

AGENT-BASED MODELS AND VIDEOGAMES CROSSING PATHS IN ARCHAEOLOGY

the case of ‘Gaming Artificial Anasazi’

Andreas Angourakis [@AndrosSpica](#)
in collaboration with *Shawn Graham* [@electricarchaeo](#)

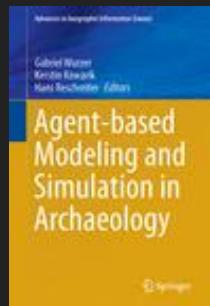
available at <https://andros-spica.github.io/Postdocs-Angourakis-2019/>
<https://andros-spica.github.io/Postdocs-Angourakis-2019/index.html?print-pdf> (printable version)

click on images to consult source

I

AGENT-BASED MODELLING IN ARCHAEOLOGY

Agent-based modelling (ABM) is a relatively extended practice in Archaeology



PNAS ● OPINION

Building a better past with the help of agent-based modeling

J. Daniel Rogers^{a,*} and Wendy H. Cegielski^b

With a few exceptions, the distant past is an anonymous land occupied by people who made things and left behind a meager record of broken pieces. Even when scientific and historical research is far removed from observing the actions of individuals in the past,



JOURNAL ARTICLE
So You Think You Can Model? A Guide to Building and Evaluating Archaeological Simulation Models of Dispersals
Iza Romanowska
Human Biology
Vol. 87, No. 3 (Summer 2015), pp. 169-192

Doug's Archaeology

Investigating the Profession and Research

Can you model that? Applications of complex systems simulation to explore the past

Posted on October 5, 2016

Journal of Anthropological Archaeology 41 (2016) 283–298

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Journal of Anthropological Archaeology

journal homepage: www.elsevier.com/locate/jaa

Rethinking the role of Agent-Based Modeling in archaeology

Wendy H. Cegielski^{a,*}, J. Daniel Rogers^b

^aSchool of Human Evolution and Social Change, Arizona State University, Tempe, AZ, United States

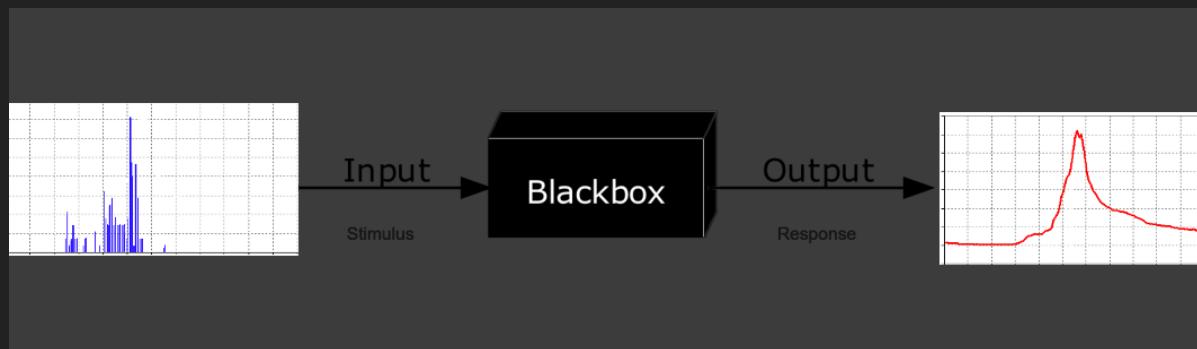
^bDepartment of Anthropology, National Museum of Natural History, Smithsonian, Washington, DC, United States

CrossMark

BIG CHALLENGE

Complicated designs + lack of documentation

=



Articles are read, results interpreted
but no one engages with the models

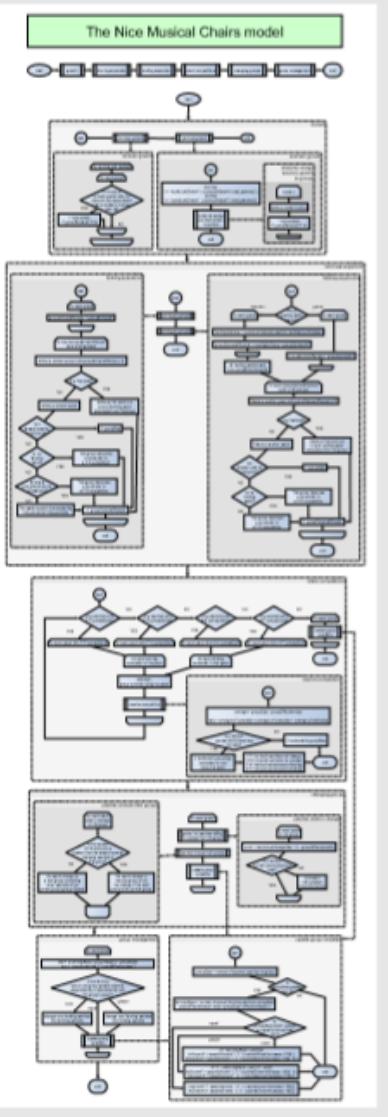


Fig. 1 – The seven elements of the ODD protocol, which can be grouped into the three blocks: Overview, Design concepts, and Details.

	Purpose
Overview	State variables and scales Process overview and scheduling
Design concepts	Design concepts Initialization
Details	Input Submodels

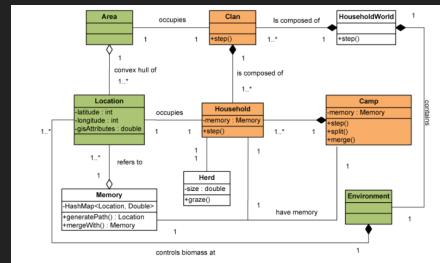
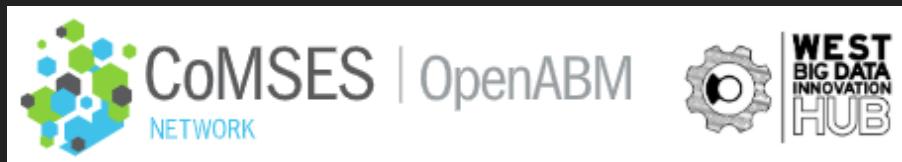
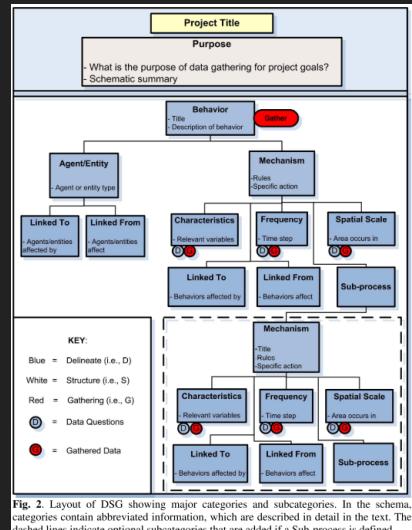


Fig. 1. High-level UML class diagram of the main components and relations in the HouseholdsWorld model, including the main attributes of Households and Camps. Agent classes (orange) and spatial classes (green) inherit from the MASON Steppable interface and from a subset of Geotools GIS attributes (describe areas, location), respectively.



pseudo code, UML, ODD, DSG...
there is no lack of intent!

||

GAMING *SIMULATED* PASTS

CROSSING PATHS WITH VIDEOGAMES

Simulation models as "games that play themselves"

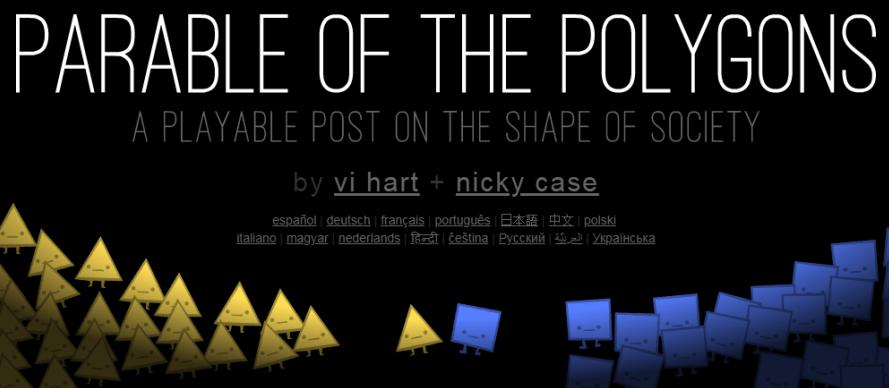
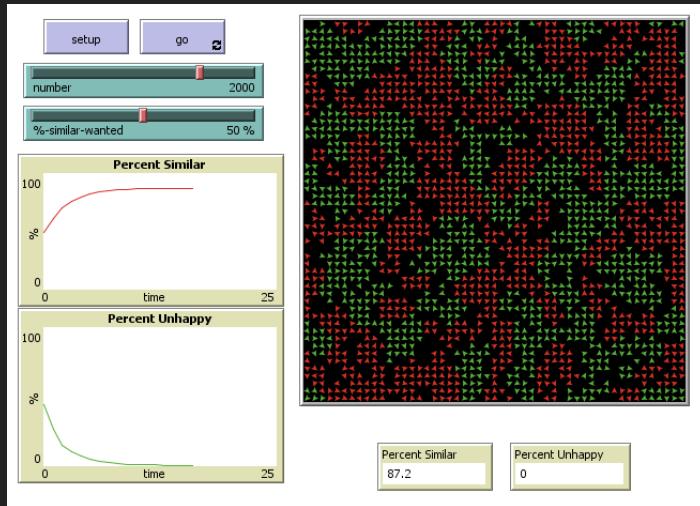
What if...

people could *play* these ABM archaeological models?

Would that improve our understanding about *models* and *case studies*?

INTERACTIVE ABM

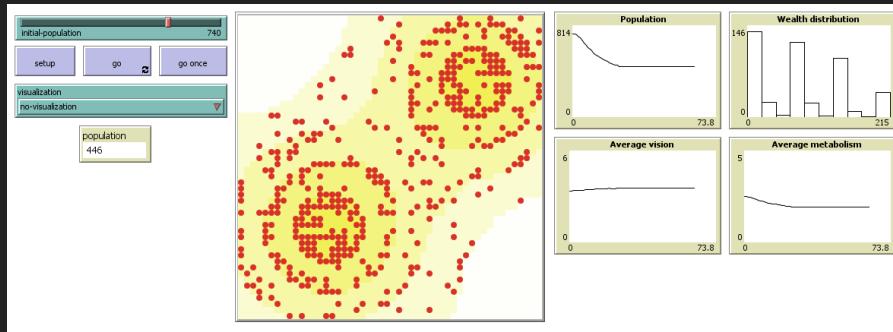
An example:



Schelling's *Segregation model* and
Parable of the Polygons

INTERACTIVE ABM

An "archeogame" example:



Sugarscape series and *Evolving planet*

INTERACTIVE ABM

Other examples from game industry:
Ancient Cities (Uncasual Games)



ECO (Strange Loop)



III

GAMING *IMMERSIVE* ABM

WHAT DO WE WANT?

- Agent-based model as *game mechanics*
- Turn the player into *an agent*
- 3D, first person, ideally VR-compatible
→ *immersive*, avoid god-like perspective
- A game, but also a tool for *communicating* the model

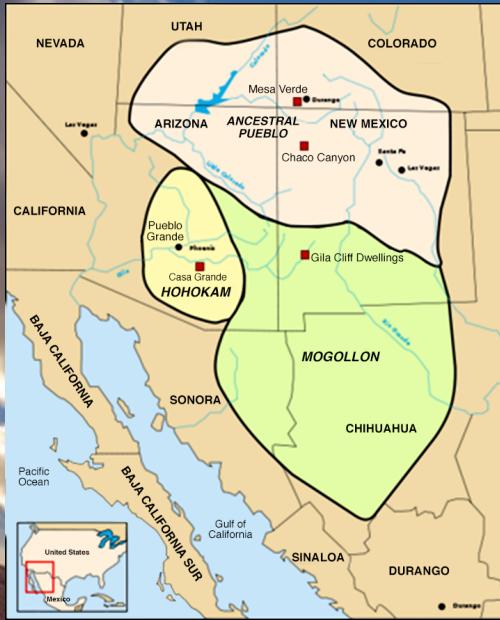
HOW CAN WE DO IT?

- *Translate* the model's code (replication)
- Complement/expand the model to *fill gaps*
- Define and implement *game mechanics*
- Bonus I: develop/import minimum artistic assets, including text
- Bonus II: user interface, game save system, and a great etc.

IV

ARTIFICIAL ANASAZI

~~ANASAZI~~ → *ANCESTRAL PUEBLOANS*



Calico Tanks Trail. Source: <https://www.flickr.com/photos/whsieh78/15763640429/>

The *Artificial Anasazi model* was designed for exploring the relation of *climate change* and *cultural collapse*

Long House Valley, NE Arizona



Population growth and collapse in a multiagent model of the Kayenta Anasazi in Long House Valley

Robert L. Axtell, Joshua M. Epstein, Jeffrey S. Dean, George J. Gumerman, Alan C. Swedlund, Jason Harburger, Shubha Chakravarty, Ross Hammond, Jon Parker, and Miles Parker
PNAS May 14, 2002 99 (suppl 3) 7275-7279; <https://doi.org/10.1073/pnas.092080799>

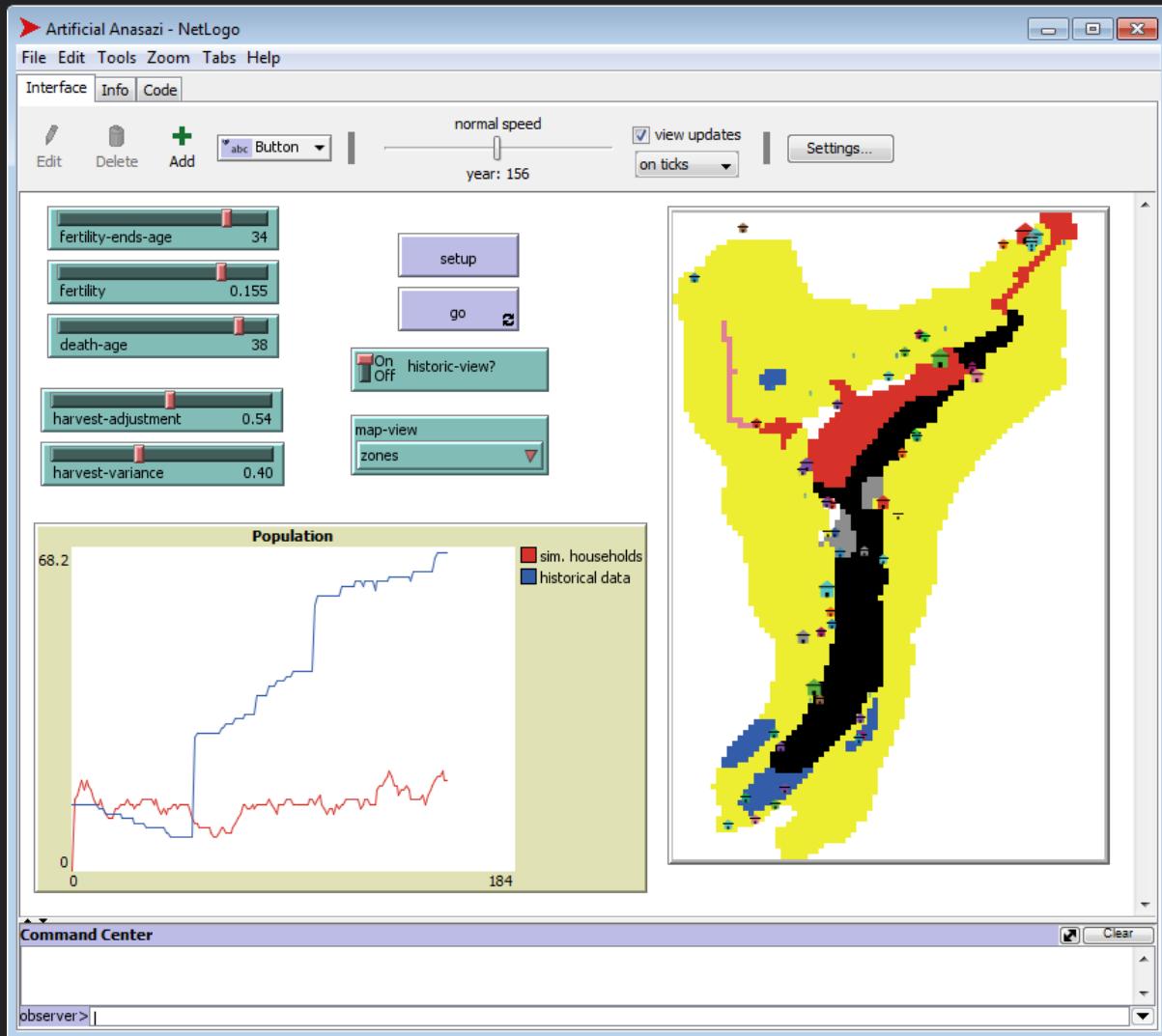


Marco A. Janssen (2009)

Understanding Artificial Anasazi

Journal of Artificial Societies and Social Simulation 12 (4) 13
<http://jasss.soc.surrey.ac.uk/12/4/13.html>

and replicated two times in NetLogo
by Janssen (2009)
and Wilensky (2010)



V

FROM *NETLOGO* TO *UNITY*



```
reset-ticks
end

to go
  if year > 1350 [ stop ]
  set historical-total-households 0
  set total-households 0
  calculate-yield

  ; potential amount of households based on level of base-yield (dependent on PSDI and water availability)
  set potential count patches with [ base-yield >= household-min-nutrition-need ]

  if historic-view? [ show-historical-population ]
  calculate-harvest-consumption
  check-death
  estimate-harvest
  ask households [
    ; agents who expect not to have sufficient food next timestep move to a new spot
    ; (if available). If no spots are available, they leave the system.
    if estimate < nutrition-need [
      ; we have to check everytime whether locations are available for moving agents,
```

```
// <summary>Initialize a simulation</summary>
public static void SetUpNew()
{
  // get new set up data
  setUpData = new SetUpData();

  // override parameters
  setUpData.SEED = Environment.TickCount;

  // save set up data
  SaveSetUpData();

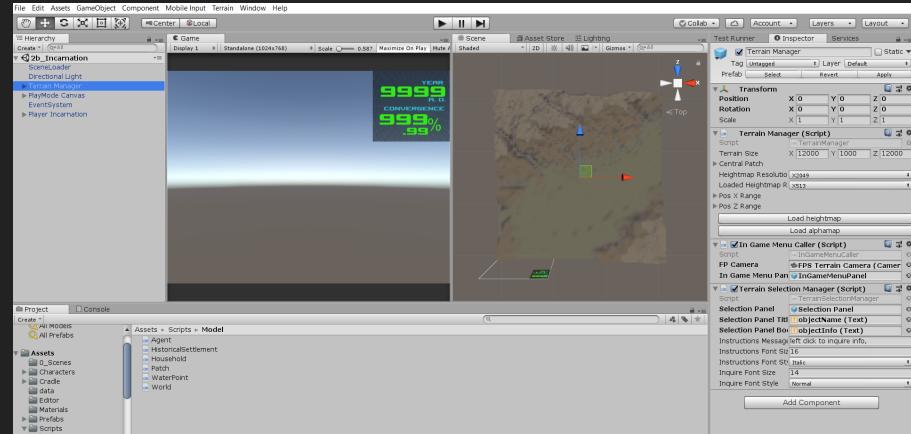
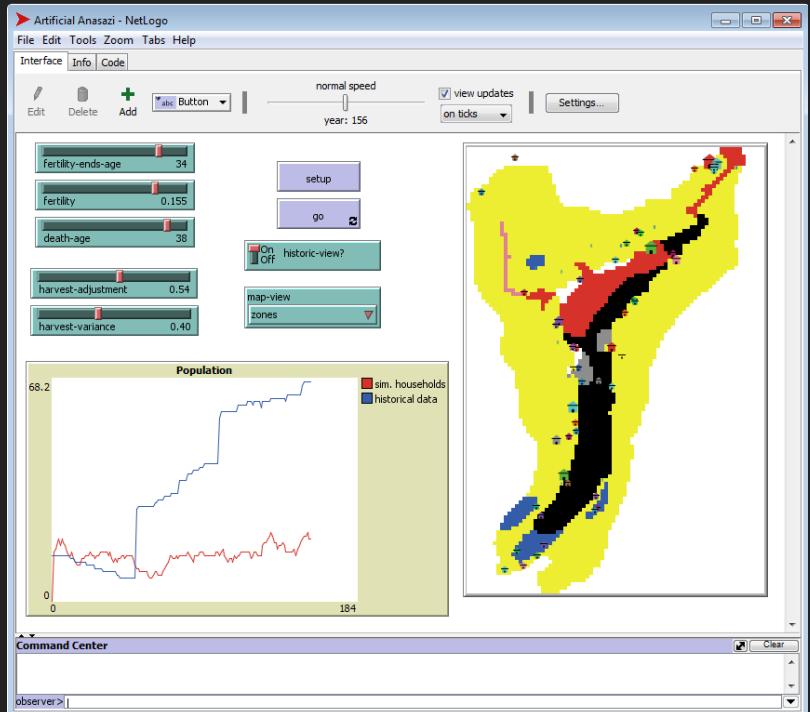
  year = setUpData.start_year;

  // set up procedures that are independent of new/load game states
  SetUp();

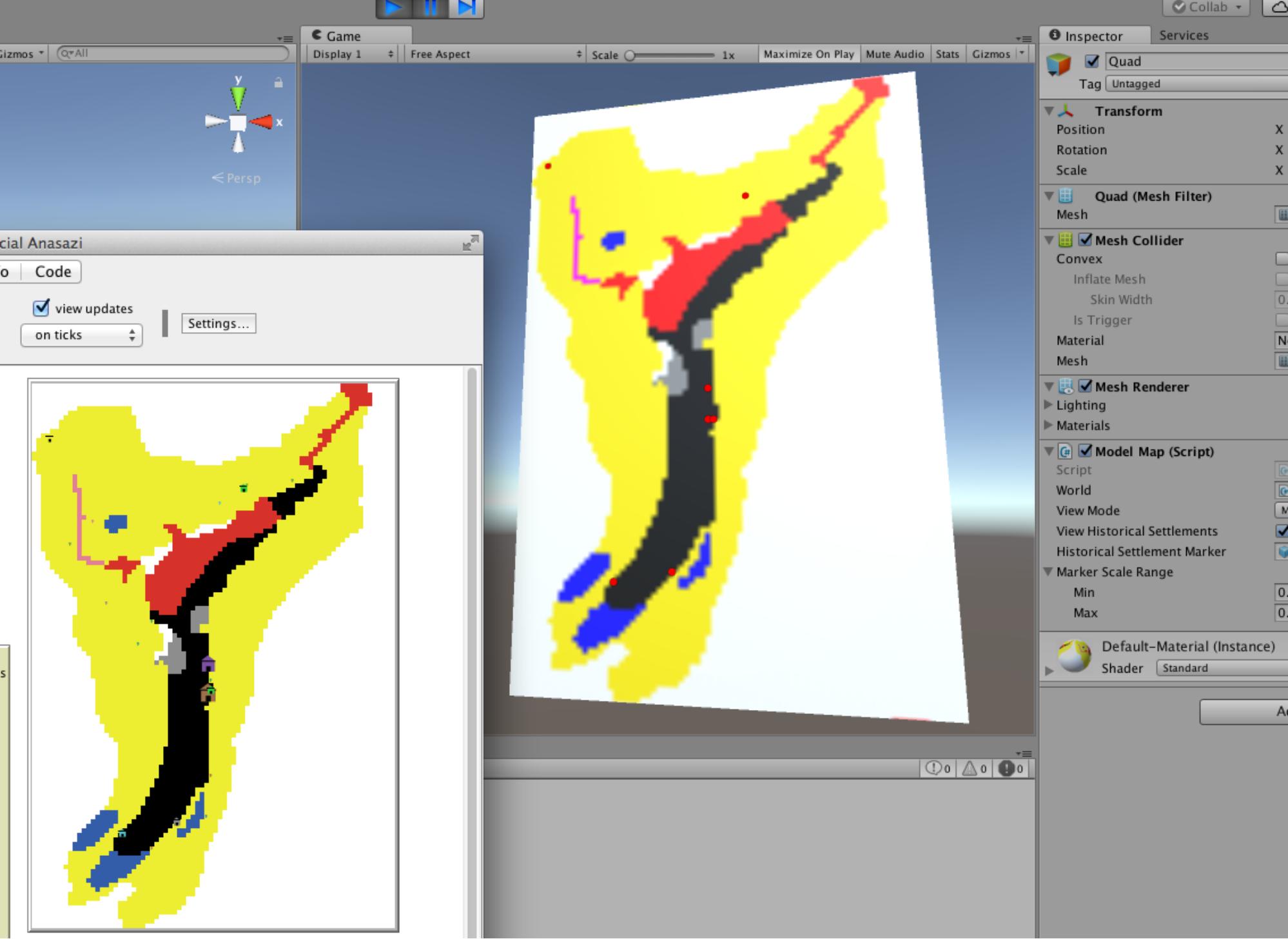
  // update input data
  DataReader.UpdateData();

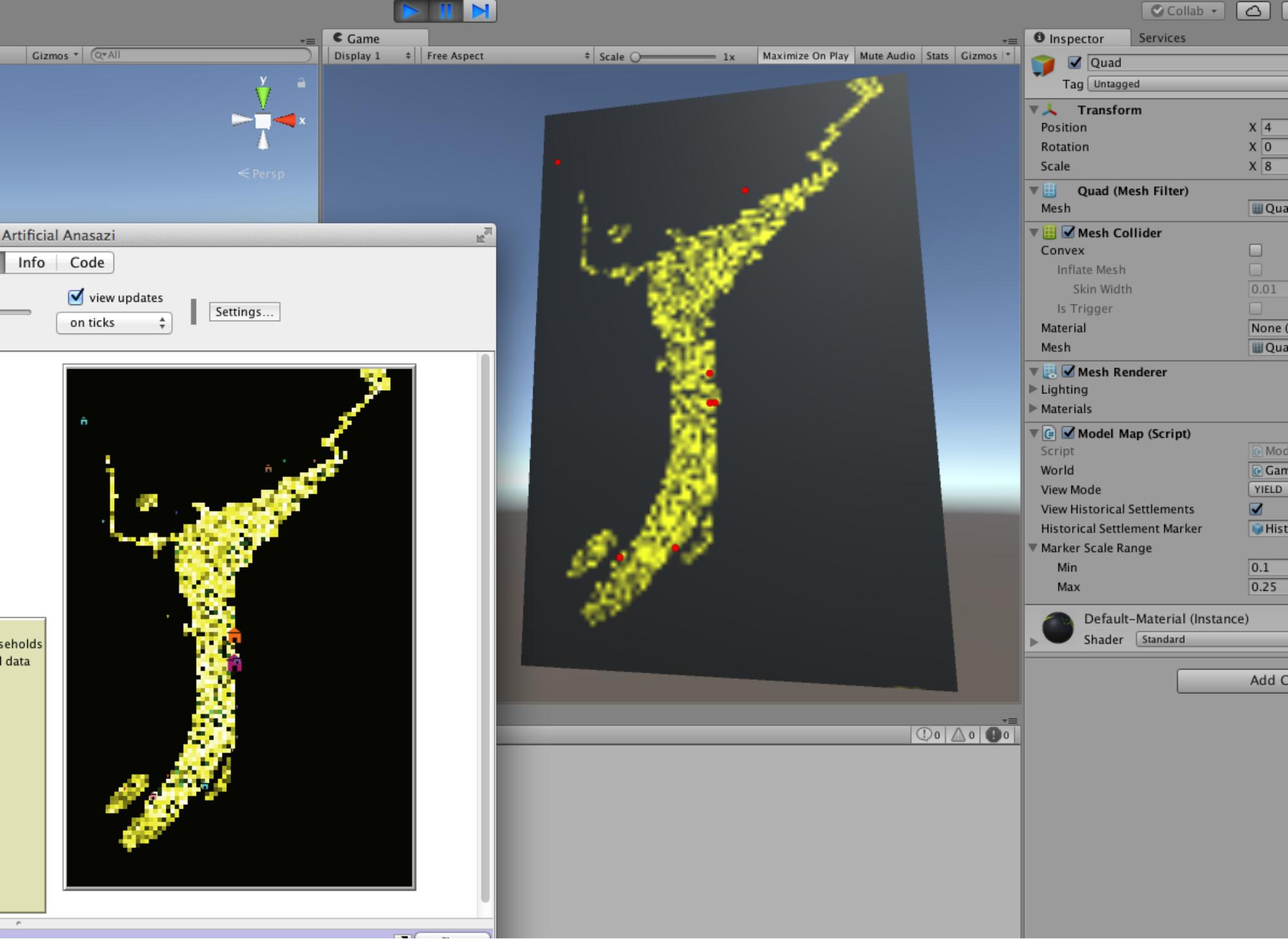
  // set patch quality and water source condition
  SetupPatchQuality();

  // calculate patch yield
  UpdatePatchesYield(true); // with the set up configuration (i.e. not affected by harvest_adjustment)
}
```



MODEL TRANSLATION







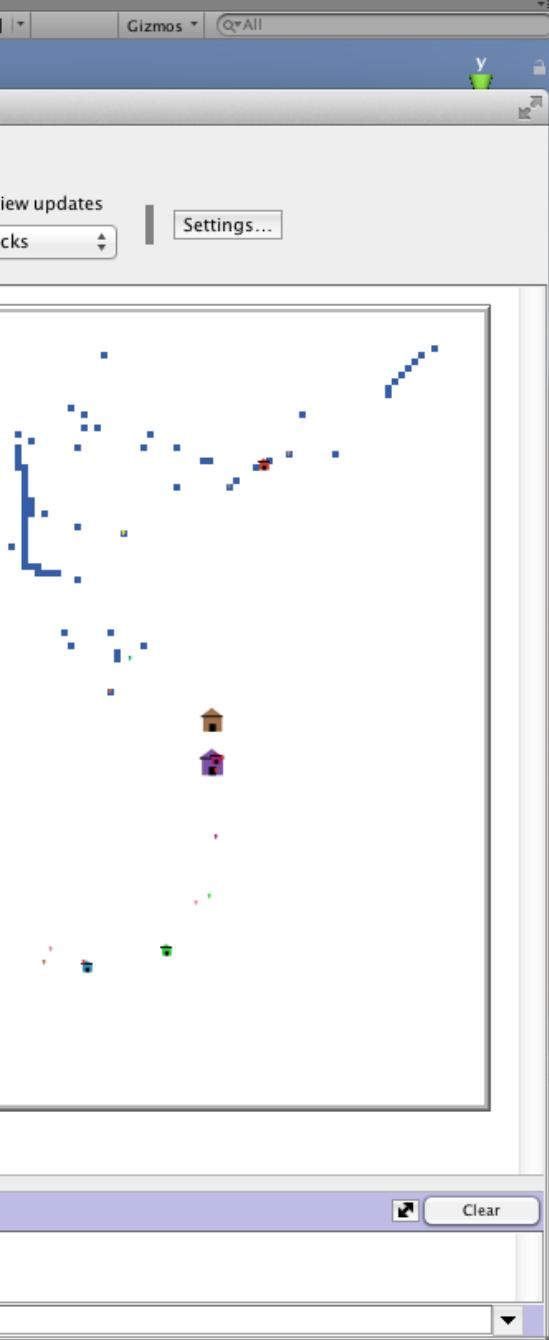
Game

Display 1 | Free Aspect

Scale

1x

Maximize On Play | Mute Audio | Stats | Gizmos



Quad
Tag Untagged

Transform
Position
Rotation
Scale

Quad (Mesh Filter)
Mesh

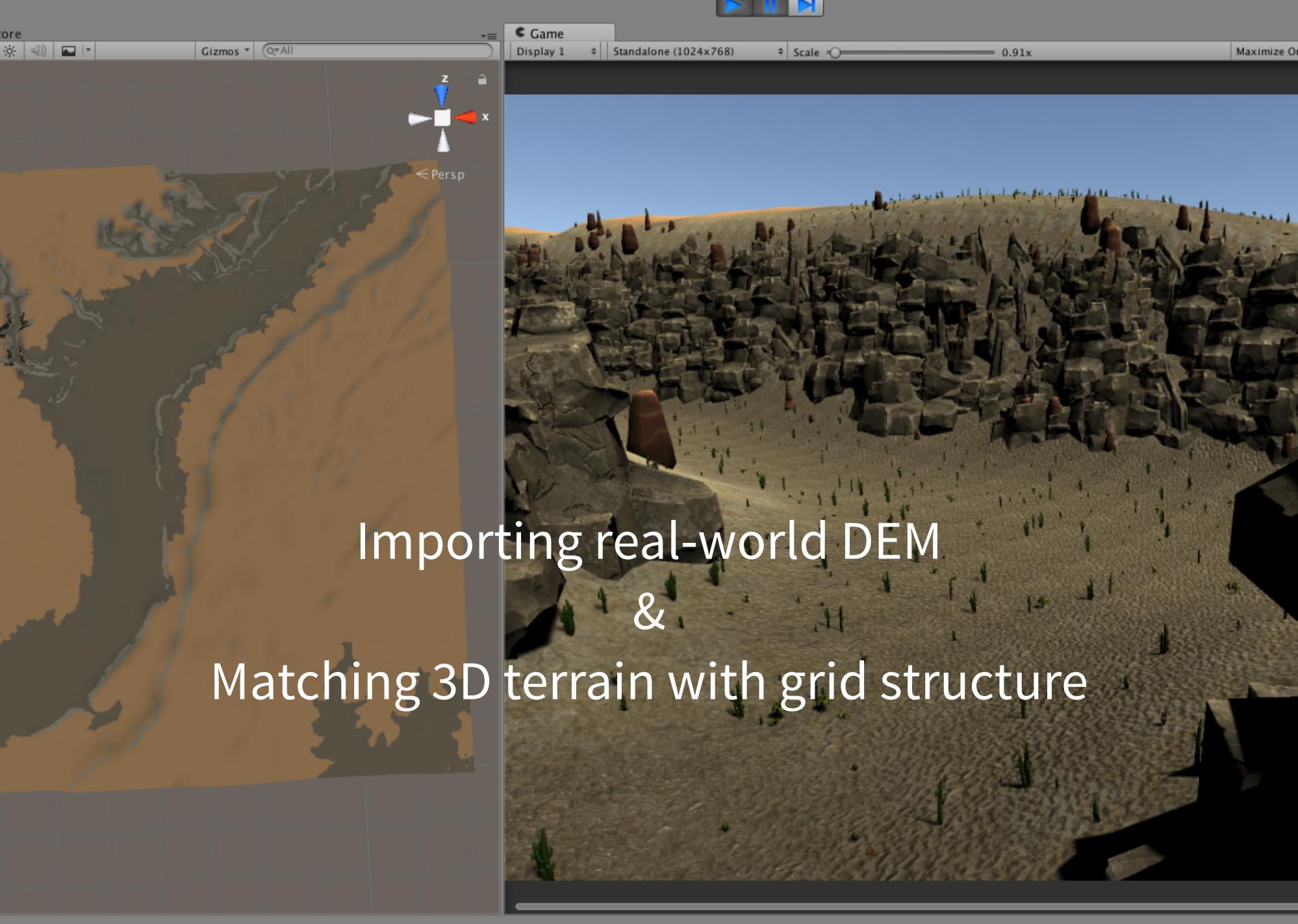
Mesh Collider
Convex
Inflate Mesh
Skin Width
Is Trigger
Material
Mesh

Mesh Renderer
Lighting
Materials

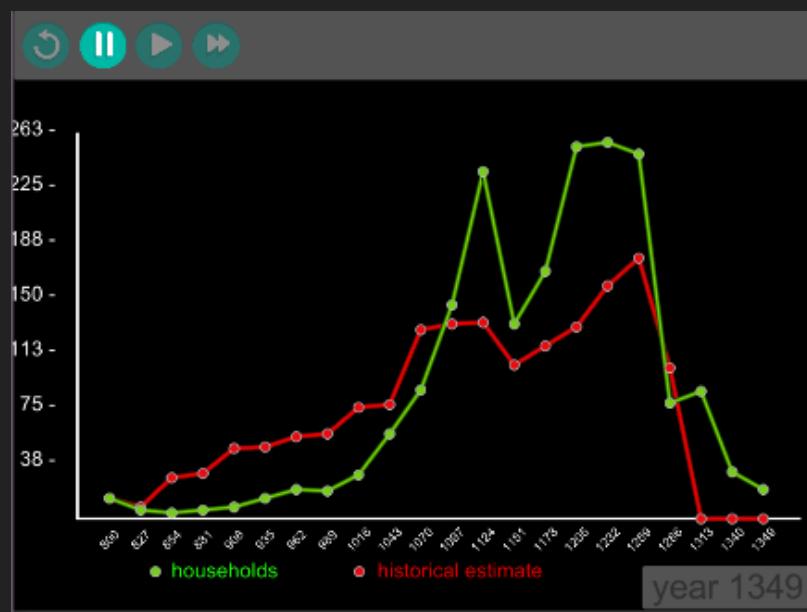
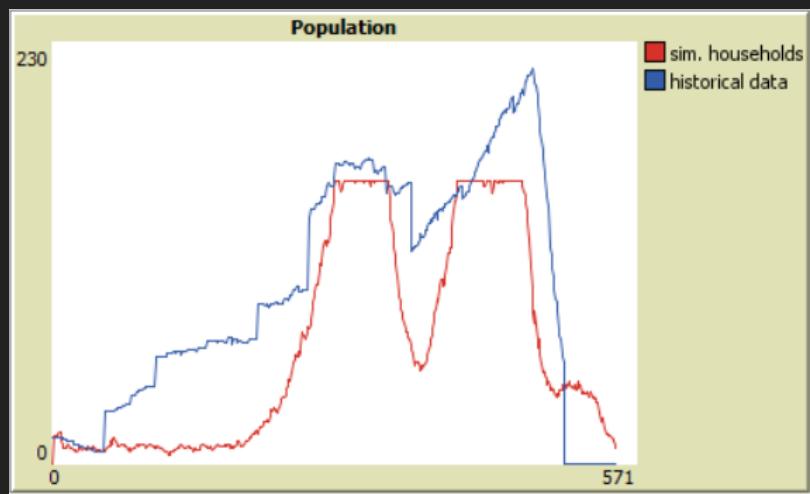
Model Map (Script)
Script
World
View Mode
View Historical Settlements
Historical Settlement Marker

Marker Scale Range
Min
Max

Default-Material (Instance)
Shader Standard



Importing real-world DEM
&
Matching 3D terrain with grid structure



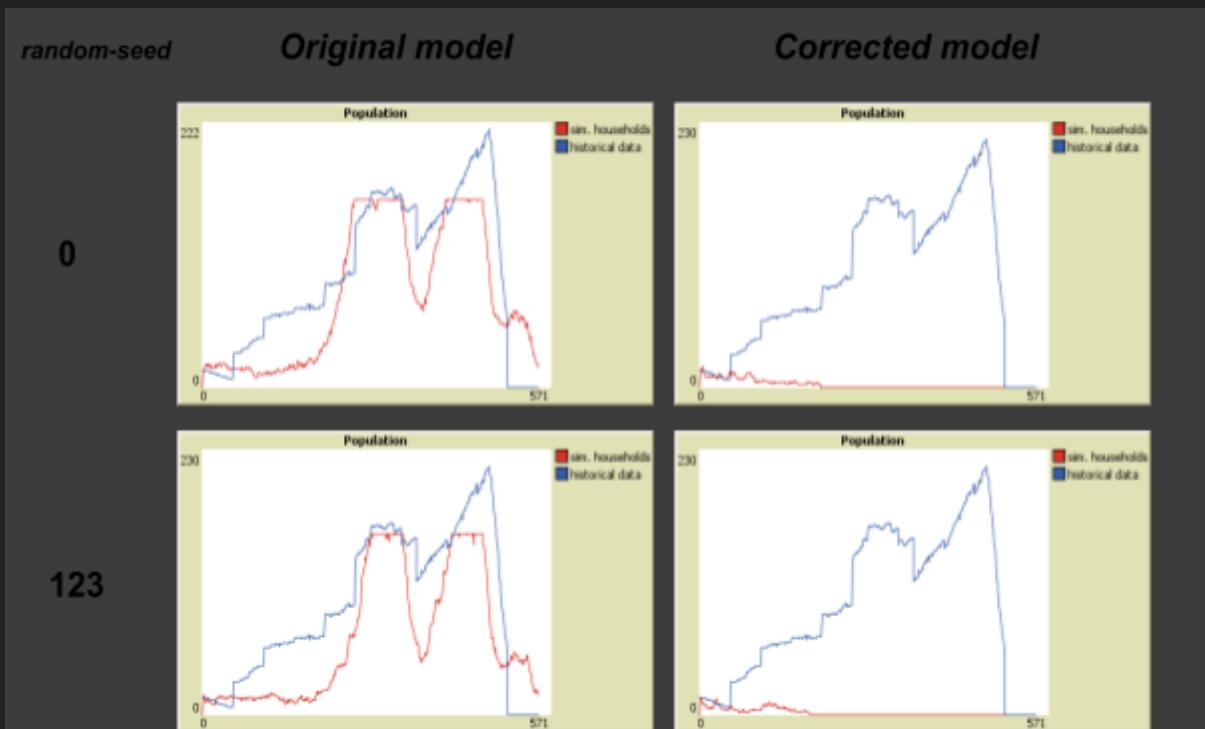
Replication:

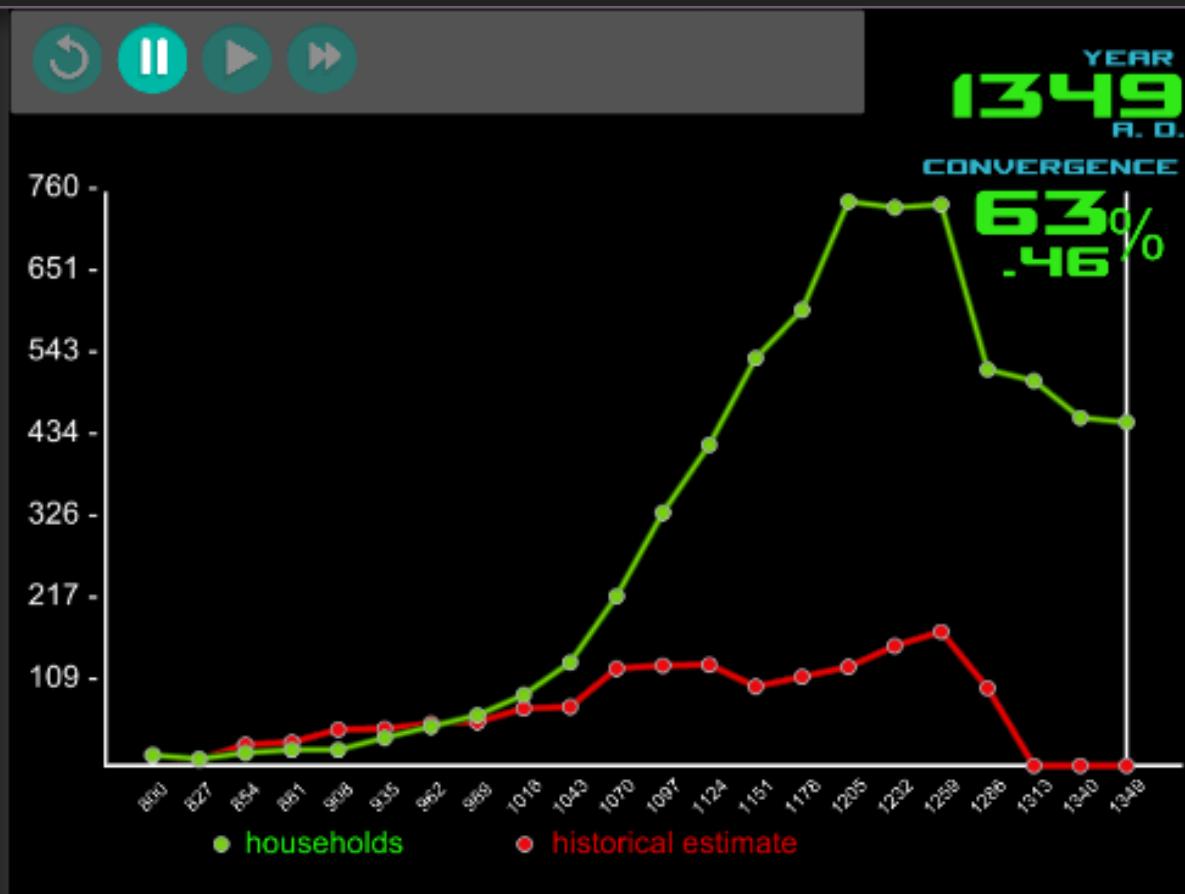
More profound understanding of the model

Revealed problematic *assumptions*

and hard-to-spot *mistakes*.

→ a general problem in ABM





corrected and accounting for *individuals* within households

VI

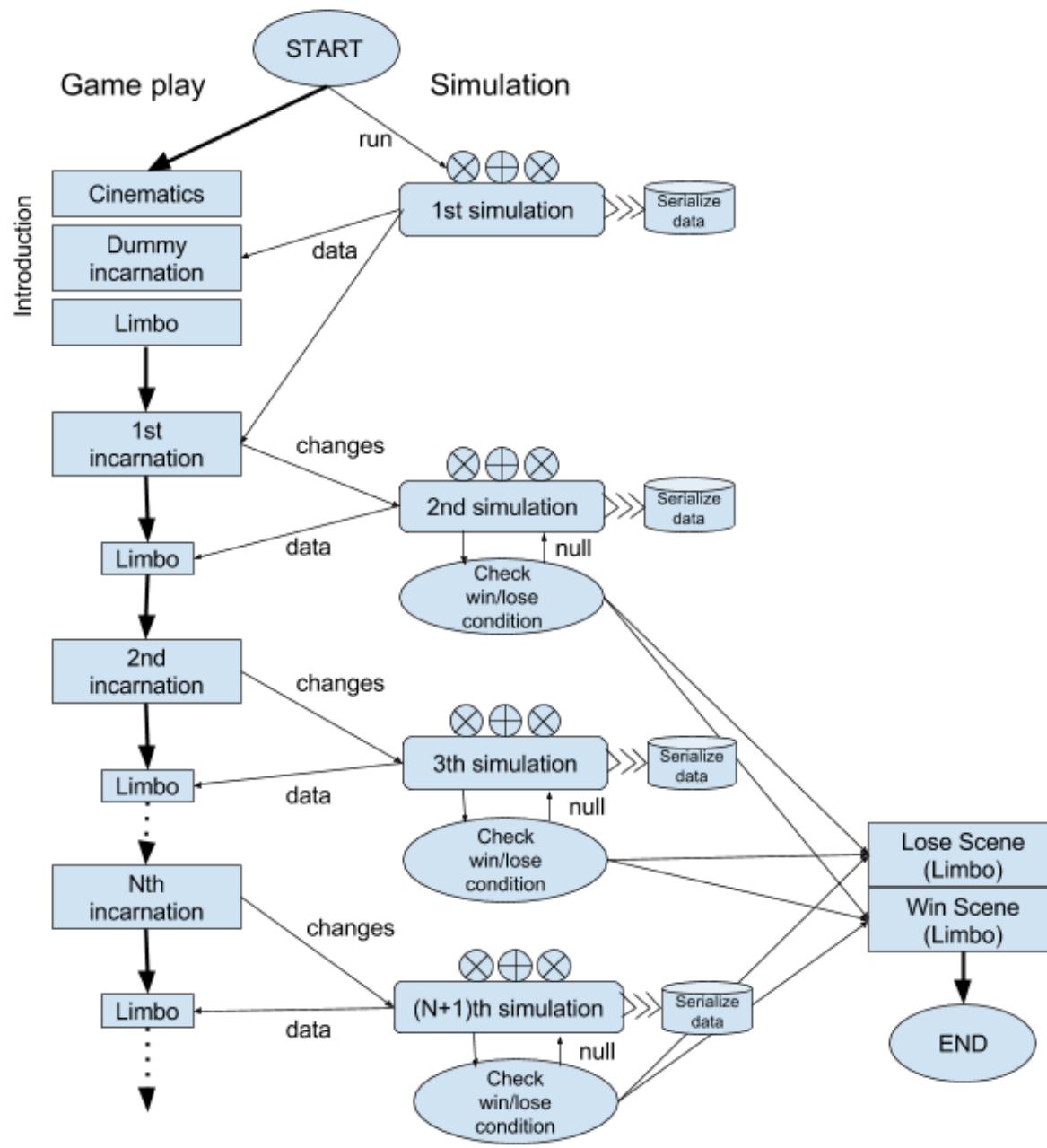
THE *GAME*

GAME CONCEPT

The point of the *model*:
to understand the factors behind the collapse of the
Ancestral Puebloans,
*by running the model many times for different
parameter settings*

The point of the *game*:
to understand the factors behind the collapse of the
Ancestral Puebloans,
*by immersive exploration, discovery, and interaction
with characters and the 3D environment*

Flow



PROTOTYPE

WORKING TITLE



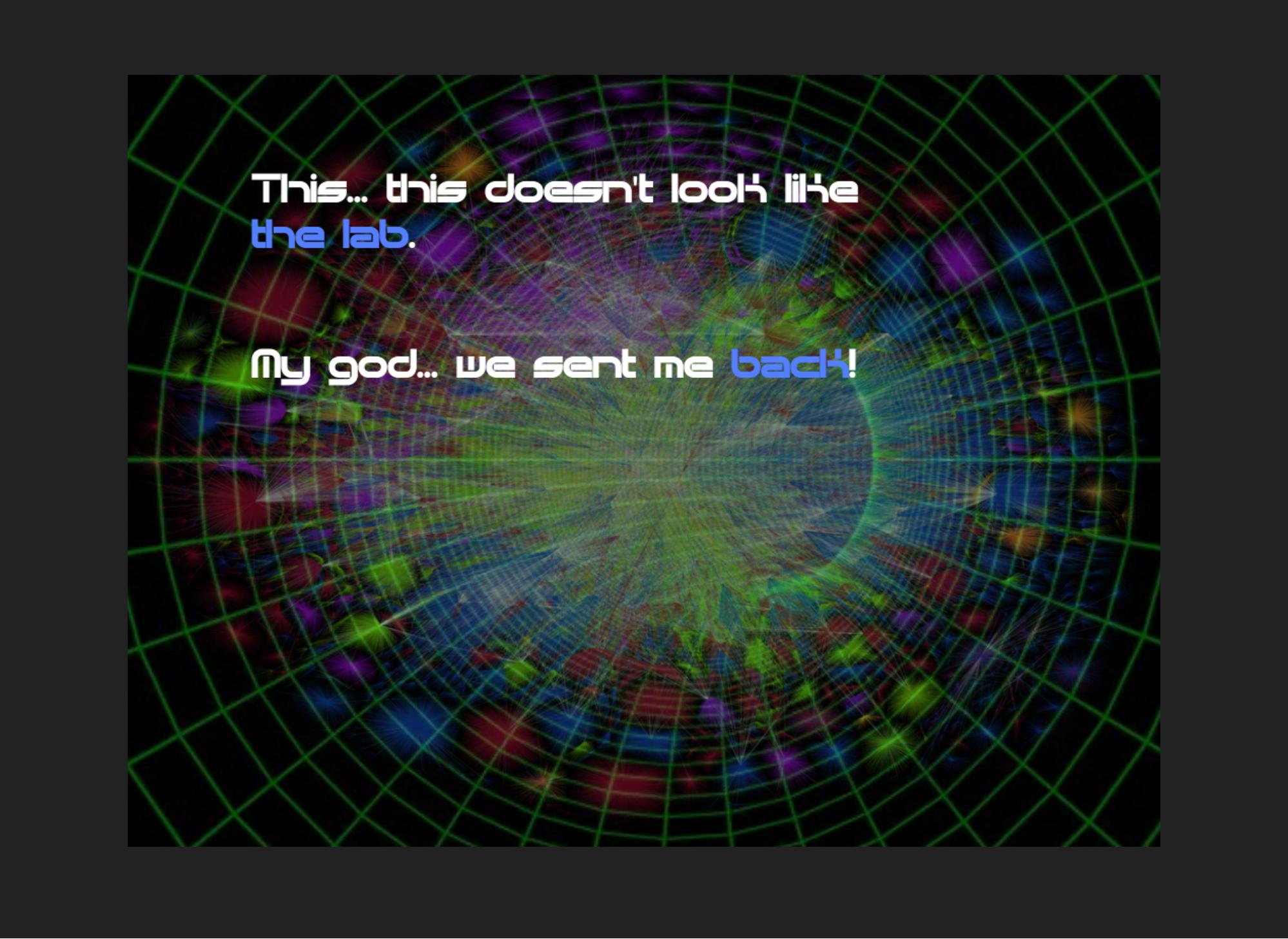
CONTINUE

**NEW
GAME**

**LOAD
GAME**

OPTIONS

QUIT

The background features a distorted grid pattern in green and blue, set against a dark space filled with colorful, glowing particles and streaks of light.

**This... this doesn't look like
the lab.**

My god... we sent me back!



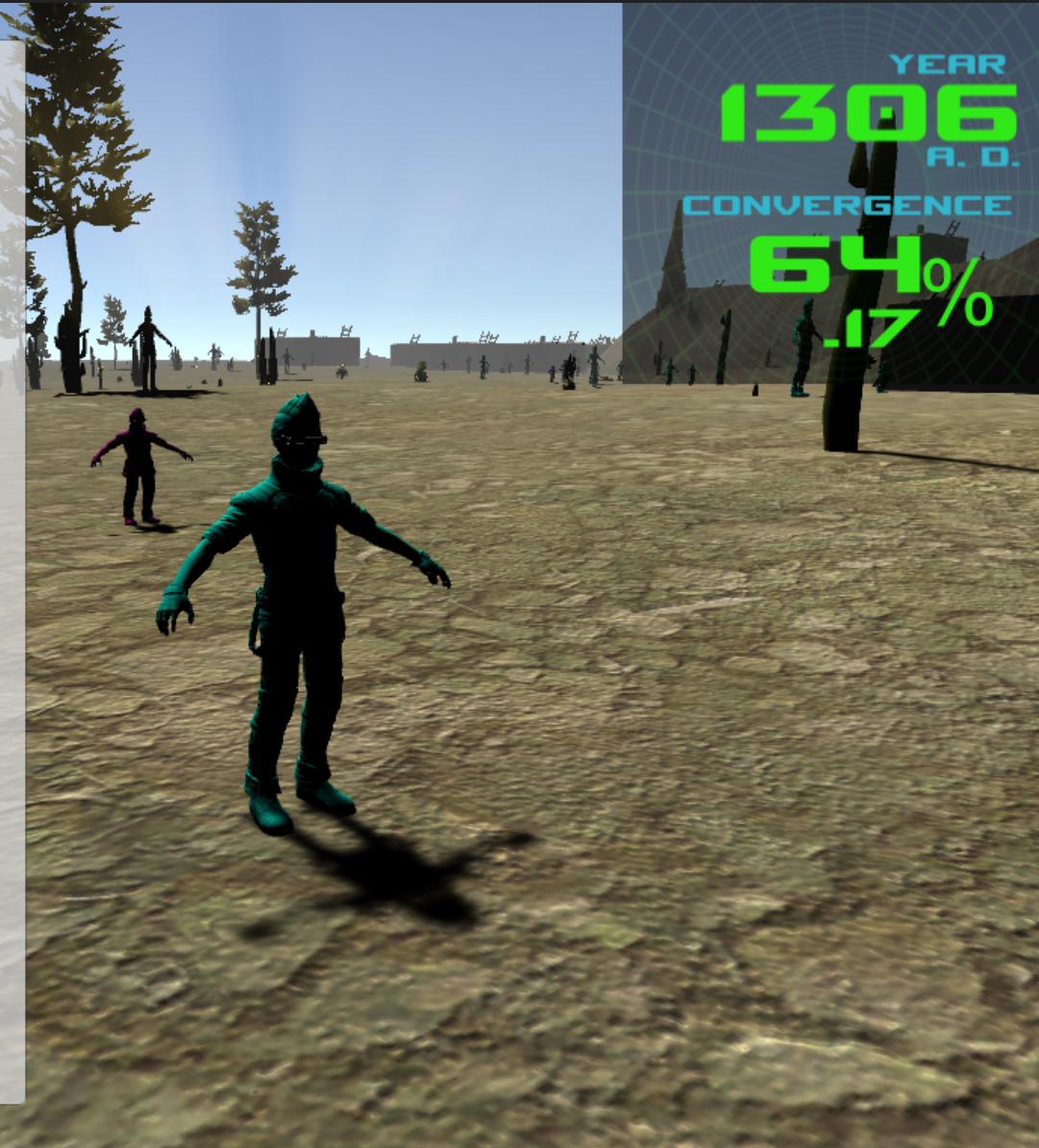
FemaleName09 (Character)

FemaleName09 of the B
(lineage) people.
She is a mature woman that
has seen 39 maize
harvests.
She lives in household 479
based at patch (37, 87).



maleName06 (Character)

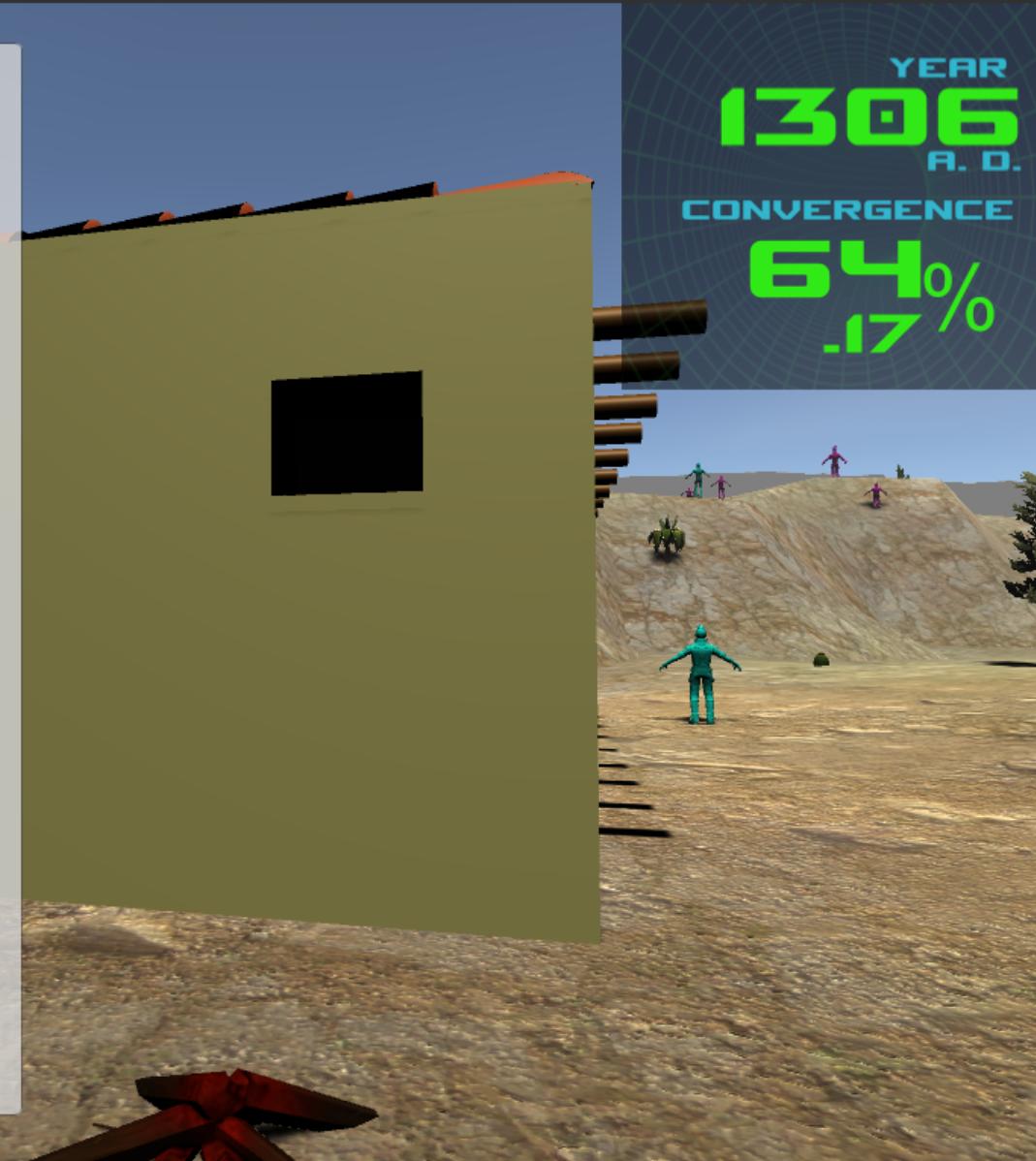
maleName06 of the B
(lineage) people.
He is a boy that has seen
12 maize harvests.
He lives in household 4791
based at patch (37, 87).

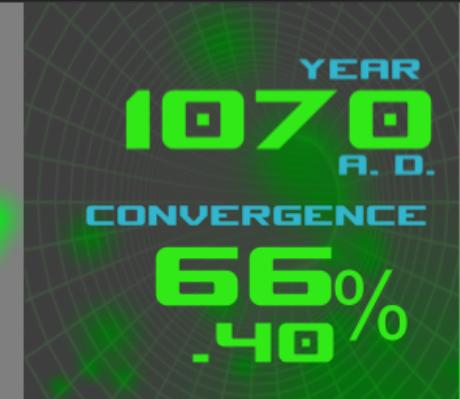


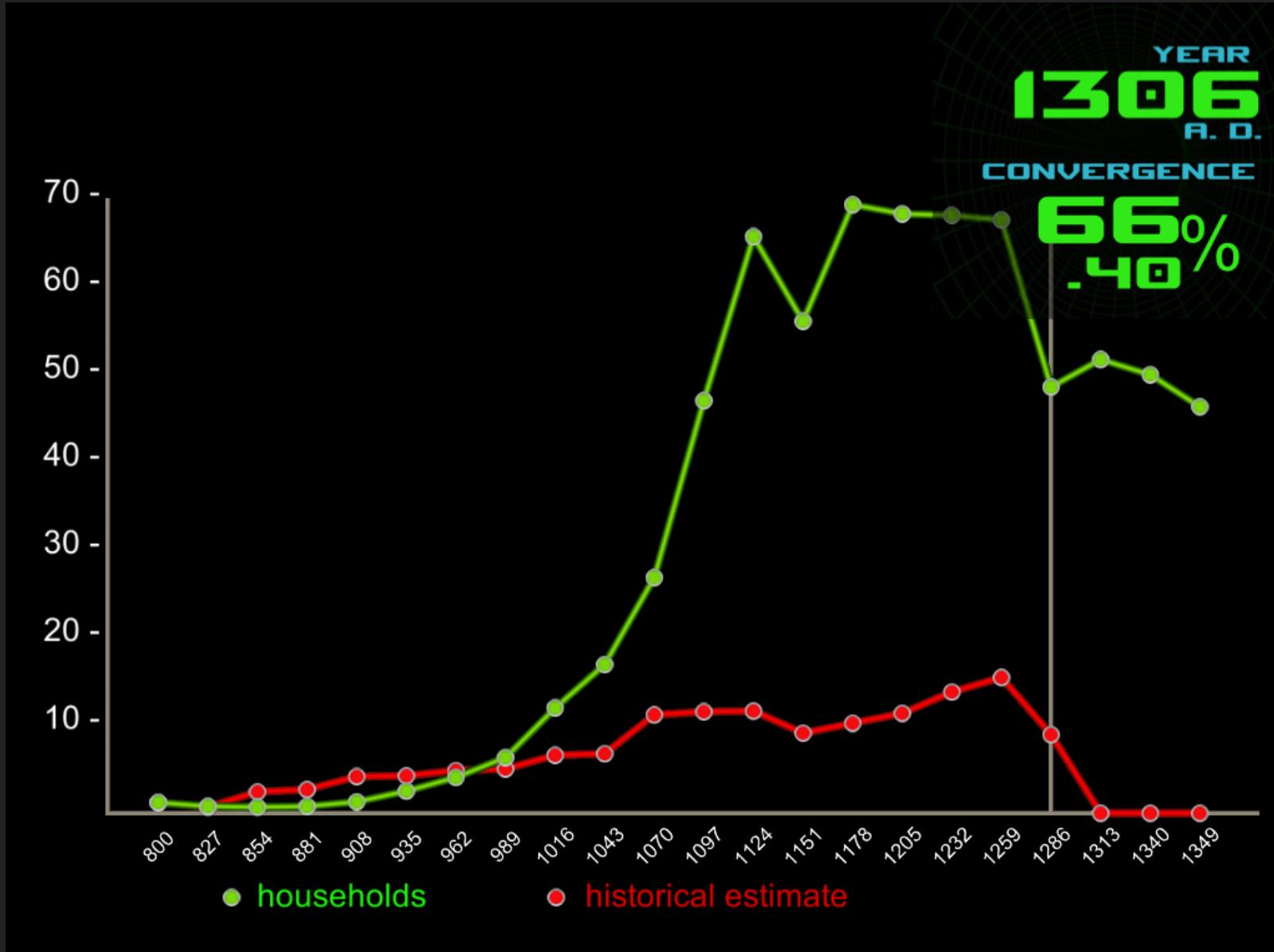


House of the household 321

The household 321 has 29
people.
It descends from
household 3 and survived
for 249 years.







Household 9903

at (29, 55)
lineage = 9
age = 1
adults = 2
couples = 1
max couple count =
3
member ID = {3,12,2,0}
member ages =
{27,27,9,7,0}
member sex =
{True,False,True,Tru
e,False}
Fertility = 0.2277659
min Fertility age:
Female = 14, male = 14
Fertility ages =
{6,6,8,6,7}
Fertility end ages =
{39,35,39,32,32}
death ages =
{54,35,35,44,52}
nutrition need =
{16,26748,4255,127,801
2,283739,109,7959}
last harvest =
579345
estimate = 2658527
nutrition overhead =



Dialog with NPCs → changing the model's parameters and variables

Using Twine+Cradle

The image is a composite of two screenshots. On the left, there is a 3D rendering of a desert landscape with sand dunes under a clear blue sky. Two white text boxes at the bottom contain the questions: "Isn't there water to the north?" and "Isn't there a stream to the south?". At the bottom center, it says "YARN VERSION 0.2.1". On the right, there is a screenshot of the Twine+Cradle interface. It shows a graph of nodes connected by arrows. The nodes are represented as white boxes with black text. The nodes include:

- Daughter**:
water [water]
daughter: My Father told me he was taking care of you, so we'll stay here. [water]
- issues**:
daughter: Perhaps one day I will be able to hear my Father again. [issues]
daughter: Why can't I go to him? [issues]
[Issues] [Issues]
- peripheriescan**:
water [water]
daughter: We said you'd bring us water. [peripheriescan]
water [water]
daughter: We said you'd bring us water. [peripheriescan]
- desert**:
perhaps now is not the time to go to the hills. Best go try to find some water in the Tand.
- dryfield**:
daughter: It has been a long time since the rainless season. [dryfield]
- mowindwater**:
daughter: You chose we haven't considered this before. But maybe, now that you're here, we can think about it. [mowindwater]
- creek**:
You do, like, well, I have been thinking why we've settled here. [creek]
- wells**:
You do, like, well, I am still thinking about it. We should try to stay here until we find another place. [wells]
- have**:
daughter: Then make I can convince Mother. [have]
[have] [have]

Arrows indicate the flow of conversation between the nodes, such as from Daughter to issues, and from issues to peripheriescan.

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<https://andros-spica.github.io/Postdocs-Angourakis-2019/index.html?print-pdf> (printable version)

THANK YOU!

Check the [Youtube playlist](#) and a related [presentation \(video\)](#)