**Cows Grazing in Field Model Design Document**

**System Under Study:**

The system under study is a herd of cows grazing in a grass field. The system will be modeled using Agent-based modeling (ABM) to create and simulate this system. The goal of this ABM is to better understand the sustainability of cow grazing patterns. The ABM will be used to study sustainability as a function of:

* The number of cows
* The amount of grass each cow consumes
* The size of the grass field
* The growth rate of the grass field

This model will be used to simulate a single herd of cows and grass field to determine how long a herd of cows can be kept and how many cows can make up the herd. When scaled up, this model will provide important logistics information to aid ranchers in scheduling herd movements across a larger set of fields. This model will allow users to predict the interactions between of a herd on a grass field, which will in turn provide users vital data on when to rotate herds through fields. This model can easily scale to study multiple herds across multiple fields for a wholistic understanding of ranch operations.

**Agents:**

The initial model implementation will make use of two agents: a cow, and a unit of grass. These agents will be simulated on a 100x100 grid representing the field, with units of grass randomly spread throughout. Later model improvements will extend the grazing animals to include multiple herd animals, e.g., sheep, and multiple types of grass.

*I. Agents and Properties*

For the initial ABM, cows will have two properties: location and hunger. The hungrier a cow is, the farther it will be willing to travel to find new grass to eat. Grass will have three properties: location, size, and growth rate.

**Cow:**

- Hunger: *0 – 5*

- Speed: *1*

- Search radius: *1-5*

**Grass:**

- Height: *0 – 10*

- Growth rate: *1-5*

*II. Agent Interaction*

For the initial ABM, the cows and grass will interact via the cows grazing. If a cow is currently occupying a grid unit containing grass, it will eat. If a cow is currently occupying a grid unit containing grass, the cow will move to the nearest available location with grass. If a cow is not occupying a grid unit of grass, and the cow is not hungry, the cow will remain in place.

**Interaction Models:**

The model will run at discrete time-steps. At each time step:

1. A cow will search for grass.
2. If a cow is at a location containing grass, the cow will graze.
3. If the grass is below a certain height, it will regrow a certain amount.

The interaction implementation is as follows:

* Each cow will have a hunger level, *0 < hunger < 5*
* Each unit of grass will have a height, *0 < height < 10*
* The cow will move a number of units towards the nearest grass equal to its hunger level
* When a cow starts a timestep inside a unit of grass, it will eat a number of grass height units equal to its hunger level
* If a unit of grass has a height of *0*, remove that grass from the field
* At the end of the timestep, a unit of grass will regrow by 1 unit of grass height

**Model Framework:**

This ABM will be created using the Godot gaming engine. The choice to build the simulation off of a game engine is made because Godot already contains the basic framework for creating agents and determining the interactions between them. Godot will allow modelers and analysts to simulate the system under study without having to first understand programming integration frameworks.

The model will be built upon a simple Godot scene containing the cow and grass agents. Based on the agents defined above, the model framework is shown below.

Diagram

Description automatically generated