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Client: Luis Escobar, Department of Fish and Wildlife Conservation

Our goal is to develop a website to display the model of the spread of infectious diseases. The website should encompass:

- Display what-if scenarios
- Modify specific parameters
- See resulting outputs
Project Timeline

- **9/30**: Understand software and statistical models
- **10/14**: Create wireframe and discuss UI
- **10/28**: Prototype, test, and implement models in R Shiny
- **11/2**: Completed prototype, Presentation 2 complete
- **11/4**: Revisions to ensure functionality, begin testing
- **11/18**: Complete report
- **11/30**: Final presentation complete, finished project
The model below is obtained from Miller et. al. (2006) [1].

\[
\frac{dS}{dt} = a - S(\beta I + \gamma E + m) \\
\frac{dI}{dt} = S(\beta I + \gamma E) - I(m + \mu) \\
\frac{dE}{dt} = \epsilon I - \tau E
\]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>the number of susceptible deer</td>
</tr>
<tr>
<td>I</td>
<td>the number of infected deer</td>
</tr>
<tr>
<td>E</td>
<td>the mass of infectious material in the environment</td>
</tr>
<tr>
<td>a</td>
<td>the per capita birth rate</td>
</tr>
<tr>
<td>(\beta)</td>
<td>transmission rate</td>
</tr>
<tr>
<td>(\mu)</td>
<td>per capita CWD mortality rate</td>
</tr>
<tr>
<td>m</td>
<td>per capita natural mortality rate</td>
</tr>
<tr>
<td>(\gamma)</td>
<td>indirect transmission</td>
</tr>
<tr>
<td>(\epsilon)</td>
<td>per capita rate of excretion of infectious material by infected animal</td>
</tr>
<tr>
<td>(\tau)</td>
<td>mass specific rate of loss of infectious material from the environment</td>
</tr>
</tbody>
</table>

Table 1: Description of the model parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>4.48307</td>
</tr>
<tr>
<td>(\beta)</td>
<td>0.002446</td>
</tr>
<tr>
<td>(\mu)</td>
<td>2.617254</td>
</tr>
<tr>
<td>m</td>
<td>0.103202</td>
</tr>
<tr>
<td>(\gamma)</td>
<td>0.206146</td>
</tr>
<tr>
<td>(\epsilon)</td>
<td>0.150344</td>
</tr>
<tr>
<td>(\tau)</td>
<td>0.135785</td>
</tr>
</tbody>
</table>
Implementation - Statistics

Formula:

\[
\begin{align*}
\frac{dS}{dt} &= a - S(\beta I + \gamma E + m) \\
\frac{dI}{dt} &= S(\beta I + \gamma E) - I(m + \mu) \\
\frac{dE}{dt} &= \varepsilon I - \tau E
\end{align*}
\]

Implementation in R:

```r
# Model Specification (user defined function) ----------------------------------------
SIEmod <- function(times, State, Pars) {

  with(as.list(c(State, Pars)), {

    dS <- alpha - S * (beta * I + gamma * E + m)
    dI <- S * (beta * I + gamma * E) - I * (m + mu)
    dE <- epsilon * I - tau * E

    return(list(c(dS, dI, dE)))
  })
}
```
Implementation - Modifiable Parameters

Sliders allow users to see the graph output based on the input they want to test.
Deliverables / Accomplishments

- Chronic Waste Disease (CWD) model website includes:
  - Graphical outputs
  - “What-if” scenarios
  - Modifiable Parameters

- Further Improvements we made:
  - Text box to input exact values
  - Table to track history of inputs
About Page

About

Background Information
This web application was developed in order to better understand the spread of the disease known as Chronic Wasting Disease (CWD). CWD is a fatal disease affecting members of the deer family. The disease is extremely contagious because the prions spread through any direct or indirect contact. The prions also have the ability to remain in the surrounding area for long periods of time. Once CWD has entered a specific region, it becomes quick to spread making it difficult to prevent spread once it has reached an area. Deer are greatly affected by CWD all over the United States and tracking the spread of this disease could give more insight into how to prevent further outbreaks.

How to Use this Web App
When first viewing the app, a user may notice a few things. First there are two columns containing mutable values. One (located on the far left) is labeled Parameters and contains all the variables which affect the final graph. The second (located on the far right) is labeled as Scaling Inputs and contains values which affect the initial scale of the graph. A user can change any of these values; the graph will update in real time accordingly. In the middle of the page, there is the graph and table. As indicated above the graph, the red line represents the current graph while the blue line represents the graph before the parameter was changed. Below the graph is the aforementioned table which lists the parameters that are different from the original, preset values. These new values, along with the original values and most recent values, are viewable in the table. Lastly, there is a reset button located at the top left corner of the page. This button clears the table and sets all the Parameters/Scaling Values to their original preset values.

Additonal Resources
For more information about this project please visit the following link.
Testing

- First phase of testing is complete
- Second and third phase are ongoing

**Test within internal team**
- Requirement analysis
- Test case development

**Test with our client**
- Further test case development

**Test with prospective users**
- Beta testing
- Identify/duplicate bugs
CWD Simulator User Testing Questionnaire

1. Please adjust the following values using the slider option.
   a. Birth Rate: 2.5
   b. Indirect Transmission: 0.25
   c. Rate of Infectious Material: 0.1

   Describe what you notice and state any issues.

2. Please adjust the following values using the textbox option.
   a. CWD Morality Rate: 1.9
   b. Transmission Rate: 0.0012
   c. Environmental Infectious Material Loss Rate: 0.16

   Describe what you notice and state any issues.

3. Change the Susceptible Deer input to any value. Can you distinguish the current and previous resulting graph? Please give your thoughts on the graph and resulting table.

4. Reset all the inputs.
5. Navigate to find Background Information about the web app. How difficult was it to find?

6. What are your overall thoughts of design of this web-app?

7. On a scale of 1 to 10, how difficult was this web-app to use? (1 – very easy, 10 – very hard) Please highlight your answer.

   1 2 3 4 5 6 7 8 9 10

8. Do you have any additional comments/thoughts?
Lessons Learned

- Establish good and consistent communication with the client
- Constantly check up on teammates throughout the project and keep the team updated with your progress
- Test functions while developing them
- Use your resources and network to their full potential
- Don’t be afraid to disappoint, come with a solution
Ideas for the Future

- Add a button to save both the graph and table
- Create more plots to further visualize the data
- Update model after user indication rather than automatically
- Create visualizations to show correlation between parameters
Acknowledgements

- Professor Luis Escobar, Department of Fish and Wildlife Conservation
- Mariana Castaneda-Guzman, M.Sc. student, Department of Fish and Wildlife Conservation
- Dr. Edward A. Fox, Professor of Computer Science
- Carlos Augusto Bautista Isaza, Graduate Teaching Assistant
References

Statistical Model Research:

Previous Work done on project:

Background Research:

Questions?

Thank you!