Modeling Our Choices

School of Human Evolution and Social Change
Global Institute of Sustainability K-12 Education Outreach Group
Research Team and Collaborating Institutions

ARIZONA STATE UNIVERSITY
School of Human Evolution and Social Change: C. Michael Barton (Project Director), Steven Falconer, co-PI, Geoffrey Clark, Ilya Berelov, Sander van der Leeuw, Isaac Ullah, Alexandra Miller, Sean Bergin
School of Computing and Informatics: Hessam Sarioughian, co-PI;
School of Geographical Sciences: Patricia Fall, co-PI and Elizabeth Wentz
School of Earth and Space Exploration: Ramón Arrowsmith, co-PI
Institute for Social Science Research-GIS Services: Jana Hutchins
Global Institute of Sustainability and School of Sustainability: Charles Redman

Hendrix College
Brett Hill

North Carolina State University
Marine, Earth, and Atmospheric Sciences; Surface Processes Group: Helena Mitasova

Universidad de Murcia
Departamento de Biología Vegetal: Jose Carrión

Universitat de València
Departament de Prehistòria I Arqueologia: Joan Bernabeu and Ernestina Badal
Departament de Geografia: Neus LaRoca

University of Jordan
Department of Archaeology: Maysoon al Nahar

University of Wisconsin, Madison
Archaeoclimatology Laboratory: Reid Bryson and Jennifer Arzt

Geoarchaeology Research Associates: Joseph Schuldenrein

Teaching materials were created by:
K-12 Education Outreach Team: Maggie McGraw, Laura Swantek, Monica Elser, Eowyn Allen
Navajo Elementary School teachers: Dee Dee Duncan, Carolyn Quist, Vicki White
Peoria Unified School District teachers: Jessica Swann, Stacy Johnson

Contact info: Global Institute of Sustainability, K-12 Education Outreach Team
PO Box 875402
Tempe, AZ 85287-5402
Websites: http://www.asu.edu/clas/shesc/projects/medland/
http://schoolofsustainability.asu.edu/school/community_outreach.php
E-mail: ecology.explorers@asu.edu
# Mediterranean Landscape Dynamics

## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>NEOLITHIC BACKGROUND</td>
<td>5</td>
</tr>
<tr>
<td>NEOLITHIC TIMELINE</td>
<td>11</td>
</tr>
<tr>
<td>ADDITIONAL RESOURCES</td>
<td>12</td>
</tr>
<tr>
<td>GLOSSARY</td>
<td>14</td>
</tr>
<tr>
<td>1-PAGE HANDOUT</td>
<td>17</td>
</tr>
<tr>
<td>IMAGE CREDITS</td>
<td>18</td>
</tr>
</tbody>
</table>
An international, interdisciplinary team of researchers began the Mediterranean Landscape Dynamics project (Medland) in 2004. This project utilizes archaeological, climate, geologic and paleobotanical data to test how farming and herding has shaped Mediterranean landscapes from the beginning of farming to the beginning of complex civilization.

All of modern society depends on the products of farming and herding. But in trying to get the most from domestic plants and animals, we have set off a cascade of effects on the landscapes and within our society. Agropastoral landuse remains the most significant way humans impact natural landscapes.

What can Archaeology tell us about today’s landscapes?

The best-studied archaeological record of the human activities that have transformed the world is in the Mediterranean Basin. This is an area of intensive study because it is where agriculture and subsequently cities first began. Archaeologists, geoscientists, and ecologists have documented the plants, soils and climate for the places where ancient people lived before they began farming and herding. They know that certain areas of the Mediterranean basin that once probably looked something like this…

Now might look like one of these…
How long does it take for these changes to occur?

Landscapes changed over the course of many decades, centuries and even millennia. Starvation, emigration, and even war can occur when soils are eroded away and communities can no longer be sustained through agriculture. By studying the archaeological record, we can learn how people preserved or destroyed their landscapes. Then we can see what happened when people farmed and herded animals in different ways. This led Archaeologist, Dr. Michael Barton to ask how we can use this knowledge to forecast the long-term impacts of our land use decisions today.

What if we could run experiments to see the consequences of different decisions?

It could take centuries to carry out controlled experiments on the effects of different agropastoral land use practices, soil erosion rates, vegetation regrowth, and soil fertility loss. But this could be done much more quickly if we could put realistic landscape forms and livestock in a computer simulation.

Dr. Barton along with the help of computer programmers, geologists, climatologists, GIS specialists and others combined the rich archaeological record of the Mediterranean Basin with recent advances in computer modeling and simulation. Now, they can run experiments in this computer laboratory to test the effects of growth in farming communities on biodiversity, the impacts of using land more intensively, soil erosion and the sustainability of human populations in different environmental and social contexts.

Where is the Mediterranean Basin?

Where are the archaeological sites? The project focuses on data collected from archaeological sites in two areas that represent the wide range of different landscapes and societies in the Mediterranean: Eastern Spain and Western Jordan.
What was the Mediterranean like in the past and what is it like now?

From classical Greek literature and from scientific study of ancient plants and soils we know the Mediterranean basin was once forested with live oaks, pines, cedars, wild carob and wild olive. The climate then was probably similar to what it is today with long, dry summers and short, wet winters. (Frequent droughts and warm winds make it a place for routine summer fires. Natural fires combined with a frequent man-made fire regimen for farming has created the diverse biota that is seen there today.) The Mediterranean region is now home to over 15,000 plant species—three times that of temperate Europe. Humans have selected plants highly resistant to fire and useful for farming (over half the landscape is used for farming). What was once a heavily forested landscape is now sparse groves of oak, almond, olive, and pistachio trees, and fields of wheat, barley, lentils and chickpeas.

How Does Farming Change the Landscape?

To farm a patch of land, ancient farmers had to first clear it of any trees or other vegetation using stone axes and fire. Farming provided a nutritious and reliable food supply, but clearing the land left the soil exposed to wind, rain and gravity, forces that would eventually cause the fertile soil to erode. This also changed the composition of the plant and animal communities in the area. The choice to repeatedly use the land for growing crops took nutrients out of the soil, making it difficult for plants to grow. Without plant roots anchoring the soil, the rate of erosion increases further inhibiting plant growth. Over time, the once forested landscape was converted into what it is today. Did people notice these changes? Probably not. How do these changes affect the sustainability of future generations?

How does the computer laboratory work?

The computer laboratory has two different kinds of computer models working together. One model, the agent-based model predicts what decisions Neolithic people will make when given a particular landscape to farm on. Agents are like characters in a video role-playing game. In the agent model each farm household is an agent that decides how and where to farm. The model places agents or households on a landscape. The agents can assess how many people they have to work the fields or their labor potential. This and the household total needs determine how much land they will farm. The amount of energy they obtain from their crops and livestock determines population size. Multiple villages can be placed on the landscape and the agents can negotiate for land that is not being currently farmed by other villages.

The second model is the geospatial model that represents a 3-D simulation of a landscape in a computer. Any given point on the landscape contains data about elevation and slope, geology, annual rainfall estimates, soil thickness and plant cover. The simulated landscapes can change overtime either naturally or due to farming and measures soil erosion and deposition, plant regrowth, changes in the percentage of cover of different types of plant communities, and changes in soil fertility.

Household decisions about farming and herding will affect the vegetation and soil, these changes in the landscape affect people’s ability to farm. The landscape influences farming decisions and farming decisions change the landscape. These complex back and forth interactions can be studied in the computer modeling laboratory so that archeologists are able to experiment with different farming strategies to explain why they see changes in populations and in the land.
INTRODUCTION

Human Decision Model (Agent Model)

Agents assess:
- Labor potential
- Calorie needs
- Moving costs

1. People clear land for farms.

2. Erosion increases and fertility decreases each year on farmed land.

3. Vegetation grows back on fallowed land each year.

4. Food harvest dictates population size.

5. Agents determine how much land to plant next season based on labor potential and last

Landscape Model

- Neolithic climate: rain and temperature
- Erosion and Deposition rates
The Neolithic

If we traveled back 10,000 years to the Mediterranean Basin (see map), people would look like us and have the same basic needs of food, clothing and shelter. These people made a decision to dramatically change their way of life so that they would have a more reliable food source. They decided to stop following the animals they hunted and settle down in one place to grow their own food. **They became Farmers!** Archaeologists call this the Neolithic Revolution, because it would forever change the way people lived on the Earth.

If you look at the timeline, you will see that archaeologists think that the idea of farming probably didn’t occur just once, but groups of people in different places began farming in the Near East, Africa and East Asia, and North and South America. Eventually the idea of farming spread across the whole world!

**Why does this change occur?**

It’s all about sustainability! Farming is more reliable than hunting and gathering. It produces a surplus of food that can be eaten throughout the year. Because hunters and gatherers could not afford to deplete wild plants and animals, people were always on the move in search of food. Farming also produced more food per acre of land than gathering, and people don’t have to travel as far to get more food. While it does take more energy to farm, the benefits of producing extra food outweighed the negative changes brought on by sedentary living (greater spread of disease, creation of jobs and unequal status in society, more hours per day spent working, etc…), so people stuck with farming. Farming was so successful that the population of humans on the earth increased from 5 million people in 8000 BCE to 50 million just 5,000 years later, a ten-fold increase, and is over 6 billion today!
How did Neolithic people live?

Culture is a word used by archaeologists to describe the way people lived including the types of houses they lived in, the kind of art they created, the rituals they took part in, the tool technologies they used and the way they farmed the land. How would you describe the culture we live in today?

- **Houses and villages**

  [Image of a Neolithic village]

  Houses were made of mud brick and stone and were usually grouped into small villages with only 150-200 people but there were towns with over 5,000 people.

- **Art**

  [Image of cave paintings]

  People painted on the walls of houses and buildings with different color pigments.

  [Image of jewelry]

  People have always worn jewelry! Neolithic jewelry is made of stone, bone and shell.

  [Image of figurines]

  People made figurines of humans and animals out of plaster, stone and later out of clay.

  (Çatal Höyük, Turkey)

  (Khirokitia, Cyprus)

  (Ain Ghazal, Jordan)
• **Ritual**

Neolithic people are tied to the land they farmed and the animals they raised for food so they performed rituals that ensured they had enough to eat. This is a reconstruction of a temple devoted to some of those animals. (Çatal Höyük, recreation of the Bull Temple)

• **Tools**

Neolithic people did not use metal so they used stone, bone and wood to make tools. This is the kind of stone axe that would have been used to cut down trees to make farm land.

At the beginning of the Neolithic, people stored surplus food in pits dug into the ground. They also used containers made of stone for food preparation but later used pottery jars made from clay. (Khirokitia, Cyprus)
• **Farming Methods**

Neolithic people practiced *Swidden* or Slash and Burn agriculture. This means that they would cut or burn down the trees and use the land that was cleared for growing crops.

This is what this process looks like:

They grew these crops in one of two ways:

- **Intensive Farming**: They farmed all of a piece of land, all the time. This produced food close to home but was not sustainable over time without the use of animal manure or other fertilizers to replace nutrients in the soil.

- **Extensive Farming**: They farmed part of the land and left the rest fallow, rotating which piece of land was used every year. This produced lower yields but was more sustainable over time.

• **Animal Grazing**

During the Neolithic, people grazed sheep and goats on their land so they wouldn't have to hunt wild animals. Like farming, grazing also changed the landscape.
How Did Life Change After Farming Began?

1. **People Live In One Place**
   Farmers do not need to move around in search of food so they can build permanent houses and create villages and towns, this is called being sedentary. This affected the landscape. How do today’s cities affect the landscape around them?

2. **New Technology**
   New types of tools and storage containers are created during the Neolithic to more efficiently plant, harvest and store this surplus of food.

3. **Social Stratification**
   People begin to group themselves together by the job they hold or by their wealth and importance in the village. Different social groups include religious and eventually government leaders.

4. **War**
   If one village or group of people has more than another because of a surplus or better access to resources, it can lead to conflict and even war.

5. **Trade**
   The extra food can be traded with other villages for different types of food or goods like tools. When people trade goods, they often trade ideas. Why does this happen?

6. **Food Surplus**
   Farming and raising animals for food (also called animal husbandry) can produce a greater amount of food than can be eaten. This extra food is called a surplus.

7. **Population Increase**
   More food means you can feed more people, but there are some negative effects like an increase in disease and a decrease in the amount of natural resources from over-use, which can include water shortages.

8. **Craft Specialization**
   People begin to specialize, or become an expert at creating certain types of goods that they can use and trade.
Are we like the Neolithic people?

You probably don’t realize it but you are living the Neolithic way of life. We live in one place and get our food from farms, even if we don’t grow it ourselves. We still eat food that is similar to what the Neolithic farmers grew. This is what archaeologists call the “Neolithic Package,” and it includes:

- 2 kinds of the most ancient kinds of wheat, called Emmer and Einkorn, and Barley

![Emmer Wheat](image1)

![Barley](image2)

We also eat wheat and barley. That is what our bread and cereal is made from, but it is a little different than the kind the Neolithic people ate.

- Legumes which are chickpeas, vetch and lentils

![Chickpeas](image3)

![Lentils](image4)

We still eat chickpeas (or garbanzo beans) and lentils, and people in other parts of the world still grow and eat vetch.

- Sheep, goats, pigs and cows

![Sheep](image5)

![Goat](image6)

Sheep and Goat are still eaten in the Mediterranean area and here in the U.S. we eat a lot of cow and pig.

What are some other ways we are like Neolithic people?
<table>
<thead>
<tr>
<th>Year BCE</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>~250,000</td>
<td><em>Homo Sapiens</em>, Modern Humans live in Africa as Hunter-Gatherers</td>
</tr>
<tr>
<td>12,000</td>
<td>Paleolithic Hunter-Gatherers</td>
</tr>
<tr>
<td>9,000</td>
<td>Mesolithic, Jericho Begins</td>
</tr>
<tr>
<td>8,500-8,000</td>
<td>Neolithic in the Mediterranean Basin: Farming Begins!</td>
</tr>
<tr>
<td>7,000</td>
<td>Neolithic begins in Europe</td>
</tr>
<tr>
<td>6,500</td>
<td>Çatal Höyük in Turkey</td>
</tr>
<tr>
<td>6,000</td>
<td>Pottery use begins in Jordan</td>
</tr>
<tr>
<td>5,000</td>
<td>Farming begins in Egypt</td>
</tr>
<tr>
<td>3,000</td>
<td>People are farming in Southwest Asia, Europe, Egypt, India, Thailand, China, Mexico and Peru</td>
</tr>
</tbody>
</table>

~250,000 BCE: Homo Sapiens, Modern Humans live in Africa as Hunter-Gatherers.
Projects on the Web

Video timeline of life on Earth

http://worldhistoryforusall.sdsu.edu/movies/flash_large.htm

The Iceman Article: description of apparel worn by Neolithic man and the legal battle between countries over this man.

http://www.american.edu/TED/iceman.htm

The Shelburne Landscape Project

The SLCP studies how natural processes and human history have interacted in Shelburne to produce the modern landscape we see today. By studying historic texts and imagery, and comparing these resources to the modern day, we can learn more about the changes Shelburne has undergone since European settlement.

http://www.uvm.edu/shelburnelandscape/introduction.html

Archaeological Adventures in the Southwest: local places of archaeological interest

http://www.archaeologicadventures.com/

Reeds Farm Archeological Site

http://www.kidsdigreed.com/default.asp

Archaeological Research Institute (ARI) at ASU

http://archaeology.asu.edu/

K-12 links from Archnet

http://archnet.asu.edu/resources/Selected_Resources/K-12%20Resource.php

Catal Höyük interactive website

http://www.smm.org/catal

Modeling Programs:

Ascape

http://ascape.sourceforge.net/index.html#Introduction

Open Agent Based Modeling Consortium:

http://www.openabm.org

Dr. Barton’s modeling pages:

http://www.public.asu.edu/~cmbarton/CMB_iWeb/Modeling.html
http://www.public.asu.edu/~cmbarton/files/netlogo/

NetLogo pages:

http://ccl.northwestern.edu/netlogo/
http://ccl.northwestern.edu/netlogo/resources.shtml
Modeling Across the Curriculum:

http://mac.concord.org/

ABM software comparison:


Wikipedia

ABM: http://en.wikipedia.org/wiki/Complex_system


WaterSim at ASU:

http://watersim.asu.edu/

USDA web resources:

Backyard conservation Publication: How to conserve soils in your own backyard.

http://www.nrcs.usda.gov/feature/backyard/BkYrdHit.html

A look at Arizona Agriculture:

http://www.agclassroom.org/kids/stats/arizona.pdf

Books


**Agent Based Computer Model**

A computer model that recreates the actions of individuals to show what could have happened in certain situations.

**Animal Husbandry**

Raising animals for food.

**Cost**

The amount of time or energy it took to perform a certain task.

**Craft Specialization**

When one person becomes an expert at a certain type of job. For example, people that were experts in making pottery or stone tools.

**Culture**

The characteristic features of everyday life shared by people in a particular place or time.

**Deposition**

The process by which soil at the earlier surface is moved to place by water, glaciers, wind, waves, etc and accumulates and builds up.

**Erosion**

The process by which the soil on the surface of the earth is worn away by the action of water, glaciers, winds, waves, etc.

**Extensive Farming – Shifting Cultivation or Swidden**

Farming a piece of land for a short time, then shifting to another spot to farm and letting the old field fallow.

**Fallow**

Land that was cleared for planting but was not planted on for that growing season and natural vegetation is allowed to grow back.

**Fertility**

The ability of the soil to supply enough nutrients for the plants grown in it and the animals that graze on it.

**Fission**

Splitting into parts.
Harvest

The gathering of mature crops from an agricultural field.

Hunter-Gatherer

People who get their food through hunting of wild animals and gathering wild plants rather than by farming.

Intensive Farming

Farming one specific area all the time, without leaving a section fallow. It is usually necessary to fertilize fields that are farmed intensively.

Labor Potential

The amount of work someone or something can produce towards economic gain.

Legumes

Type of plant in which the fruit is a seed pod. This includes chickpeas, beans, lentils, vetch, peas and peanuts.

Mediterranean Basin

The land that surrounds the Mediterranean Sea, including the modern countries of Spain, Italy, Greece, Turkey, Syria, Lebanon, Israel and Jordan and the North coast of Africa.

Neolithic

“The New Stone Age.” Period of time, beginning 10,000 years ago when humans changed from hunter-gatherers to farmers. People lived by farming but did not yet use tools made of metal.

Neolithic Package

Includes the types of food people grew and ate during the Neolithic and the types of technology they developed.

Nomadic

People who have no fixed home and wanderer from place to place in search of food.

Ritual

Ceremony or ceremonial act.

Sedentary/Sedentism

Not moving around, living in one place
Slash and Burn Agriculture/Swidden Farming

A way of preparing land for agriculture that begins with cutting down and burning the trees and plants that live on the land.

Social Stratification

Arrangement of people into social classes like rulers, peasants, priesthood. People can also be arranged according to the type of work they do, farmers, potters and tool makers.

Surplus

The amount more than what is required or necessary.

Sustain

To support and continue.

Swidden Farming Model

A computer model used by archaeologists to better understand the effects of the switch to agriculture during the Neolithic in the Mediterranean Basin.

Technological Innovations

The use of scientific thinking to create new tools and better ways of doing things.

Tenure

The amount of time someone can own something, for example: farmers owning land.
The Mediterranean Landscape Dynamics Project (Medland)

Scientists working in Jordan and Spain decided to figure out what happened to the landscape when people first started farming during the Neolithic, 10,000 years ago!

They created a computer model that shows the decisions farmers made about land choice and farming practices and what the effects of those decisions were on the landscape along with natural changes in climate and environment.

They asked:

How did this

Turn into this in some places?

During the Neolithic, people stopped moving around in search of food and started farming. This was a more sustainable way to live! People started growing wheat and barley along with chickpeas and lentils. They also domesticated animals like pigs, goats, sheep and cattle. Clearing land for farming, planting new crops and raising animals had effects on the landscapes of the Mediterranean and the way people lived.

Something strange happens during the Neolithic…… People begin farming and build large villages, after 2,000 years, they move out of the villages and live in very small groups. **Why did this happen?**

The Medlands model suggests that the way people farmed caused them to make this change. People caused:

- Depletion of nutrients in the soil
- Soil erosion

Changes in the landscape forced people to make different decisions about farming and how they lived.
Mediterranean map

Catal Hōyük excavation

Catal Hōyük recreation

Catal Hōyük wall painting

Khirokitia, Cyprus jewelry

‘Ain Ghazal, Jordan figures

Catal Hōyük bull sanctuary

Hafted stone ax

Khirokitia, Cyprus bowl

Slash and burn agriculture

Neolithic village drawing

Neolithic pottery from Spain

Mesa Verde, Colorado spear

Ancient Trade

Food surplus

Baby-population picture
Mediterranean Landscape Dynamics

Flint knapping

http://commons.wikimedia.org/wiki/Image:Usdaemmer1.jpg

3 stalk wheat picture

http://www.freefoto.com/images/9907/06/9907_06_31---Barley_web.jpg

Barley

http://commons.wikimedia.org/wiki/Image:Sa-whitegreen-chickpea.jpg

Chickpeas

http://commons.wikimedia.org/wiki/Image:3_types_of_lentil.jpg

Lentils


Flock of sheep

http://intelligenttravel.typepad.com/photos/uncategorized/2007/08/24/goat.jpeg

Goat

http://upload.wikimedia.org/wikipedia/commons/thumb/1/1e/Lascaux_painting.jpg/420px-Lascaux_painting.jpg

Lascaux, France cave painting

http://commons.wikimedia.org/wiki/Image:Kornmark.jpg

Grain field

http://www.woodlands-junior.kent.sch.uk/Homework/egypt/images/harvest.jpg

Egyptian book of the dead fragment- wheat harvest

All other images are courtesy of the Medland research team