Neolithic Spread Model Version 1.0

OVERVIEW

Purpose

The purpose of this model is to explore several mechanisms and origins for the spread of agriculture. It was designed to carry out experiments in the spread of agriculture to the Iberian peninsula, but could be applied to any other area of the world. This model does not assume a spread of farmers or farming ideas, but simply models the spread of farming practice under variable ecological conditions and with different ways of spreading geographically.

Several different spreading algorithms are available to the user (explained in more detail below). The starting point(s) of the spread of agriculture can be set interactively with a mouse or by importing a text file of xy coordinates (geospatial earth coordinates, not NetLogo world coordinates).

The GIS Extension allows the user to import a raster basemap in which cell values represent the suitability of the associated land for agriculture (applicable in several spread routines), and a vector map of known prehistoric farming sites. The time of arrival of agriculture (in model ticks) is recorded at each site, and site information can be saved at the end of a simulation run. The time of arrival of agriculture at each site in the simulation can then be compared with the real-world arrival of agriculture at the same sites.

State Variables & Scales

The model centers on patch based agents which keep track of the presence or absence of agriculture at a a given location. Each agent contains a clock which stops at the arrival of agriculture to record agriculture's earliest arrival at a given patch. The grid is spatially explicit- based upon GIS data imported by the user. In the case of our simulations, the Iberian peninsula is used as a case study. The exact resolution can be controlled via an input in the model interface. A second agent type, site agents, is created from an input file containing locations and radiocarbon data for early Neolithic sites. These agents are only used to compare model arrival times to.

Process Overview and Scheduling

Once the maps and associated datasets have been loaded into the model, the main processes is the spread of agriculture across the map. The function used to spread depends on the settings defined by the user and only one can be used in a given simulation instance. The types of spread include neighborhood, neighborhood without constraints, leapfrog, leapfrog without constraints and IDD. At each tick of the simulation, each patch with agriculture present attempts to spread according to the spread scenario defined by the user. It is only possible to spread to suitable patches, those that are on land and those patches with an ecological potential equal to or greater than that chosen by the modeler.

When agriculture spreads to a new patch the simulation records the number of steps since the model was begun that have occurred. The spread begins at one or more locations defined by the user. The start locations can be entered as coordinates or with the click of a mouse.

Five types of spreading algorithms can be selected. Two of these are neighborhood spreading routines.

"*Neighborhood*" spreading will spread from any patch that has agriculture to neighboring patches that do not already have agriculture and are suitable for agriculture. The probability of spreading to any of these neighboring patches is determined by the relative suitability.

"*Leapfrog*" spreading will spread from any patch that has agriculture to a randomly selected patch within the radius of a user set that does not already have agriculture and is suitable for agriculture. Again, the probability of spreading to any of neighboring patch is determined by the relative suitability.

"*IDD*" spreading simulates the dynamics of "ideal free distribution" and "ideal despotic distribution" models from human behavioral ecology (Abrahams and Healey 1990; Fretwell and Lucas Jr. 1970; McClure et al 2006; Whitehead and ope 1991). Each patch that has agriculture will look for the 'best' neighboring patches–i.e., those that have the highest suitability values of all neighboring patches. Agriculture can spread to a patch that is suitable for agriculture whether or not agriculture already is present in that patch. But each time that agriculture spreads to a patch, it lowers its suitability value by the percentage given in the factor (set by the user). Thus, patches that are initially highly suitable for agriculture can become less and less suitable the more often they are occupied, representing an increasingly dense population of farmers using up the most desirable land in a patch.

The two other spreading types are "neighborhood no constraints" and "leapfrog no constraints". These work like the 'constrained versions already described but without taking into account the suitability of the cell for agriculture.

DESIGN CONCEPTS

Emergence: The model is designed to study the chronological and spatial patterns of agricultural spread across the Iberian peninsula.

Sensing: Patches are able to sense the ecological suitability of patches near them and the presence or absence of agriculture near them.

Stochasticity: In all of the spread models the direction and timing of spread is stochastic. The patch which is spread to is first compared to those around it with reference to ecological suitability. However, if that value is identical between patches, then the patch is randomly chosen using the netlogo one-of command.

Observation: (how data are gathered from the model) The model's purpose is to record the arrival time of agriculture and compare that time to the radiocarbon data from the archaeological record. At the conclusion of the simulation the arrival time at each patch which has an archaeological site (site-agent) is saved along with the archaeological data for that site. Further analysis outside of the simulation is used to compare with a regression the simulation timestep, and the data indicated by the archaeological sample from a site. Optionally, the model will save a .csv file of all sites (if a file of sites has been loaded), showing their identifying field, the time of arrival of agriculture in model ticks, and the xy coordinates of each site. The file is automatically time and date stamped.

DETAILS

Initialization & Input

To set up a simulation, the user first needs to load a raster basemap of the area to be investigated. Optionally, the user can also load a vector points map of sites. The raster and vector map must be in the same geospatial projection.

Base Map

The raster basemap needs to be in ESRI ASCII format to be read by the GIS extension. Each raster cell should have a value that indicates the relative suitability for agriculture. The model assumes that a higher value indicates greater suitability. A slider for can be used to identify the value below which agriculture is not possible. There is a higher probability of agriculture spreading to cells with a higher suitability value than with a lower value. The model automatically scales this probability between the highest value on the map and the threshold value.

Sites Map

The vector points map sites needs to be in ESRI shapfile format. Any associated attribute fields will be used in the output from the simulation.

Starting points

An origin point or set of points for farming can be set interactively with a mouse or from a text file of geospatial coordinate pairs.

For a coordinates file, the coordinates must be in a geospatial projection recognized by the GIS base map (e.g., longitude/latitude or UTM). Each coordinate pair must be
1) written as east (horizontal or x coordinate) and north (vertical or y coordinate),
2) separated by a space,
3) inside square brackets, and
4) on a new line

For example, if the UTM coordinates for point 1 are 728707 east, 4374094 north, and the coordinates for point 2 are 996073 east 4720022 north, they must be written as:

[728707 4374094] [996073 4720022]

REFERENCES

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