An Agent-based Model of the Western Chitwan Valley, Nepal

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Outline

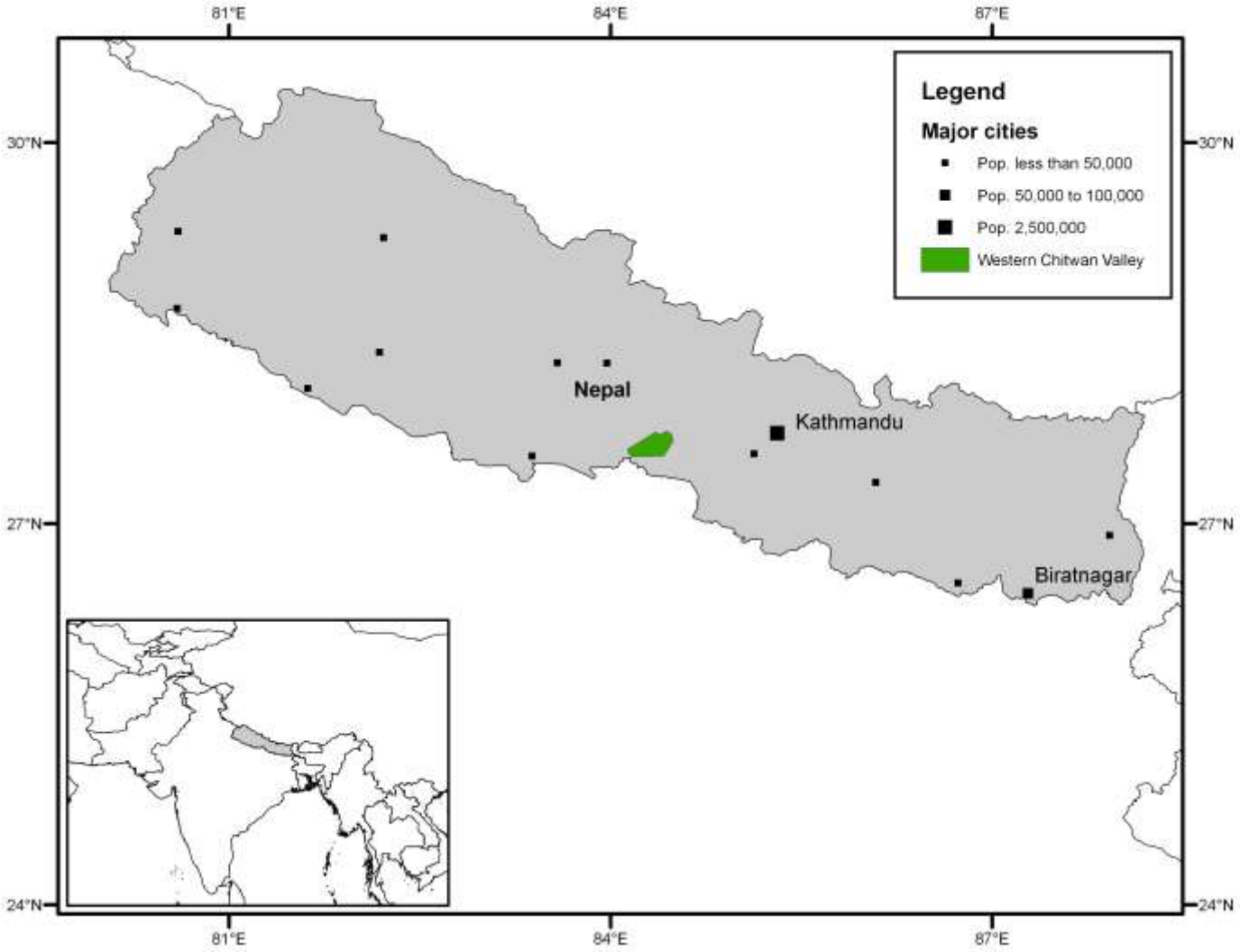
- Introduction to PIRE project & Chitwan site
- Model overview
  - Structure
  - Code verification
  - Experiment
- Discussion

INTRODUCTION

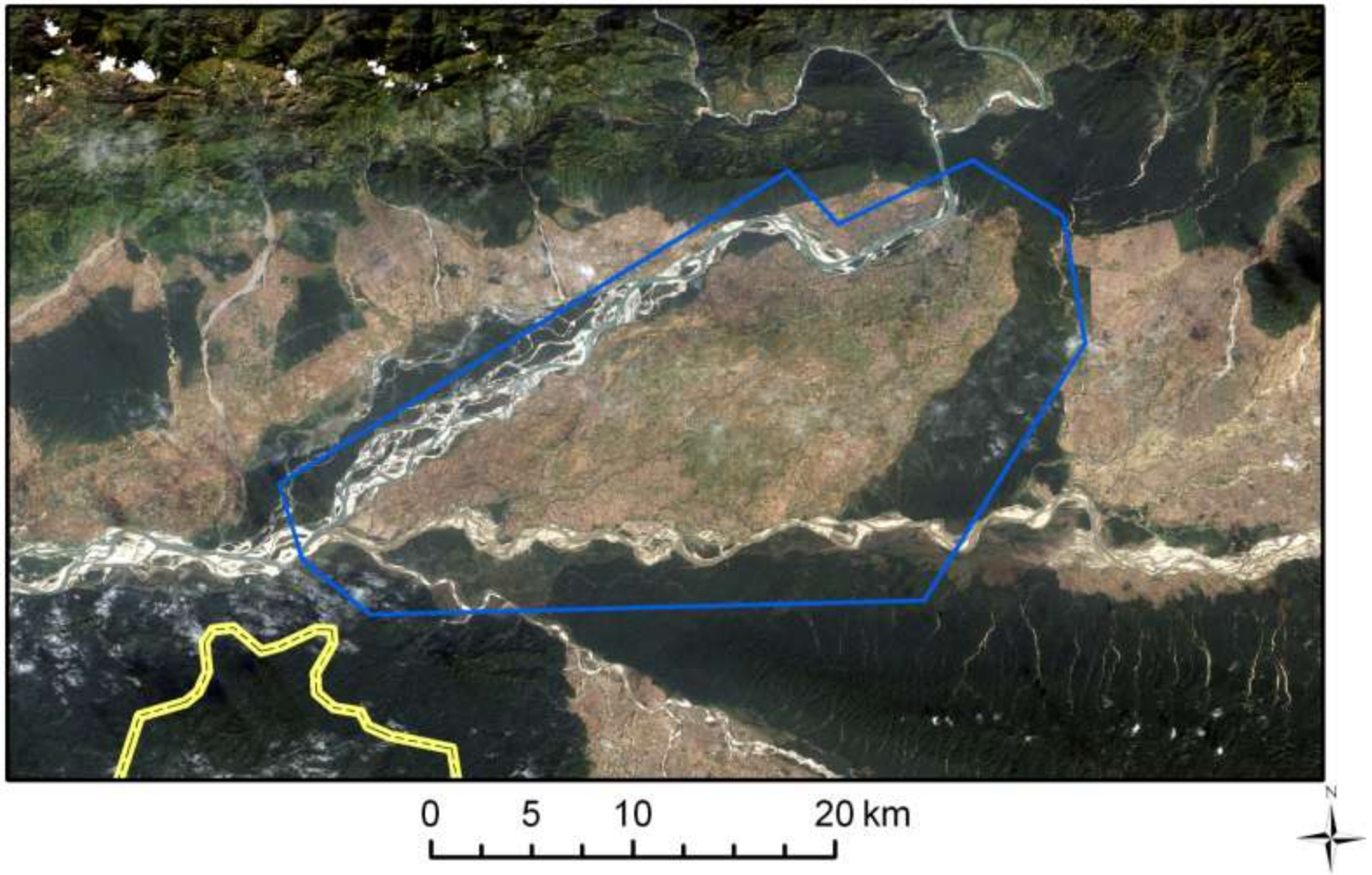
Introduction - PIRE

- Goal: To make comparative studies on two field sites in Nepal and China
  - Western Chitwan Valley, Nepal
  - Wolong Nature Reserve, China
- Today:
  - Focus on an agent-based model of the Western Chitwan Valley, Nepal

The Western Chitwan Valley, Nepal



The Western Chitwan Valley, Nepal



The Chitwan Valley data

- Survey first carried out in 1996
- Detailed survey every 5 years
- Monthly household surveys (births, marriages, deaths)
- Neighborhood-level LULC every 5 years

THE MODEL

Model objectives

- Investigate the connection between micro-scale demographic variability and macro-scale environmental change
- Include significant feedbacks between environmental and demographic change

The "ChitwanABM"

- The agents (borrowing from the CVFS)
  - People (9640)
  - Households (1773)
  - Neighborhoods (171)
  - Regions (1)
- Agents are drawn from the CVFS data
  - There is a one-one relation between persons, neighborhoods, and households in the data, and agents in the model

Person

- Attributes
  - Sex
  - Age
  - Ethnicity
  - Mother (and her attributes)
  - Father (and his attributes)
  - Family size preference
  - Contraceptive use history

Person (cont)

- Derived attributes
  - Number of living children
- Each person is a member of a
  - Household, Neighborhood, and **REGION**

Household

- Attributes
  - Use of any non-wood fuel
  - Land ownership (house plot, any land)
- Derived attributes
  - Household size

Neighborhood

- Each household is a member of a neighborhood
- Attributes
  - Non family services
  - Availability of electricity
  - Land-use / land-cover (more later)
- Derived attributes
  - Number of households members

Neighborhoods – LULC

- LULC classes are defined as in Axinn and Ghimire (2007):
  - Agricultural vegetation
  - Non-agricultural vegetation
  - Private buildings
  - Public infrastructure
  - Other (ponds, silted riverbanks, etc.)

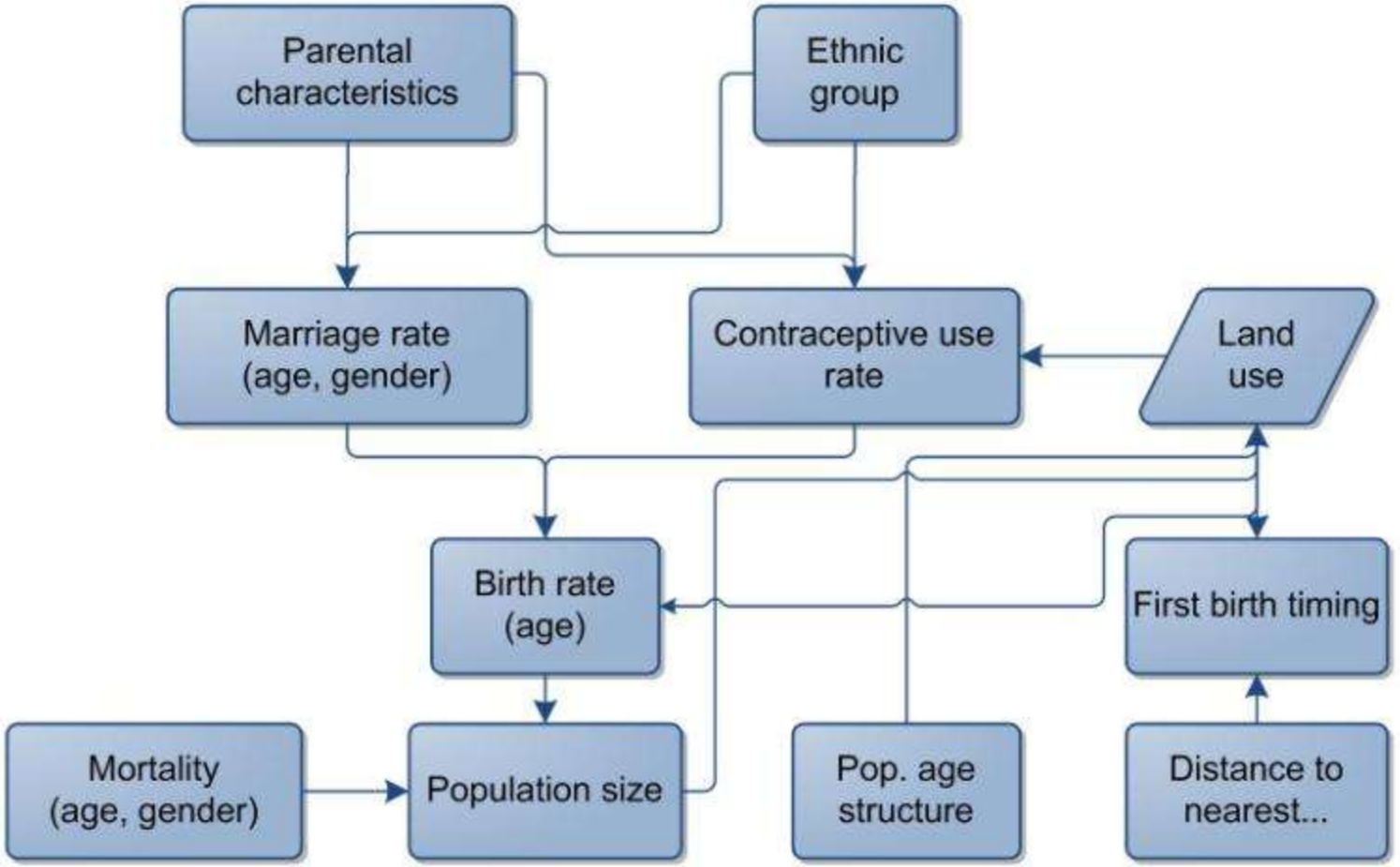
Region

- Each neighborhood is a member of a region
- Only one region in the model
- Future:
  - Multiple regions could allow variation in parameters/processes between groups of neighborhoods
  - Don’t have to be spatially contiguous

The processes

- Fertility
- Marriage
- Death
- Land use change
- Household fission (still preliminary)
- Migration (still preliminary)

Conceptual model



Fertility

- Probability of birth calculated dependent on
  - Age
  - Ethnicity
  - Parents contraceptive use
- Each person has an intended fertility rate (taken from the CVFS data)
- Intended fertility rate is taken as an upper limit on number of children

Fertility (cont)

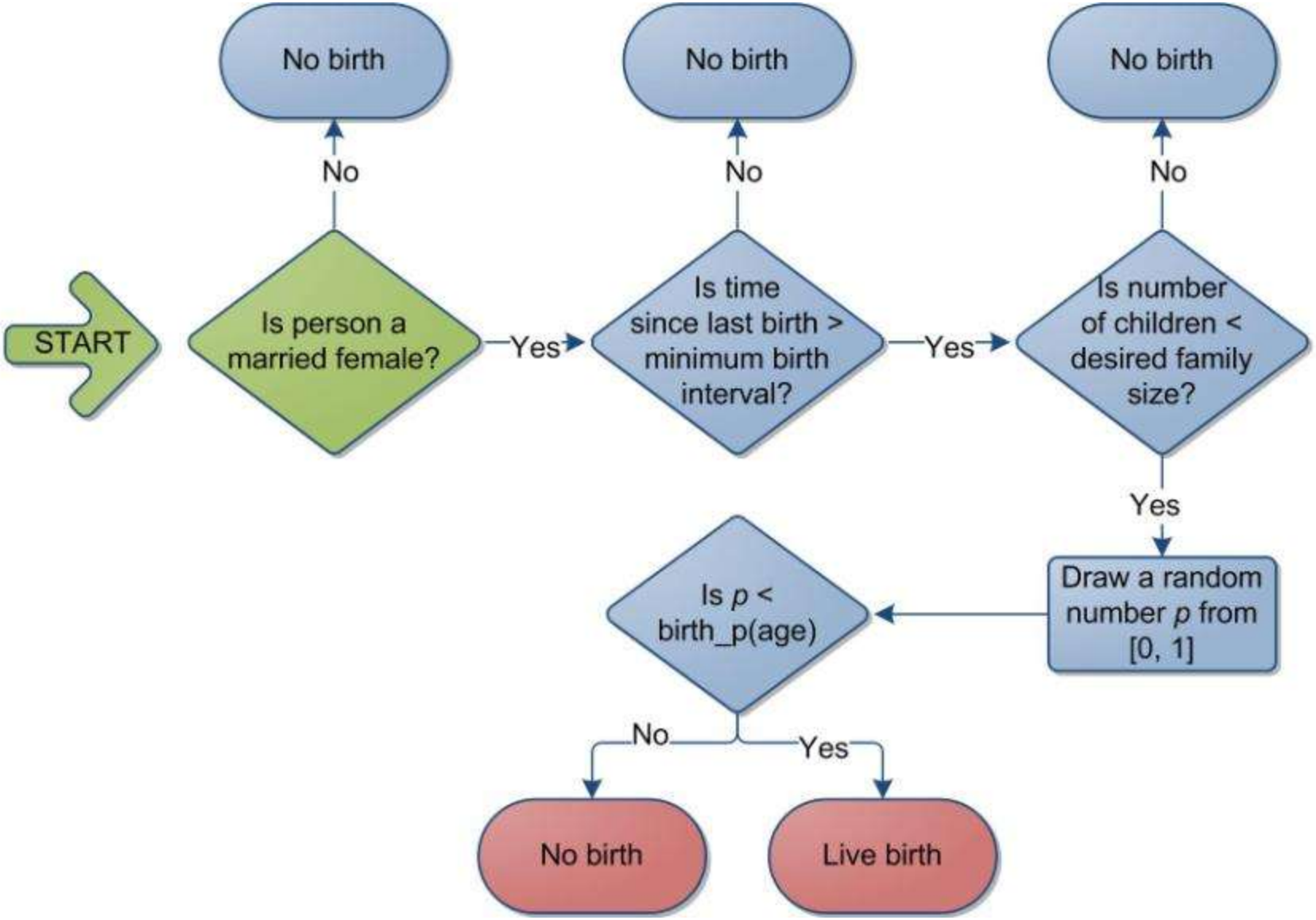
- Birth probability calculated over several bins:

  0, 15, 16, 18, 20, 23, 26, 30, 35, 40, 45

- Probability of birth in a given bin is calculated as

$$p_{m,n} = \frac{num\ births}{num\ \ psn\ months}$$

- Where *num psn months* is only calculated over women > 9 months from their last birth


No birth
No birth
No birth
No
No
No
START
Is person a married female?
Yes
Is time since last birth > minimum birth interval?
Yes
Is number of children < desired family size?
Yes
Draw a random number p from [0, 1]
Is p < birth_p(age)
No
Yes
No birth
Live birth

Marriage

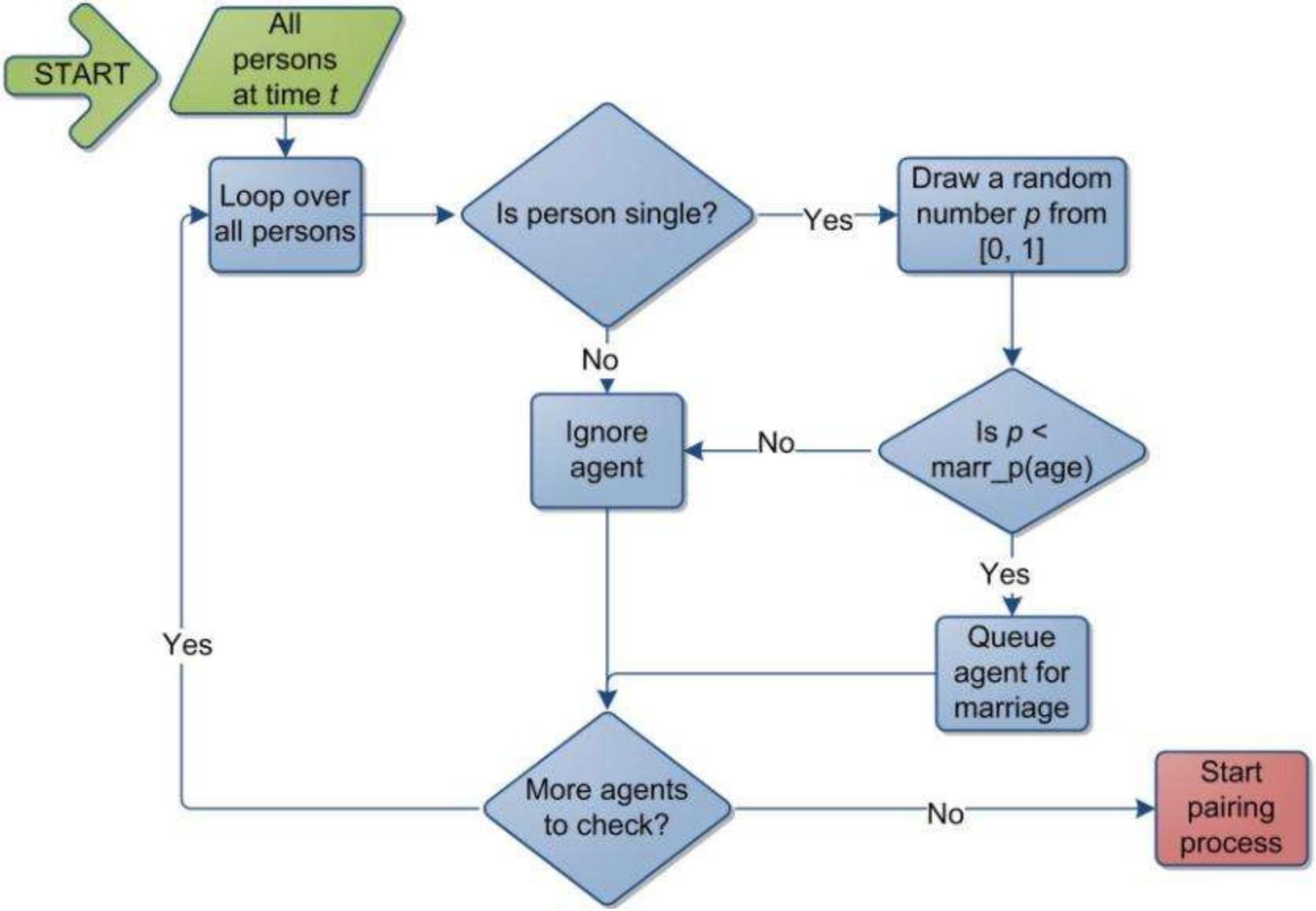
- Marriage occurs with probability based on
  - Age
  - Sex
- Marriage rate calculated over 8 bins of those eligible for marriage (all single individuals)
  - Lower limits:

0, 10, 14, 18, 22, 30, 40, 60

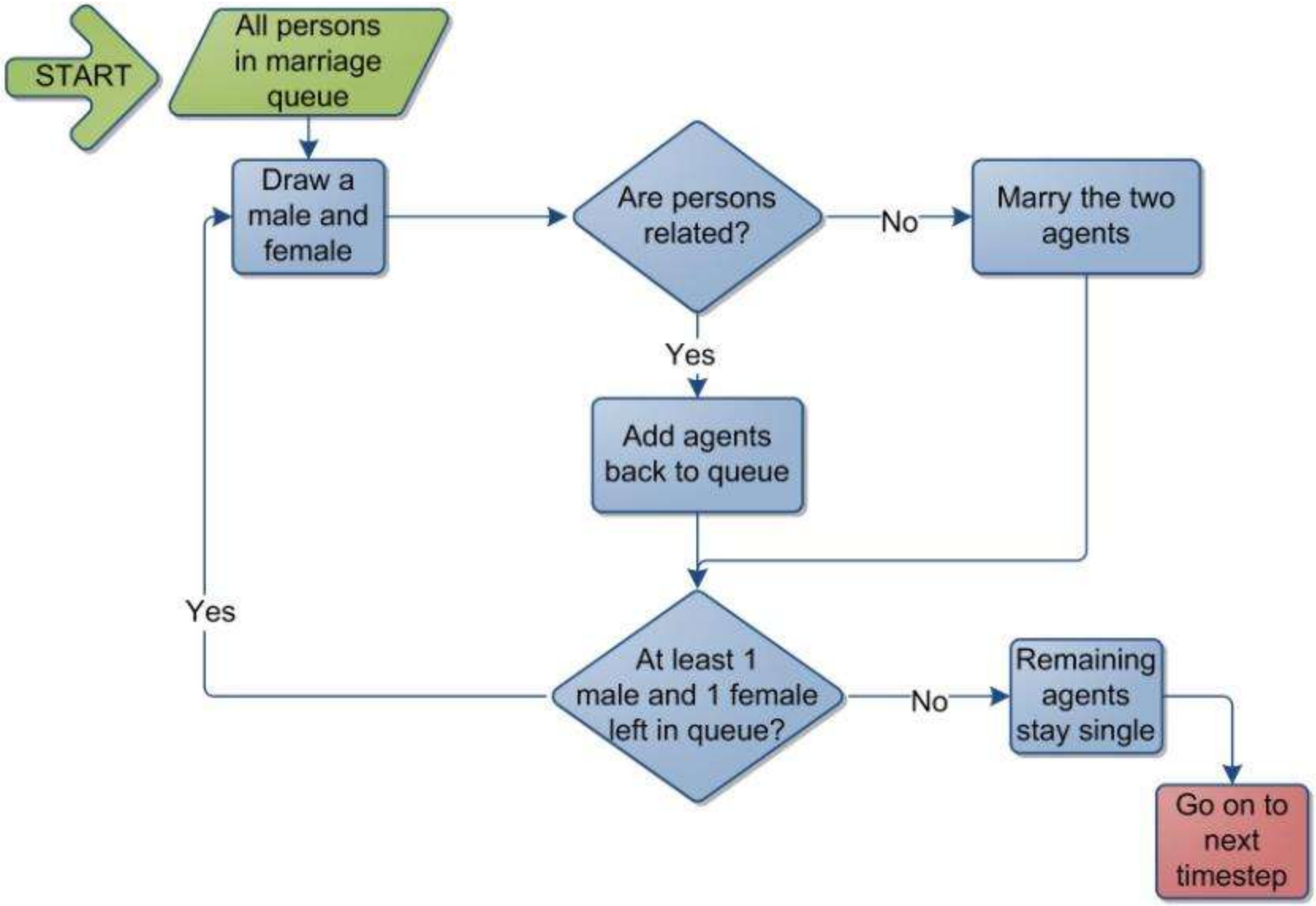
- Marriage rate is calculated for each bin as:

$$p_{m,n} = \frac{num\ marriages}{num\ \ psn\ months}$$

Marriage process (1)



Marriage process (2)



Marriage – future work

- Incorporate work of Yabiku (2006a, 2006b)
  - Tie marriage rates to:
    - Age
    - Sex
    - Ethnicity
    - Neighborhood agricultural land
    - Environmental perceptions?
    - Other controls?

Mortality

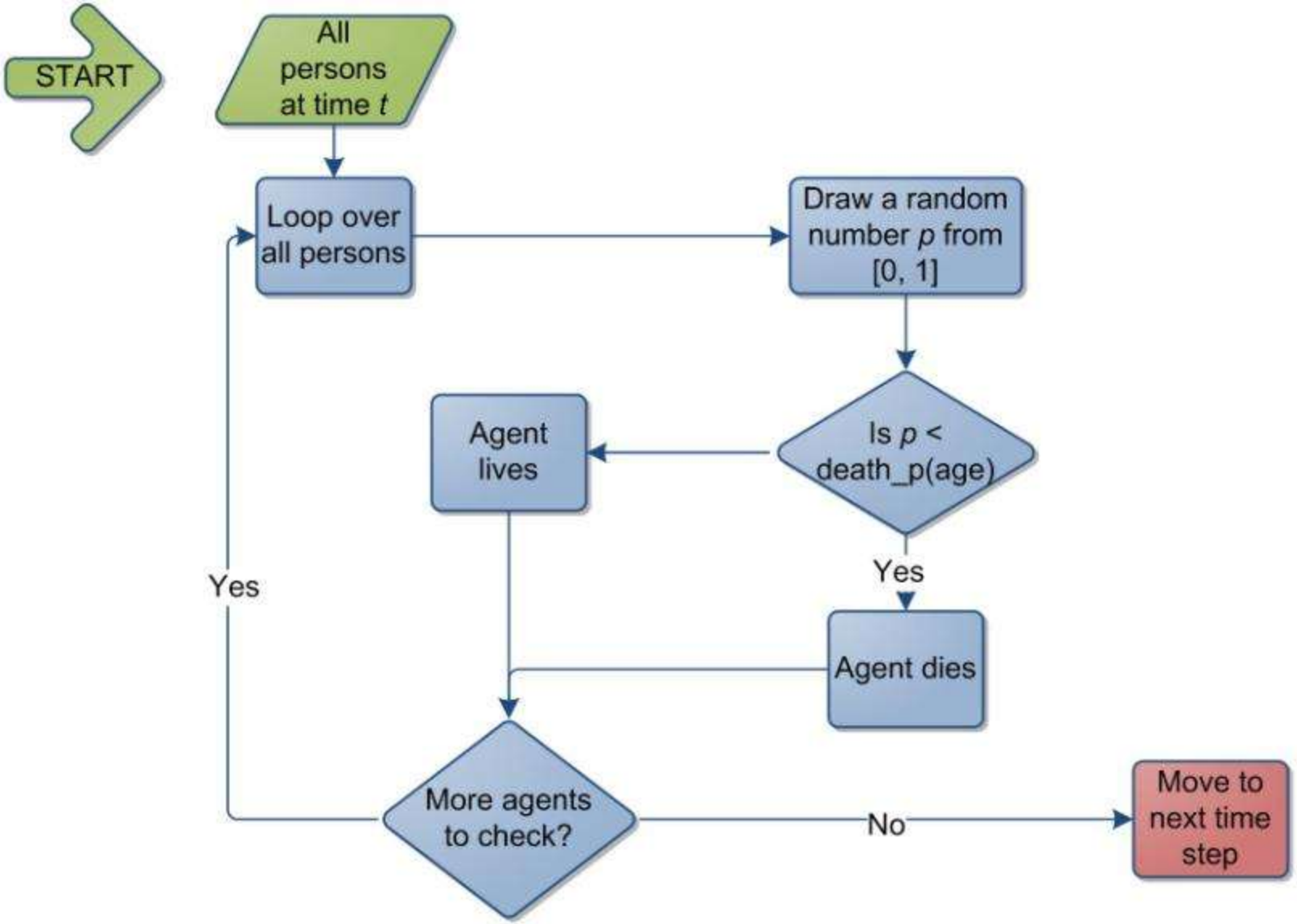
- Death occurs with a probability based on
  - Age
  - Sex
- Mortality rate calculated over 10 bins
  - Lower limits:

0, 3, 6, 12, 20, 40, 60, 80

- Probability of death per month is calculated for each bin *n* as:

$$p_{d,n} = \frac{num\ deaths}{num\ \ psn\ months}$$

Mortality process



Household fission

- Currently:
  - New households form when marriage occurs
  - Households locate (at random) within either spouse's neighborhood
- **This biases model towards smaller HH sizes**
- More work needed

Land use change

- Land use is tracked at the *neighborhood* level
- New households
  - → increase in private buildings
  - → decrease in non-agricultural vegetation
  - → decrease in agricultural vegetation

Migration

- Still preliminary
- Code exists for distant migration, but parameterization is incomplete
- Referring to Massey, Axinn and Ghimire (2007)

A POSSIBLE EXPERIMENT

A possible experiment

- Feedbacks between land-use change and fertility
  - Biddlecom, Axinn, and Barber (2005)
  - Axinn and Ghimire (2007)
  - Ghimire and Hoelter (2007)

Feedbacks: Population → LULC

- From Axinn and Ghimire (2007)
  - ↑ Younger population age structure →
    - ↑ private buildings
    - ↓ vegetation (both agricultural and non-agricultural)
  - ↑ Crude birth rate →
    - ↑ private buildings
    - ↓ vegetation (both agricultural and non-agricultural)

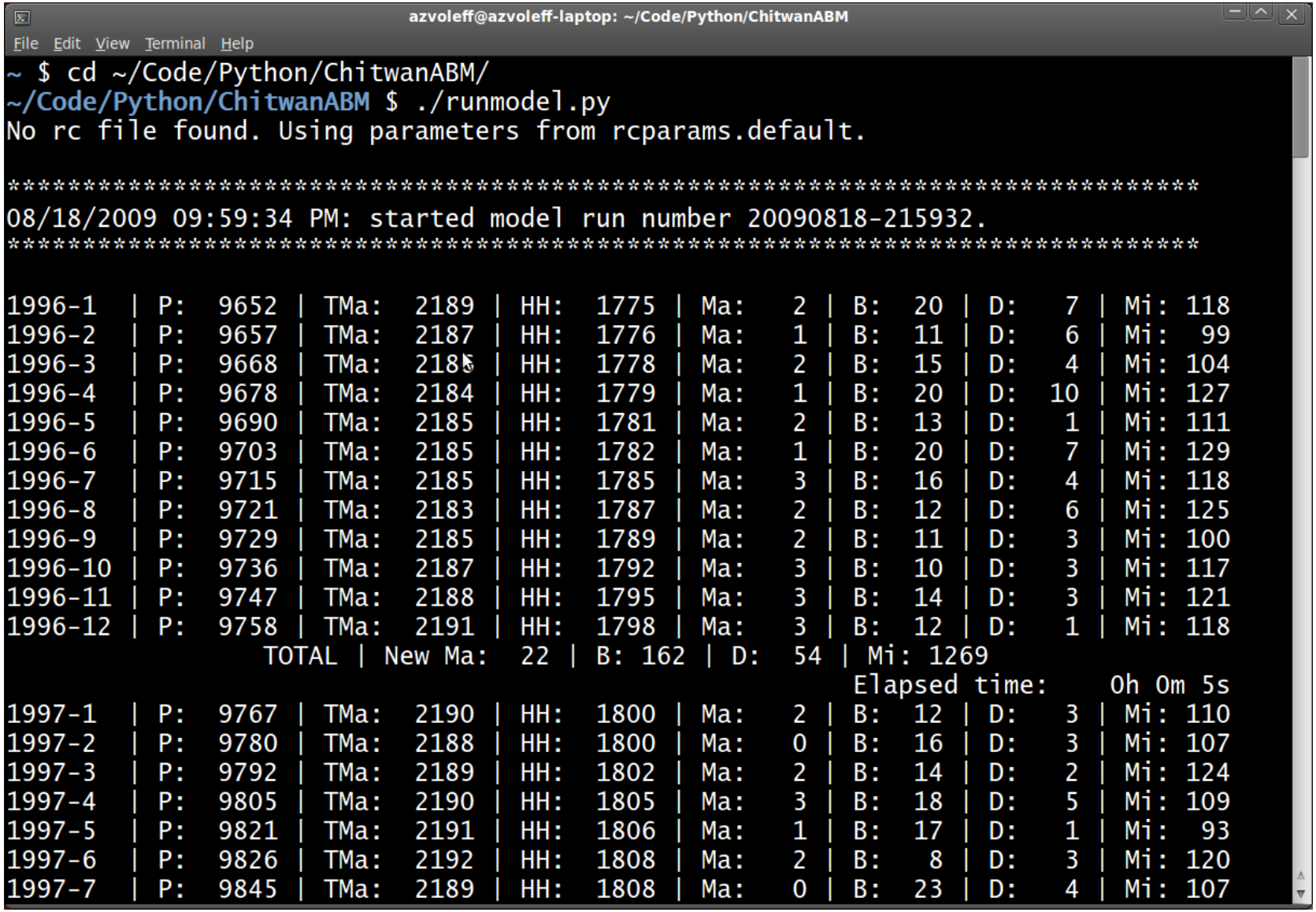
Feedbacks: LULC → population

- From Ghimire and Hoelter (2007)
  - ↓ Agricultural land →
    - ↑ Hazard of first birth
- From Biddlecom, Axinn, Barber (2005)
  - ↑ Dependence on public lands →
    - ↑ Family size preferences
  - ↑ Fodder collection times →
    - ↑ Family size preferences

“Verification”

- Models are never “true” (Turner)
- Model verification
  - Does code mean what I think it means?
  - Do agent attributes reflect the data?
- Future
  - Use a “jackknife” approach with HH registry data

Running the model



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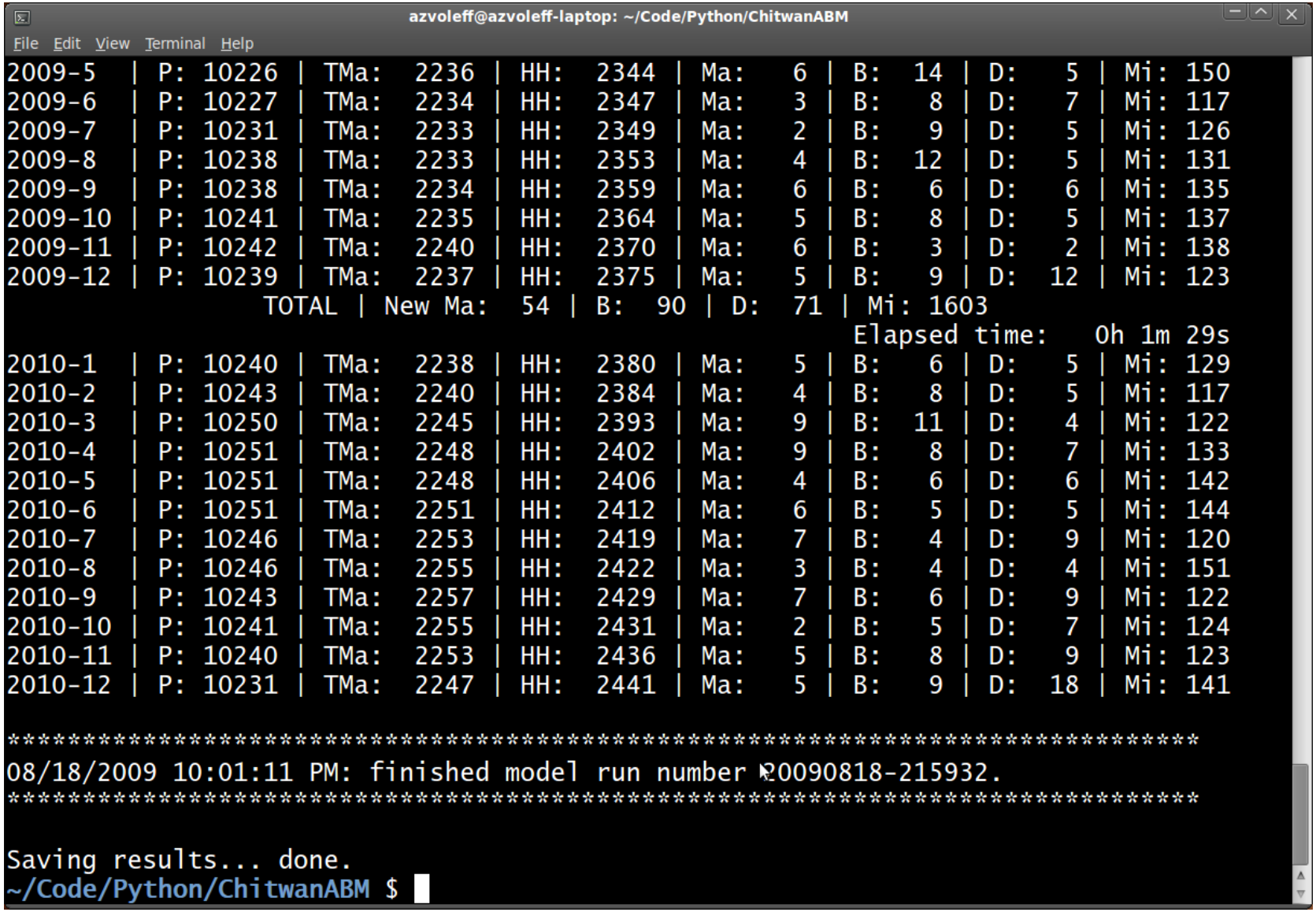

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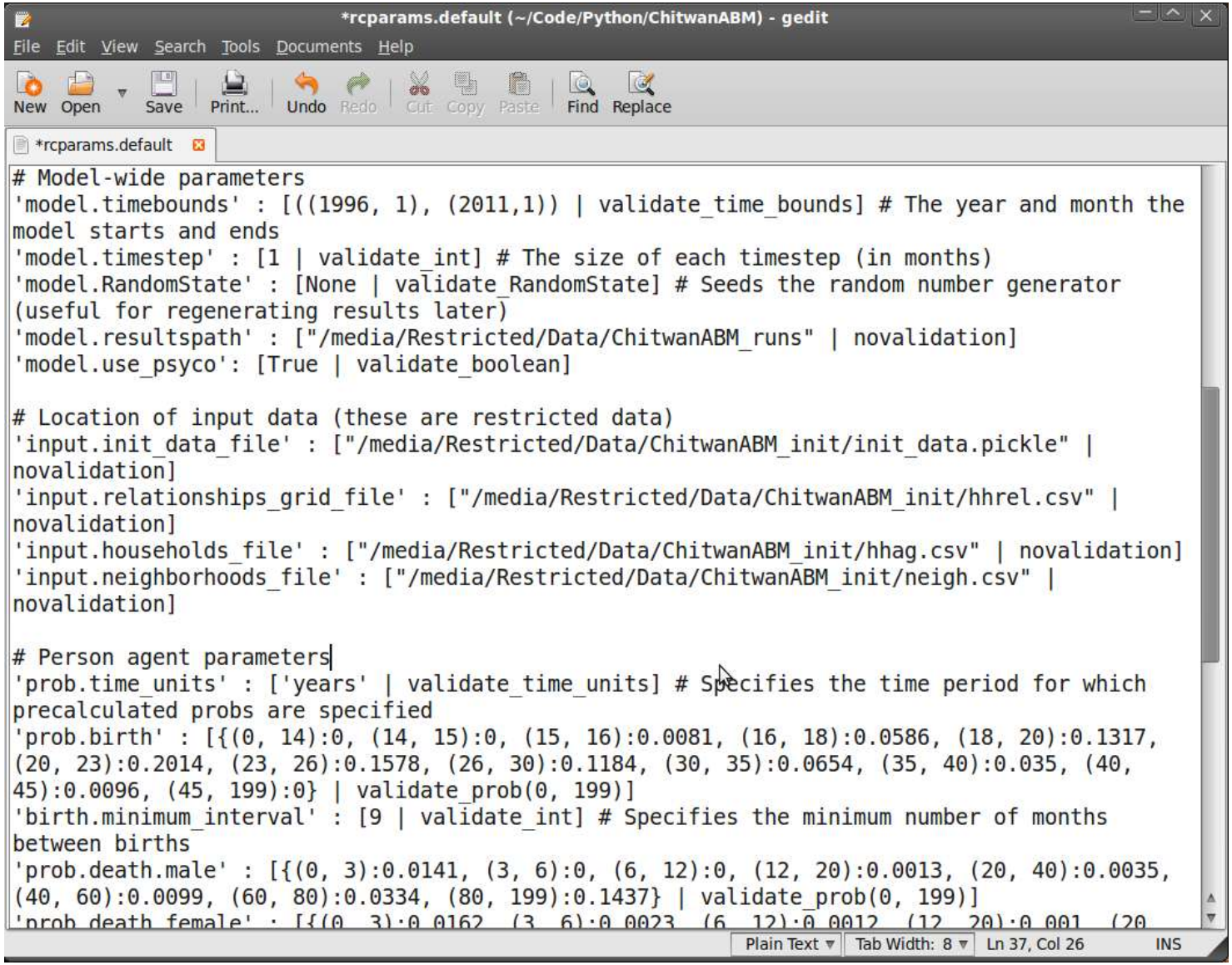
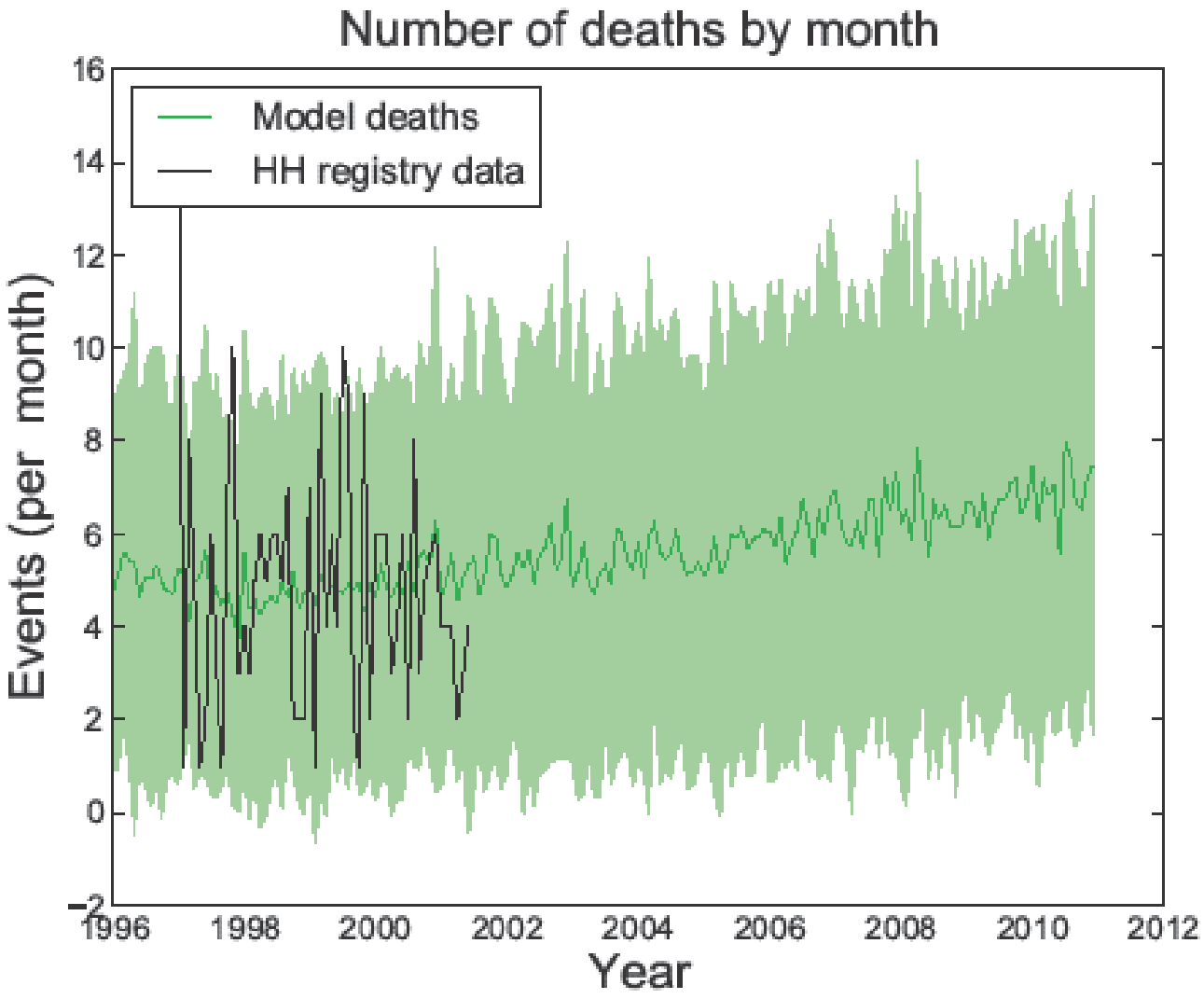


Running the model - output



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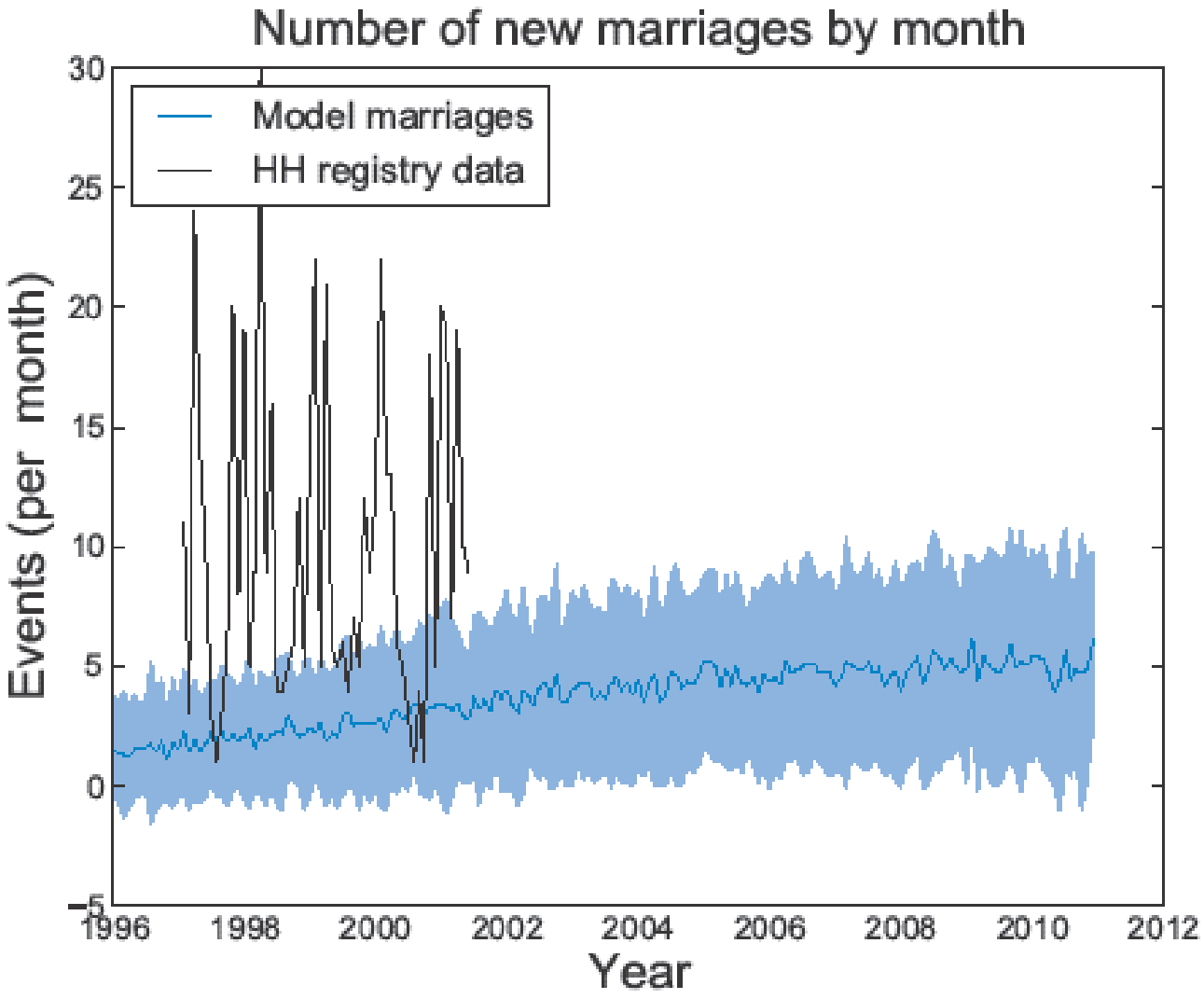

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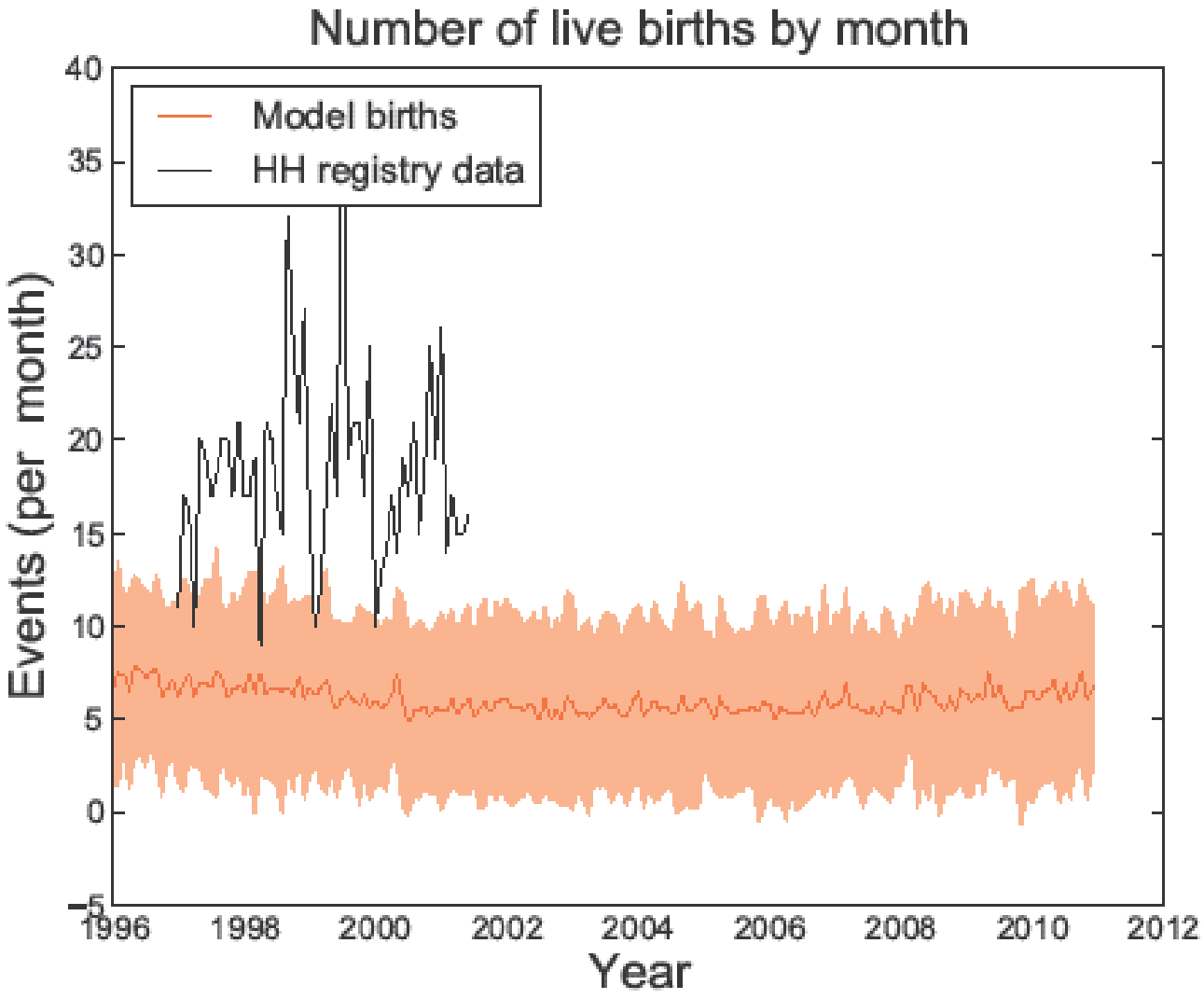

Technical notes

- Model is coded in Python
- Requires no special software to run
- Changing parameters is simple
- Shapefile output possible
- Available online:
  - http://rohan.sdsu.edu/~zvoleff
- Data confidentiality?

Thank you.

LUNCH!

CONTROLS – WHAT TO INCLUDE?

Selection of controls

- Fertility
  - First birth timing
  - Family size preferences
- Marriage age
  - Yabiku (2006, 2007), Pierce (2000)
- New household formation

Fertility: first birth timing + environment

Possible controls

(Ghimire and Hoelter, 2007; Ghimire and Axinn, 2008)

- Land use under agriculture
- Non family services
- Parental characteristics
  - Number of children
  - Education
  - Work
  - Contraceptive use
- Ethnicity
- Marriage duration
- Schooling
- Media exposure
- Contraceptive use

Fertility: family size preference

Possible controls (Biddlecom, Axinn and Barber, 2005)

- Environmental measures
  - Time to coll. wood
  - Time to coll. wood has inc. (+)
  - Time to coll. fodder
  - Time to coll. fodder has inc.
  - Wood is from public land (*)
  - Fodder is from public land
- Indiv. level controls
  - Age group (***)
  - Age at first marriage
  - Yrs of school before marr. (**)
  - Ever used contraception (**)
  - Num. of living male child. (**)
- Household level controls
  - Own home (*)

+P<.10, *P<.05,**P<.01, ***P<.001

Marriage timing

Possible controls (Yabiku, 2006)

- Neighborhood ag. Land
- Distance to NFOs
  - School
  - Health post
  - Bus stop
  - Market
  - Employer
- Non family activities
  - Salaried job
  - Family owned business
  - Wage labor**
  - Years schooling completed
  - Enrolled in school**
- % opp. sex single in neigh.
- Born in current neigh?
- Sex**
- Ethnicity
- Age**
- Age-squared**

*P<.05,**P<.01, ***P<.001, two tailed tests

Migration

Possible controls (Massey, Axinn, and Ghimire, 2007) (19)

- Age
- Sex (sep. models)
- Distant vs. local moves
- Environmental conditions
  - Perceived prod. decline
  - Share of neighborhood green
  - Time to collect firewood
- Human capital
  - Years of schooling
  - Currently have a wage job
  - Currently have a salaried job
- Social capital
  - Household network tie
  - Neighborhood prevalence
- Age (birth cohort)
- Physical capital
  - Farmland
  - Livestock
  - House plot owned
  - Home quality
- Ethnicity
- Time

All P<.05 in *at least one* model

Household fission

Possible controls (no previous work?)

- Any ideas from Monday 8/19 discussion led by Lisa Pierce?

References

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Thank you! Questions?