years from the prediction date. While the deer are reproducing very fast, in the first five years the deer reproduce slower, but after those five years they start taking over the area of nature preserve, meaning after fifteen years they become four times greater than the first five years, unlike the horses which after thirteen years start declining downwards.

# Conclusion

The general conclusion that can be drawn here is the fact that after about twenty years from now, the cows in Oostvaardersplassen will reach extinction, due to the fact that the cows reach their peak point after seven years of prediction, and from that point declining downwards towards extinction. Another conclusion which can be drawn from this project is that deer will keep populate as long as they can and if grass was not an issue in this competition, according to the graph, the deer population can reproduce in twenty years by 34 times, reaching his peak point after twenty years. When it comes to the horses, the result shows that the horses reaching their peak point after thirteen years from the prediction day, and from that point on slight declining each year but not reaching extinction.

# Recommendations

According to the conclusion and the result that we faced, the most important recommendation we can give to Oostvaardersplassen client is to expand the territory of the dry land and even dry more land in order to allow the cows to reproduce in an open environment. Another recommendation is to bring more cows to the nature preserve while getting rid of half of the deer in the nature due to the fact they reproduce too fast and stealing all the food from the cows, due to the fact they share the most surface for food with them cows.

# Bibliographies

*1.1* Startpagina Staatsbosbeheer. Het zit in onze natuur. (n.d.). Retrieved November 23, 2016, from <https://www.staatsbosbeheer.nl/>

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3.3 *Red Deer*:

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*4.4Horse* Source:

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*6.6Goose* Source:

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8.8 Source of grass conversion to kilograms   
[https://www.reference.com/home-garden/much-pallet-sod-weigh-390e9d062e1a93a8#](https://www.reference.com/home-garden/much-pallet-sod-weigh-390e9d062e1a93a8)

# Appendices

1. UML – Unified Modeling Language is a general-purpose, developmental, modeling language in the field of software engineering, which intends to provide a standard way to visualize the design of a system. [↑](#footnote-ref-1)
2. GUI – Graphical User Interface is a type of user interface that allows users to interact with electronic devices through graphical icons and visual indicators such as secondary notation, instead of text-based user interfaces, typed command labels or text navigation. [↑](#footnote-ref-2)
3. JavaFX - software platform for creating and delivering desktop applications, intended as the standard use of GUI library for Java. [↑](#footnote-ref-3)
4. DM – abbreviation for dry matter; [↑](#footnote-ref-4)
5. SPSS – Statistics is a software package used for logical batched and non-batched statistical analysis. [↑](#footnote-ref-5)
6. Scene Builder – is a visual layout tool for JavaFX applications. The JavaFXScene lets a user rapidly project a JavaFX application user interfaces, without coding. [↑](#footnote-ref-6)