



# Conflict in Complex Socio-Natural Systems: Using Agent-Based Modeling to Understand the Behavioral Roots of Social Unrest within the Manderia Triangle

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# Research Team

## **Center for Social Complexity and EC Lab, George Mason University**

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# The Mandera Triangle

- **Mandera Triangle region spans parts of Ethiopia, Somalia and Kenya**
- **Includes various types of conflict:**
  - Herder-Farmer
  - Herder-Herder
  - Political violence
  - Ethnic violence
  - Armed non-state group conflict
  - Piracy
- **Current model focuses on the first of these.**



# Herder-Farmer Case

## Overview

- **Pre-colonial Mandera largely pastoral**
  - Marginal for farming, unreliable rains
  - Complex traditional system of resource conflict within institutional bounds
  - Raiding and trespass served as means of subsistence and redistribution in lean times
- **Western state system highly disruptive**
  - Ethiopia, Kenya, Somalia are power centers
  - States grant land tenure to farmers
  - Encourage cash economy which favors sedentary land use patterns
  - Traditional raiding and trespass behaviors more destructive to farms than to rangeland

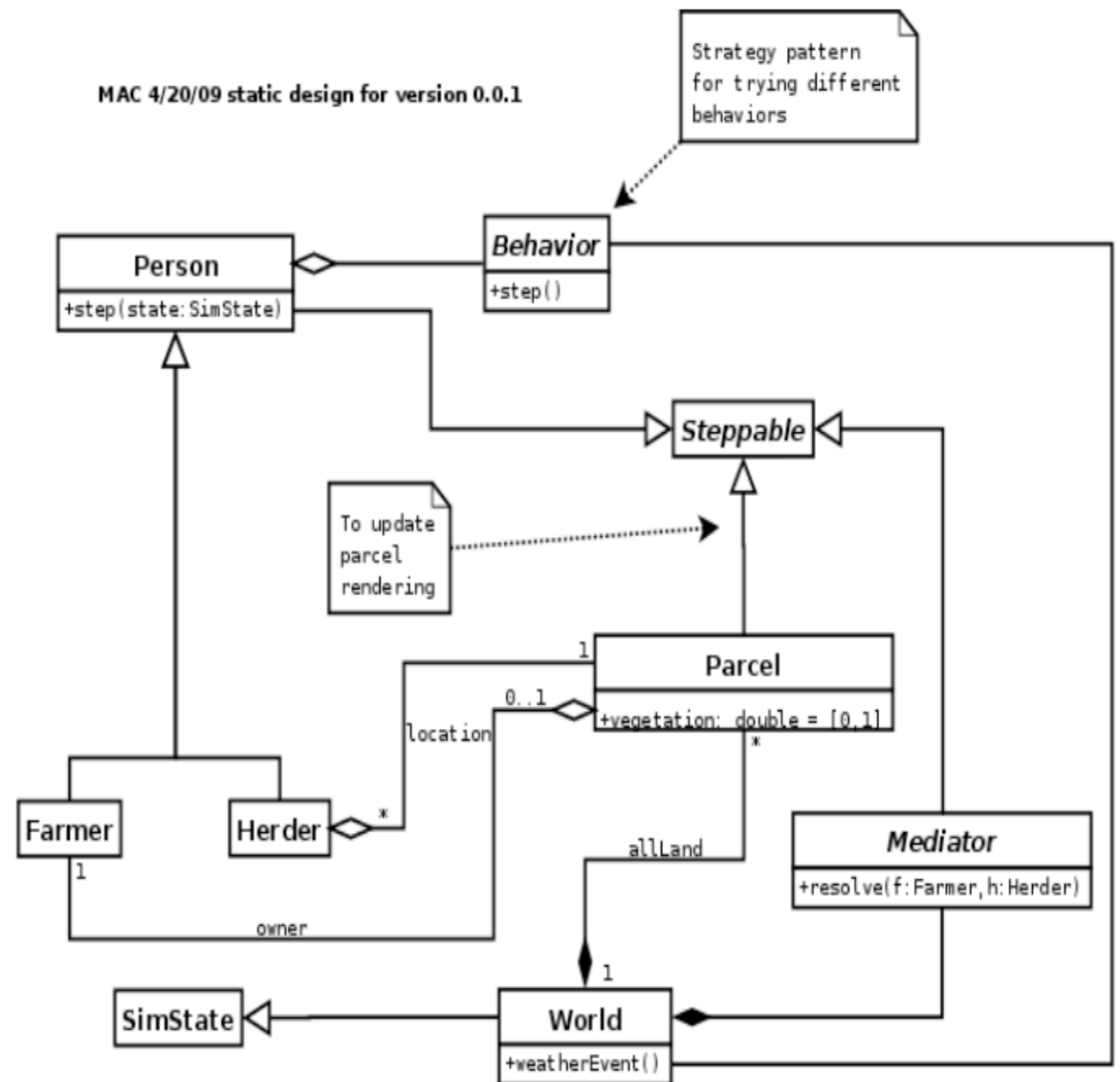
# Research Questions

- What factors are critical to understanding the dynamics of conflict between herders and farmers in the Mendera Triangle?
- Can better land management practices ease conflict without requiring major concessions from stakeholders?
- How much of what is central to this conflict can be generalized to other conflicts within Africa and beyond?

# Herder-Farmer Model

Prototype for Series of East Africa Conflict Models

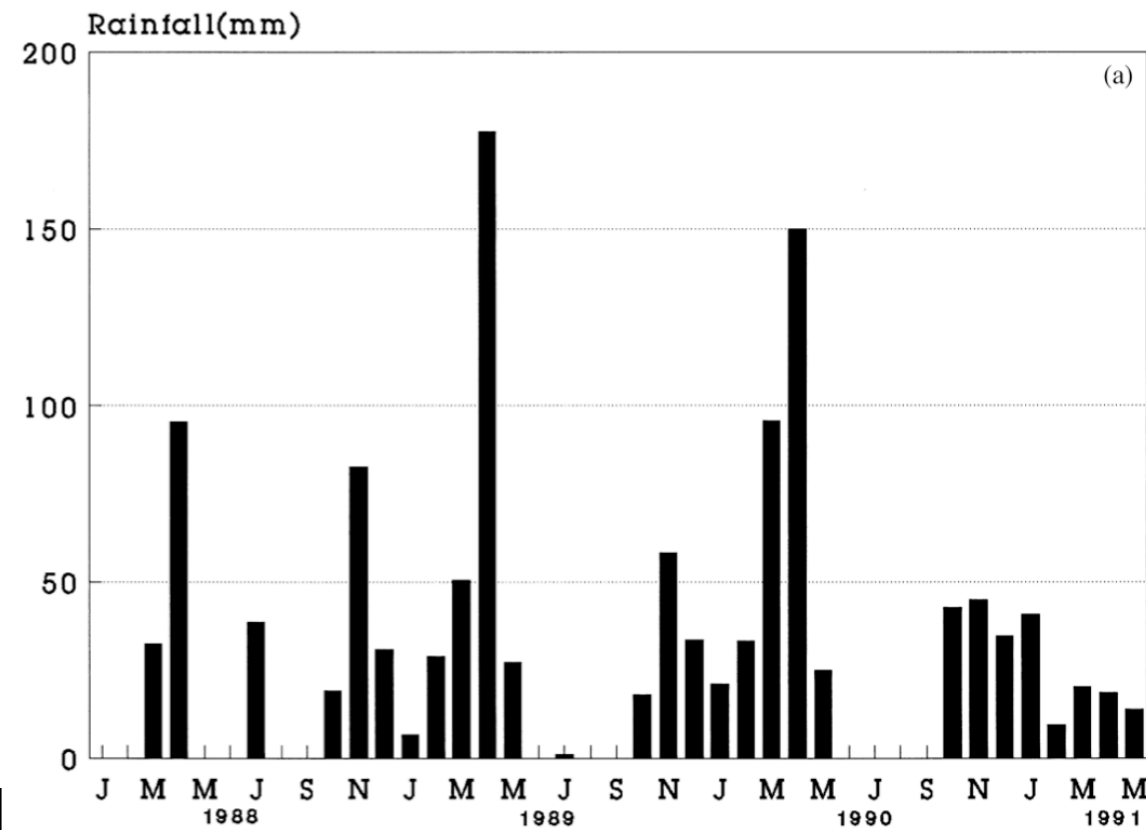
- **Platform:**
  - MASON
  - Java Based
  - Comparable to REPASt, but faster
- **Environment:**
  - Parcels
  - Weather
- **Agent Types:**
  - Farmers
  - Herders
  - Mediator



# Parcels

- **30 arc second grid -- a bit less than 1km<sup>2</sup>**
- Loads Directly from ArcGIS Raster ASCII dump
- **State Variables:**
  - **Land Quality [0..2]**
    - initialized using GIS data on land cover and slope (rough)
    - 1 is maximum quality in natural state
    - Farming doubles quality, to a max of 2
  - **Vegetation [0..1,500 kg/km<sup>2</sup>]**
    - initialized to Land Quality \* 1,500 (max veg. base on lit.)
    - Reduced (quickly) by grazing herds based on data
    - Regenerates (slowly) according to a logistic function with growth rate dependent on rain. During dry times, growth rate goes negative.
  - **Ownership [boolean]**
    - Initialized using GIS data on land use (rough)
    - Farmer ownership doubles maximum vegetation
    - Herders take ownership status into account when planning movement

# Weather



- **One State Variable: Rainfall**
  - Varies by month to match average year
  - Currently no variation day-to-day or year-to-year
- **Designed to make it easy to plug in more realism if needed:**
  - Temperature, humidity...
  - Spatial variability (currently uniform over study area)
  - Interaction with Parcels: Hydrology



# Farmers



- **Currently passive agents**
  - Occupy high-quality land
  - Increase vegetative production of land
  - Conflict with herders when trespass occurs
- **Possibilities for extension**
  - Track farmer wealth -- how able to withstand raids, recover from losses, etc.
  - Family size and land use change dynamics
  - Explicit modeling of farmer relationship to government (gov't grants land rights, provides defense)

# Herders



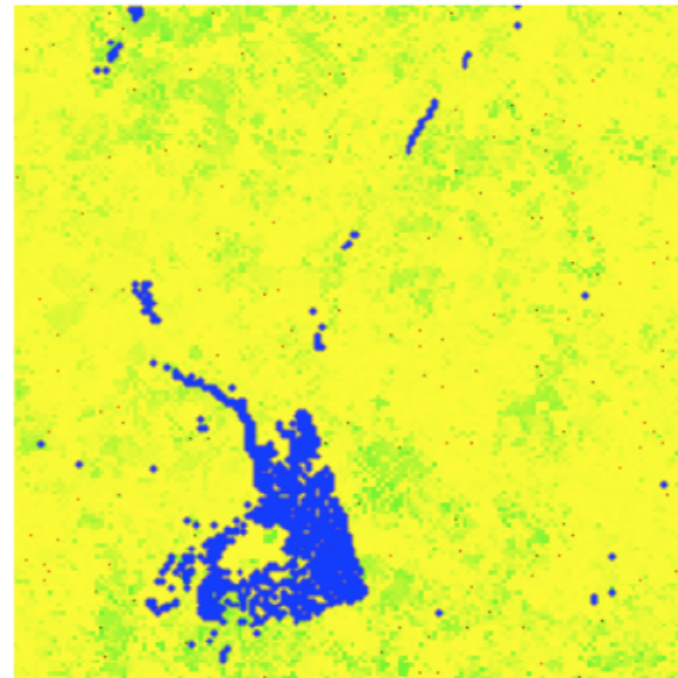
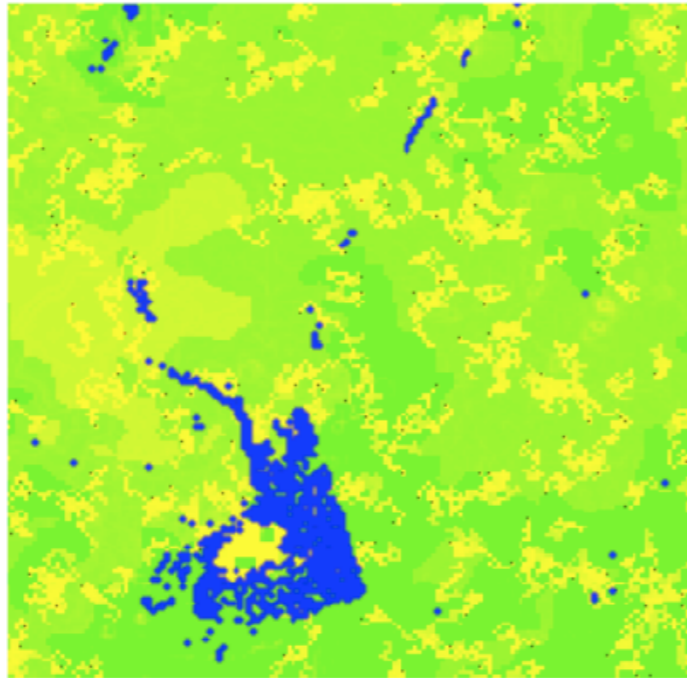
- **Herd and Herder modeled as single unit**
- **State Variables:**
  - Location (parcel)
  - Herd Size (TLU's)
  - Health (function of recent food intake)
- **Movement Rules:**
  - If vegetation is above threshold, stay
  - If not, move to best unfarmed parcel in vision (3 km at present)
  - If no good, unfarmed parcels, and health is poor, move to best parcel in vision regardless of status

# Mediator



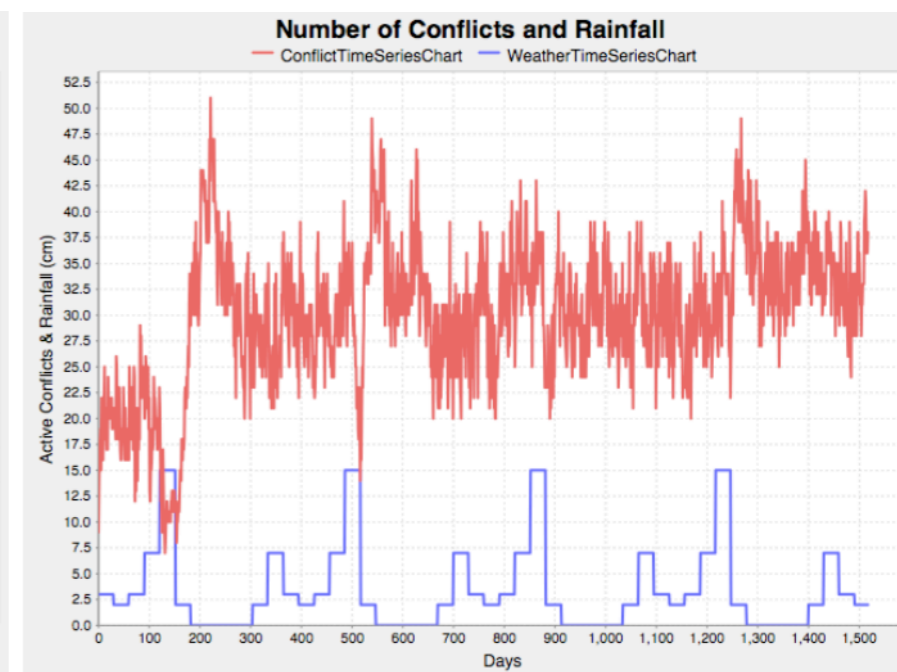
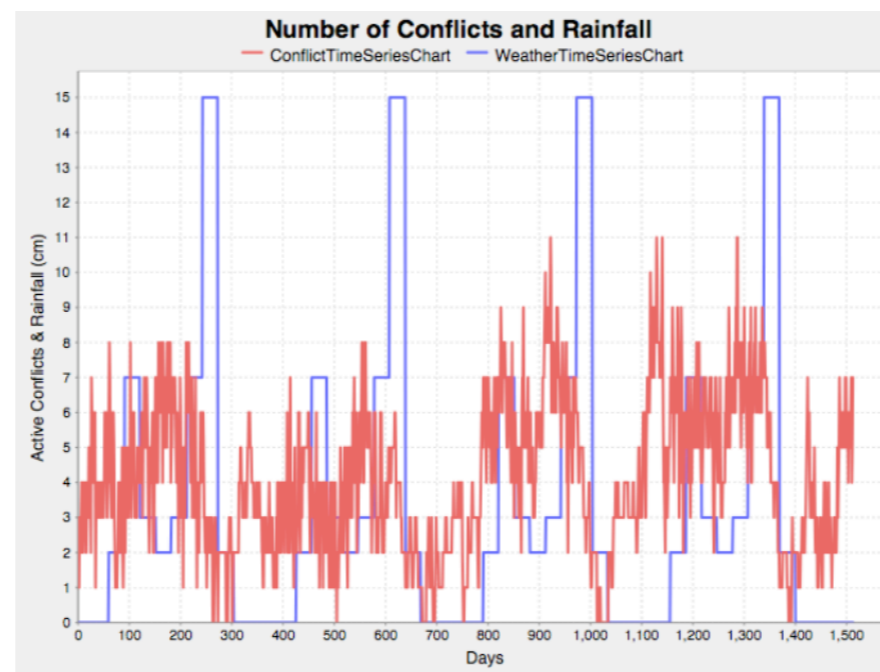
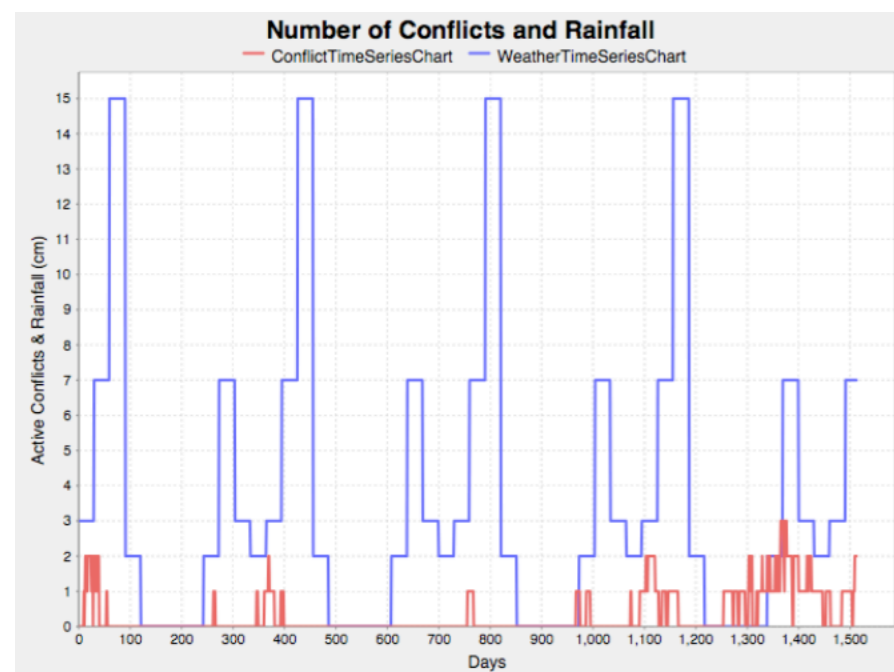
- **“Mediator” is a design pattern, rather than a model of a human mediator**
- When a herder trespasses on a farm, the herder and the farmer are passed to the mediator to resolve the conflict.
- Currently, the mediator simply records (graphs, etc.) the conflict.
- Can be used to hold much richer behavior

# Demonstration



# Preliminary Results

- **Emphasis so far is on validating basic model behavior**
  - There is a carrying capacity below which conflict is rare
  - Conflict increases during dry season as carrying capacity is reached
  - When herder population is so large relative to available land that vegetation can't recover in rainy season, seasonality of conflict disappears.



# Next Steps

- **Movement Rules:**
  - More realistic herder movement rules
  - Challenging to do this within bounds of reasonable computation
- **Population dynamics:**
  - entry and exit rules for both farmers and herders to build dynamic understanding of carrying capacity
- **Land Use Dynamics:**
  - May be useful to model farm expansion dynamics
  - These are much slower than herd movement dynamics
- **Institutional arrangements:**
  - Herders rely on kin and clan to back them up in conflict. Farmers are more vulnerable until they can mobilize the government
- **Deeper GIS integration:**
  - Support for vector data types