ODD protocol
Game of Thrones model Step 3

OVERVIEW

Purpose

This model explores the demographic dynamics between sheep, wolves, and humans. This is the third step towards creating a model of Westeros. It is based on the Wolf Sheep Predation model (Wilenski 1997). In this new step, the model is now set onto a map of Westeros, which is separated into the seven kingdoms and what's beyond the wall. Humans take on the identity of the house that owns that land from which they come.

Entities, state variables, and scales

This model uses the wolves and sheep agents of the Wolf Sheep Predation model. To those, it adds a breed of human agents who can feed on grass or sheep, and who domesticate some of the wolves they encounter.

Table 1. Global variables used in this model.

Global variables	**Explanation**
Max-sheep	To stop the simulation if there are too many sheep
Land-patches	Identifies that patches that are land (can be walked on)
Initial-number-sheep	Determines the number of sheep at setup
Initial-number-wolves	Determines the number of wolves at setup
Initial-number-humans	Determines the number of humans at setup
Grass-regrowth-time	After how many ticks grass regrows (resource)
Sheep-gain-from-food	How much energy sheep get from grass
Wolf-gain-from-food	How much energy wolves get from eating a sheep
Rate-sheep-eating	How often humans eat an encountered sheep
Sheep-reproduce	Each sheep's probabilities of reproducing if they have energy
Wolf-reproduce	Each wolf's probabilities of reproducing if they have energy
Humans-reproduce	Each human's probabilities of reproducing if they have energy
Show-energy?	Switch, determines if we see sheep's energy on the window

Table 2. Turtle variables

turtle variables	**Explanation**
Energy	Counter that gets updated when an agent moves and eats. At 0, the agent dies.
Wolves variables	
Domesticated?	True/False. Record if a wolf has been domesticated.

Table 3. Patch variables

Patch variables	**Explanation**
countdown	Counter used to regrow grass.
Land?	Boolean that identifies if the patch is land

Wall?	Boolean that identifies if the patch overlaps with the wall (and thus becomes it)
House	Identifies which house owns the patch
House-color	Records the color linked to the house (for visibility purposes)

Process overview and scheduling

This model is pretty simple. At every tick, all agents move, which depletes their energy, and they look for food. If their energy is depleted, they die. If they still have energy, they consider reproducing.

Ticks do not represent any specific unit of time.

DESIGN CONCEPT

Basic principles

This model added humans to the Wolf Sheep Predation model, which aimed to show the predator-prey equilibrium that can arise between two species. In addition, it added a map of Westeros, which can hinder mobility.

Emergence

None.

Adaptation

None.

Objectives

This modification of the Wolf Sheep Predation model is simply to add humans, which complicates the equilibrium between the two animals.

Learning

None.

Prediction

None.

Sensing

Agents can sense if they have reached water or the edge of the map, in which case, they turn around.

Interaction

Wolves and humans interact with sheep by eating them. Humans interact with wolves by either domesticating them or getting eaten by them.

Stochasticity

Only the energy level of the agents is set randomly at the beginning of a simulation (with a maximum value set by a slider). Which patches are depleted at setup is also random, as well as the regrowth countdown of depleted patches.

Collectives

Land-patches identifies the set of patches that can be walked through and that have resources to deplete.

Observation

There is one plot that follows the population sizes of sheep, wolves, dogs, and humans.

DETAILS

Initialization

At setup, the model imports a raster and resizes the World window to fit the new map's dimensions. That values of the raster represent the house-color of the seven kingdoms. All patches record the raster's value as their house-color. Patches with house-color above 0 are land patches, whereas others are water. Water patches set their colors to blue. The model then imports a line vector that covers the extent of the wall. All patches that intersect that line become the wall. They set their 'land?' variable to *false* to make sure that they cannot get walked through. Wall patches are white. The model finally imports a political polygon map. That map holds vector polygons of the different kingdoms with specific information. For the moment, patches that intersect with any polygon record that polygon's 'claimedBy' value, which is the identity of the house that owns the land (e.g. Stark, Tyrell,…). All water patches are claimed by 'no one'. As there is a bit of disconnect between the polygon vector and the Westeros raster, the model tells any patch who thinks it is water but that overlaps with a house polygon to simply forget about that house and instead be claimed by 'no one'.

About half the land patches become green, which means that they have resources. The rest get a countdown value that determines when their grass will grow back. The number of sheep,

wolves, and humans are determined by sliders. They are placed randomly on the land, with a random energy value with max based on a slider. Humans are colored based on the territory they were 'born' into (e.g., Starks are grey).

Input data

This model uses three GIS maps. These maps were taken from https://www.cartographersguild.com/showthread.php?t=30472 and modified to suit our modeling needs.

- Land_raster.asc: raster map with the values representing the color number (in NetLogo swatch) of the house that owns the land.
- Wall.shp: line vector that covers the extent of the wall.
- W_political_revised.shp: Polygon vector. Each polygon represents a house. It holds the following information for each polygon:
    - Name: Name of the kindgom (e.g., "The North","Crownsland",…)
    - Population: Estimated millions of people living in each kingdom (based on https://atlasoficeandfireblog.wordpress.com/2016/03/06/the-population-of-the-seven-kingdoms/)
    - House-color: NetLogo number associated with each house's colors (arbitrary).
    - claimedBy: The name of the house that claims each kingdom (at the beginning of A Song of Ice and Fire).

Submodels

Move:
This is called by all turtles. The turtles wiggle a bit. If the patch ahead is either the edge of the world or water, they turn 180 degree. They then move forward by 1.

Eat-grass:
This is called by sheep. The patch becomes brown and the sheep adds a certain value (based on slider) to its energy level.

Eat-sheep:
This is called by wolves. If there is a sheep on the same patch as the wolf, the sheep dies and the wolf adds a certain value (based on slider to its energy level).

Death:
Called by all agents. If energy reaches 0, the agent dies.

Grow-grass:
Called by all land patches. If the patch is brown, it checks its counter. If the counter is at 0, the patch becomes green. If not, the counter is updated to its value -1.

Display-labels:

Called only if the switch is ON. It shows the energy level of wolves and sheep.

Add-humans:
Called during setup. Creates a certain number of humans. They set their colors based on the house that owns the patch where they were born.

Reproduce:
Called by all agents. They roll a die. If it is successful, they create a new agent and give them half of their energy.

Humans-eat:
Called by humans. A certain percentage of the time, they will look for a sheep to eat. If there is one on the same patch, that sheep dies, and the human adds a certain value (based on the wolf-gain-from-food slider) to its energy level.

When the human does not look for a sheep, it looks at the grass. If there is grass on the patch it is on, the patch becomes brown and the human adds a certain value (a quarter of what sheep gain from grass, as humans cannot convert plants to energy as well as animals) to its energy level.

Domesticate-wolves:
Called by humans. If there is a wolf on the same patch, and that wolf is still wild, the human rolls the dice. About 50% of the time, it will domesticate the wolf. The remaining times, it will get eaten by the wolf (who gets 1.5 times energy as it would from a sheep, arbitrary decision).

Humans-feed-animals:
If there is a domesticated wolf on the same patch (aka, a dog), it will ask the dog to feed on a sheep if there is one around, but the human will take some of that energy (they share the sheep).

REFERENCES CITED

Wilensky, U. (1997). NetLogo Wolf Sheep Predation model. http://ccl.northwestern.edu/netlogo/models/WolfSheepPredation. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.

Most of the ideas modeled here come from the A Song of Ice and Fire books, written by George R.R. Martin.

Some ideas and concepts (colors of houses, for example) are inspired by the HBO Game of Thrones show.