1_Slides.pdf

Introduction to Agent-Based Modeling

EES 4760/5760

Agent-Based & Individual-Based Computational Modeling

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Class #1: Tues. January 10 2018

Who Are You?

1. Who are you? (Name, year, major)
2. Computational skills (if any)
   - programming, statistical analysis, ...
3. What do you want to get from this class?
4. Ask me a question about computational modeling
5. Something interesting about yourself

Getting Started

For Thursday:

- Download and install NetLogo on your computer.
  - URL in syllabus and assignment sheet
- Set up Box account
  - Details in syllabus and assignment sheet
  - https://vanderbilt.box.com
  - Make folder for this class with your last name:
    - lastname_EES_4760 or lastname_EES_5760
    - Share it with me and Brandt Gibson as Editors
    - Homework goes in subfolders:
      - HW_1, HW_2, ...

Agent-Based Modeling

- Simulate individuals:
  - Autonomous
  - Heterogeneous
  - Quasi-local
  - Bounded rationality
- Simulate environment
- Emphasize simplicity, minimal assumptions
- **Emergence:** Large-scale phenomena arise from small-scale individual interactions
  - Interesting when large-scale is not easily predicted from small-scale

Simple Experiments

- Play with economics
  - Simple agents trade with each other
  - Confirm 1st welfare theorem:

    Trading leads to Pareto equilibrium
  - Find conditions for satisfying theorem:
    - Not necessary for traders to be completely rational
      - How much rationality do you need?
    - Equilibration can be slow
    - Time-varying preferences can prevent equilibration
- Dynamics of agent-based models connect to nonlinear dynamics and chaos

Economics of Cooperation

Game Theory

- Prisoner's Dilemma Game:

A \ B	B Cooperates	B Defects
A Cooperates	(3,3)	(0,4)
A Defects	(4,0)	(1,1)

- Nash Equilibrium:
  - No matter what player A does, player B is better off defecting
  - No matter what player B does, player A is better off defecting
  - **End result:** Both players end up worse off than if they had both cooperated.

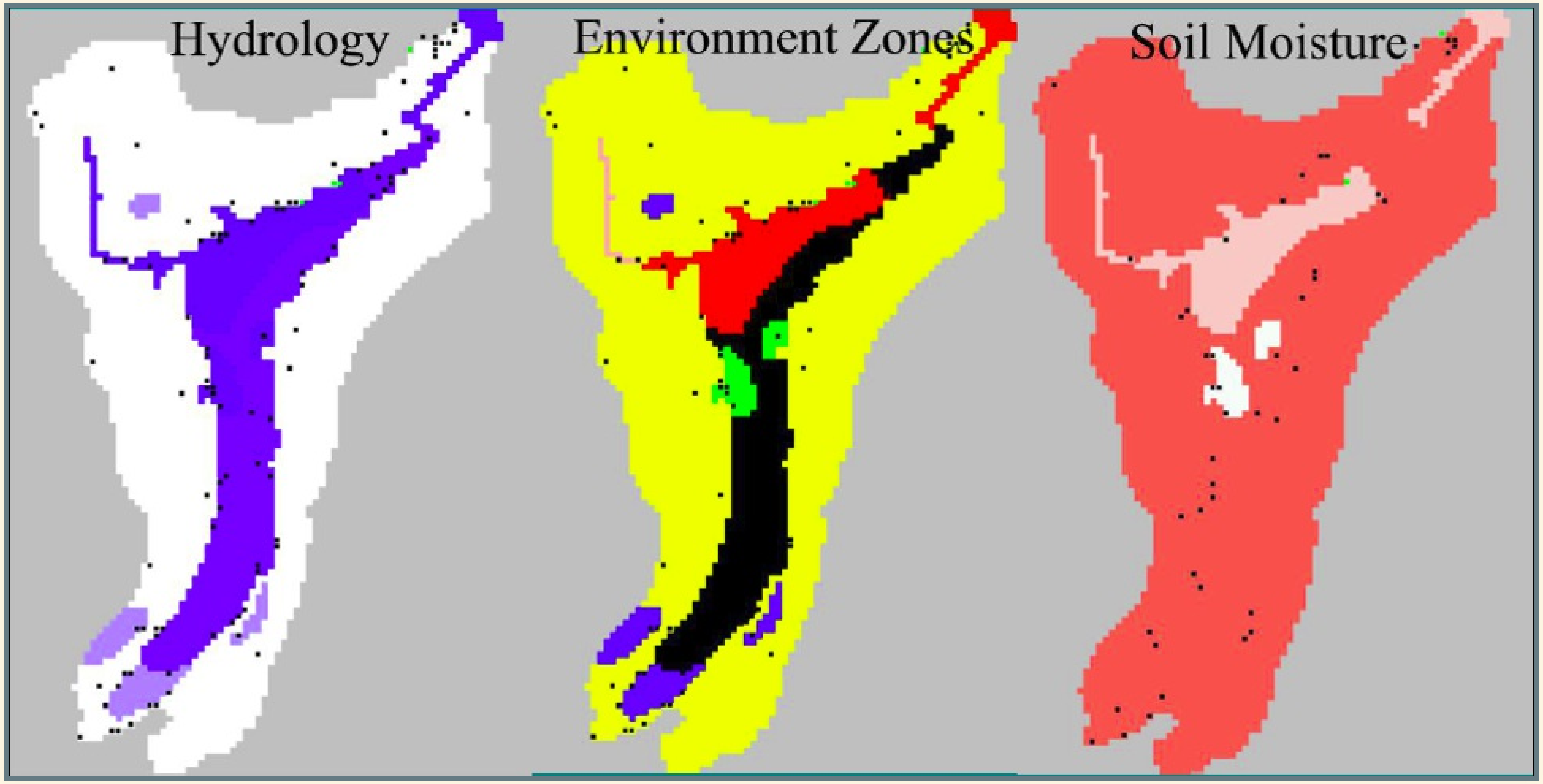
Iterated Prisoner's Dilemma

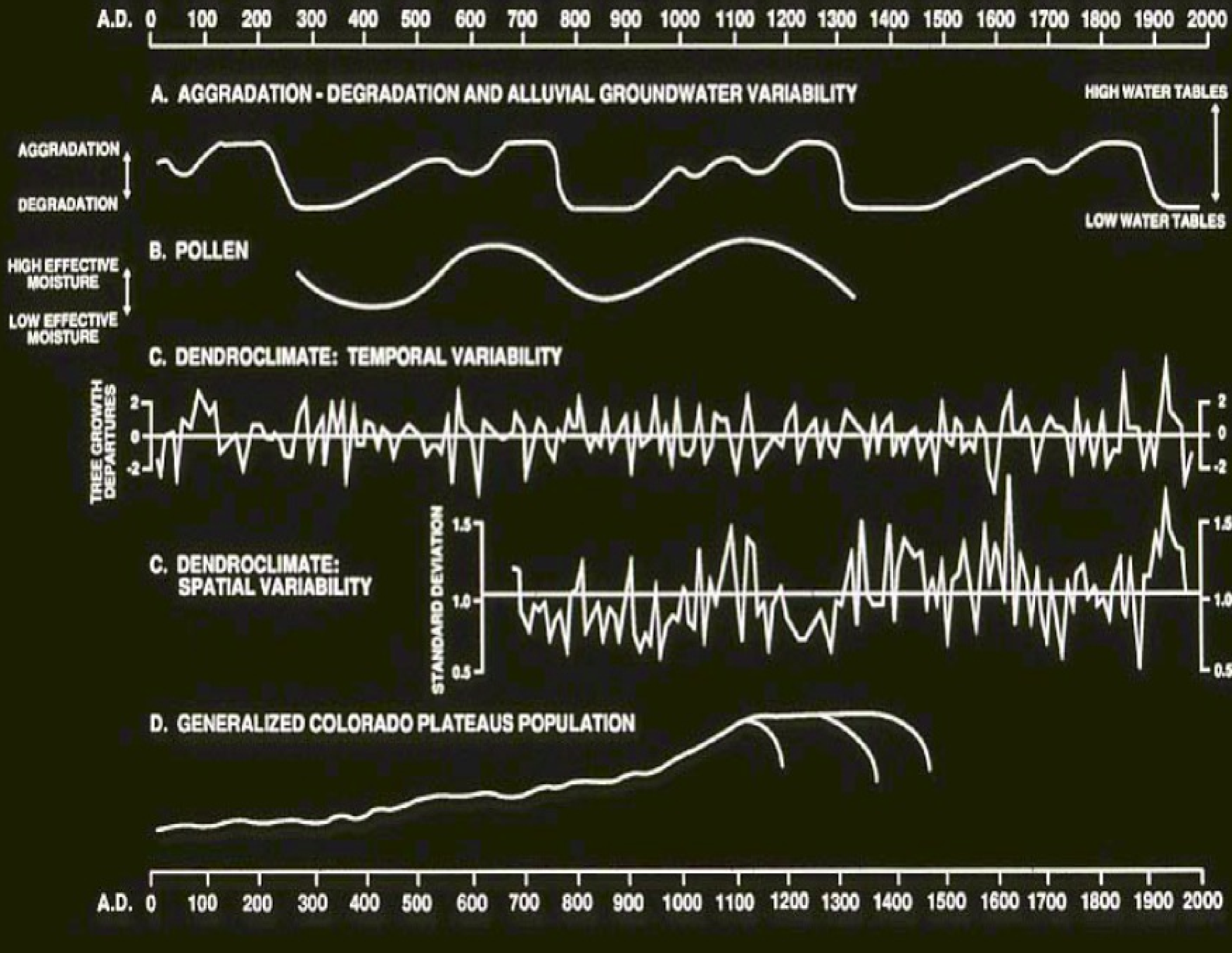
- R. Axelrod (1981)
- Tournament of algorithms
- Winner: "tit-for-tat"
- Evolutionary Game Theory:
  - Basic principles of good strategies:
    - Be nice
    - Be provocable
    - Don't be too envious
    - Don't be too clever
- Nay & Gilligan (2015)
  - Real-world strategies involve randomness, unpredictability

Example: Artificial Anasazi

Axtell, Dean, Epstein, *et al.*

Modeling Environment





A.D. 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000
A. AGGRADATION - DEGRADATION AND ALLUVIAL GROUNDWATER VARIABILITY
HIGH WATER TABLES
AGGRADATION
DEGRADATION
LOW WATER TABLES
B. POLLEN
HIGH EFFECTIVE MOISTURE
LOW EFFECTIVE MOISTURE
C. DENDROCLIMATE: TEMPORAL VARIABILITY
TREE GROWTH DEPARTURES
2
0
-2
C. DENDROCLIMATE: SPATIAL VARIABILITY
STANDARD DEVIATION
1.5
1.0
0.5
D. GENERALIZED COLORADO PLATEAUS POPULATION
A.D. 0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600 1700 1800 1900 2000

Constructing model

- Paleoclimate:
  - Assess different kinds of soil
  - Assess tree rings, pollen, etc.
  - Reconstruct drought severity index
- Society:
  - Archaeology gives #, location of households
- Make assumptions about:
  - # people per household,
  - Agriculture,
  - …
- Devise rules for behavior:
  - Marriage, reproduction, migration, …
- Simulate years 800–1300

Results

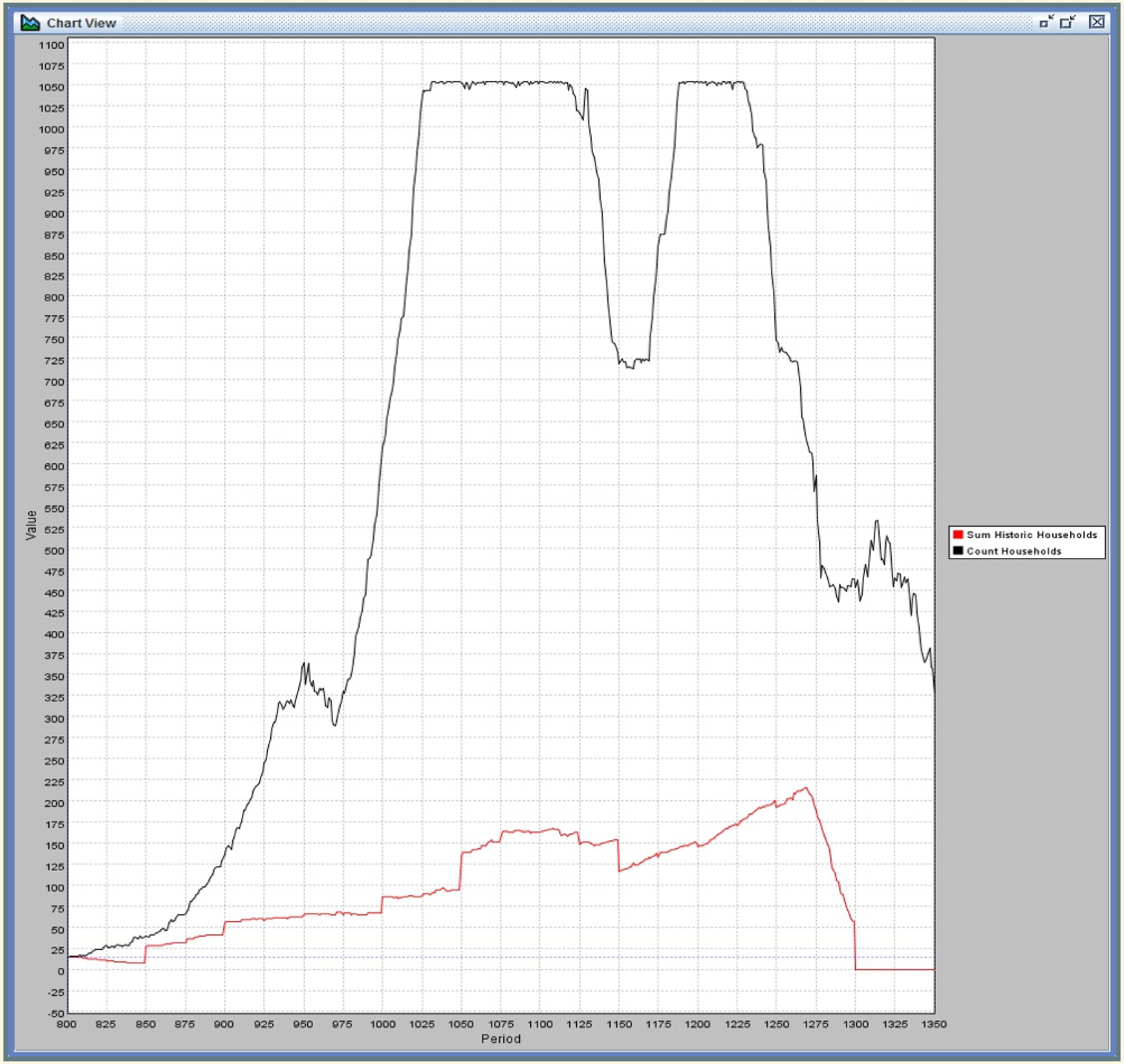
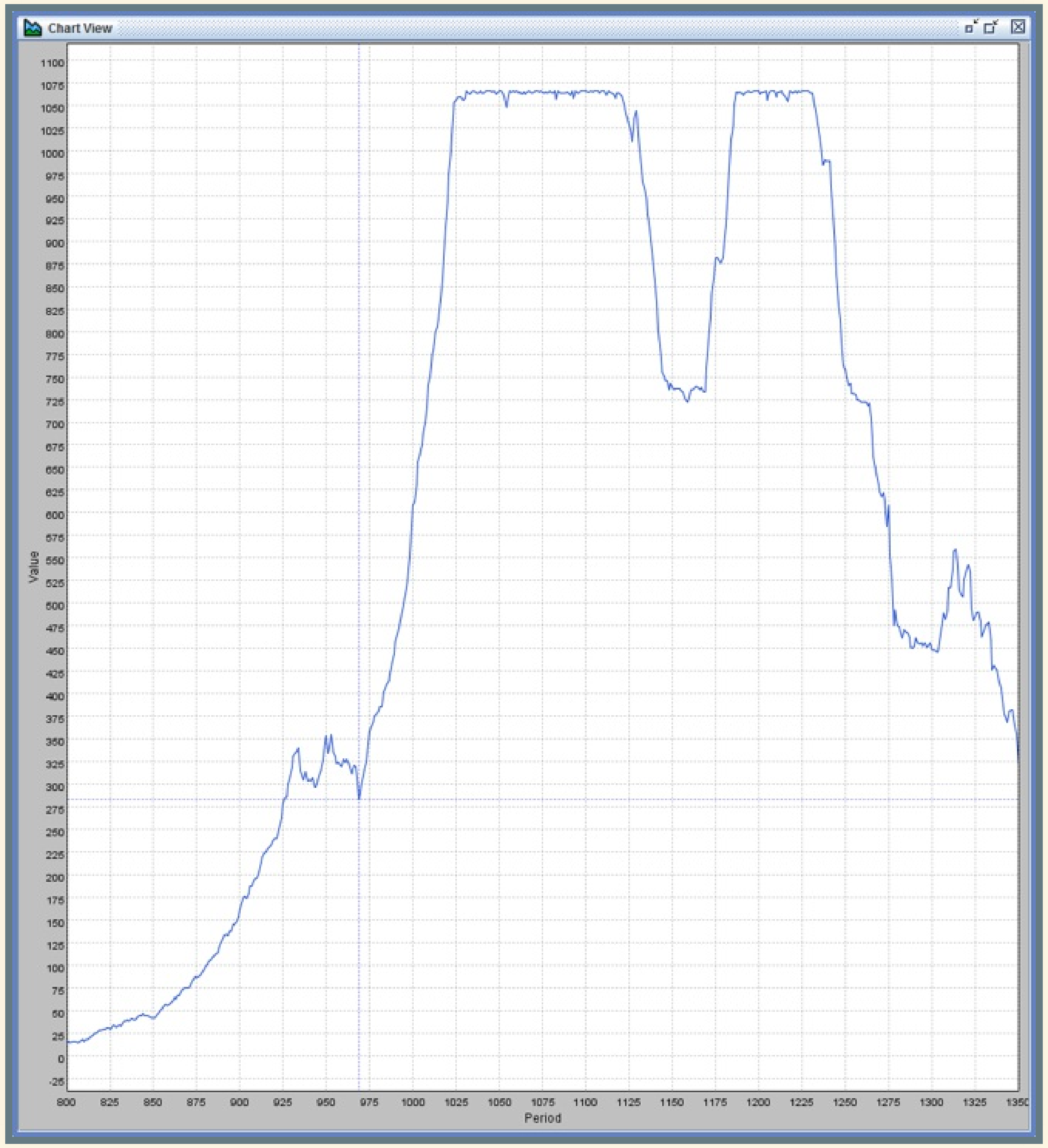
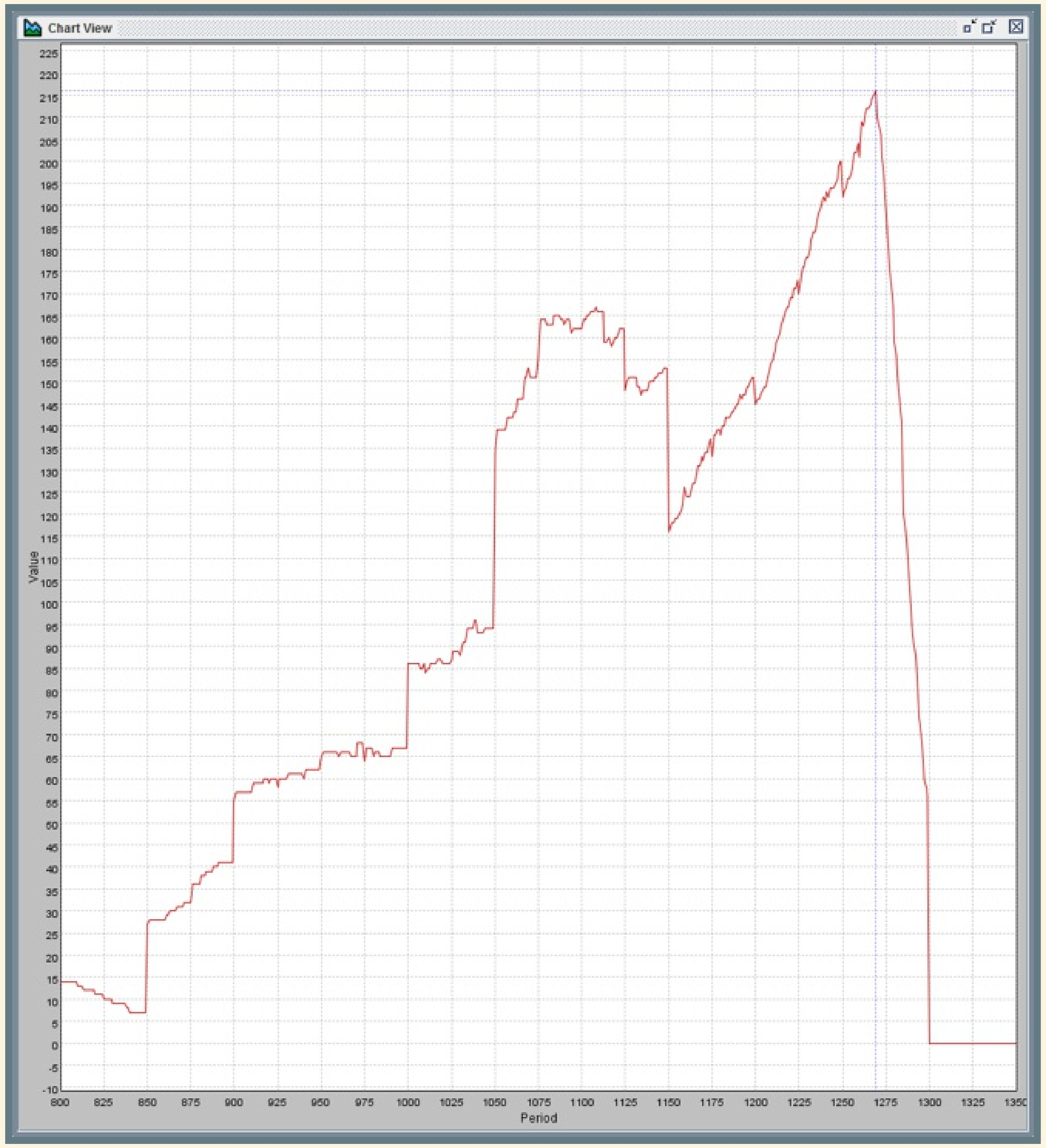


Chart View
Value
Period
Sum Historic Households
Count Households
1100
1075
1050
1025
1000
975
950
925
900
875
850
825
800
775
750
725
700
675
650
625
600
575
550
525
500
475
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
-25
-50
800
825
850
875
900
925
950
975
1000
1025
1050
1075
1100
1125
1150
1175
1200
1225
1250
1275
1300
1325
1350

Comparison

Simulated	Historical
	

Improvements

- Make agents heterogeneous
- Fit parameters to historical data

Results

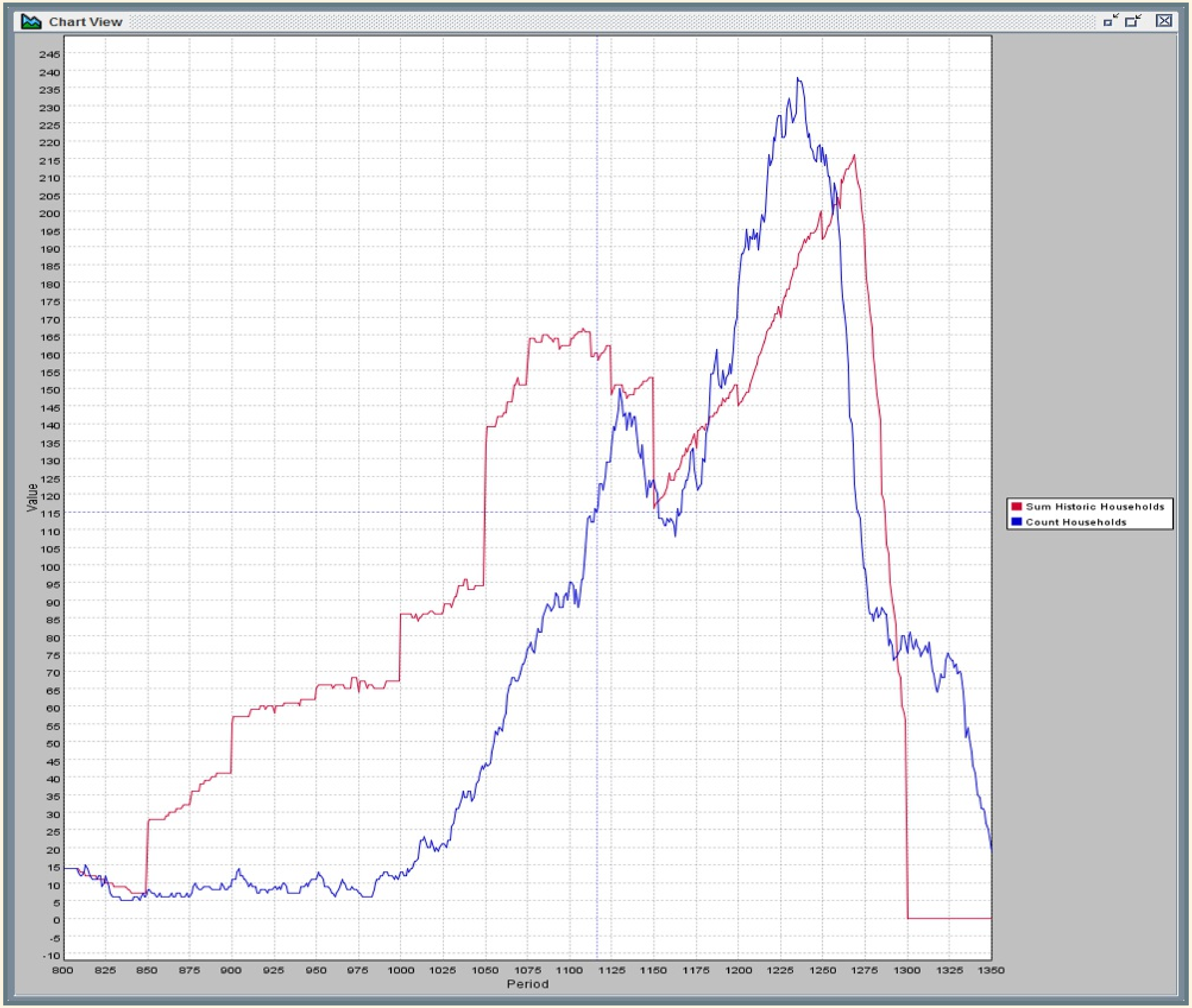


Chart View
Value
Period
Sum Historic Households
Count Households