Agent Based Models

IDAHO EPSCoR

GEM3
Genes by Environment
Modeling · Mechanisms · Mapping

Objectives

- Introduce agent-based models as tool for assessing adaptive capacity and population resilience
- Discuss pros and cons of agent-based models (ABMs)
- Generate enthusiasm for using ABMs as a tool for integrating 3Ms!

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G2P2Pop Research: the challenge

- G2P2Pop effects are likely to occur over time/space scales that are greater than the period of a single research project.
- Pressing need to identify mechanisms underlying adaptation or plasticity, recognize vulnerable species, and develop management strategies

- ABMs are simulation models of individuals (agents) in a virtual physical and biological environment
  - make decisions to maximize survival and reproduction
  - rules that govern are informed by empirical information
  - population patterns emerge that match real-world patterns

https://vimeo.com/132161478?from=outro-embed

ABM development

- Decide on the purpose of the model: appropriate scale and scope
- Characteristics of the agents (life history and genetics)
- Characteristics of the environment (spatially explicit – patches)
- Rules that govern agent behavior in response to interaction with environment or other agents
- Collect output of population patterns emerge from the individual agents
- Match patterns to empirical data to validate and calibrate
- Test hypotheses and forecast population changes
- Test management options in an adaptive management framework

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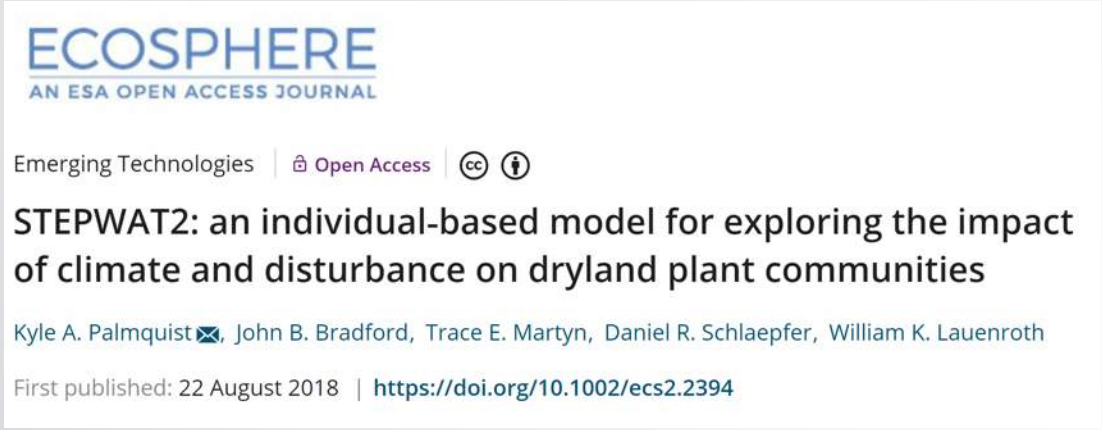
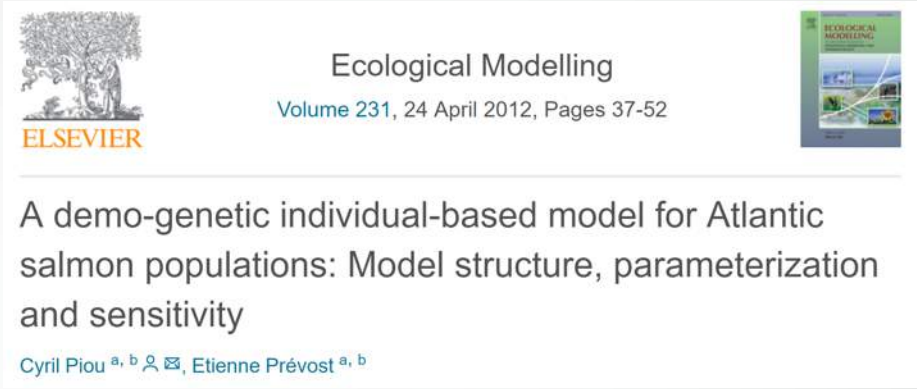
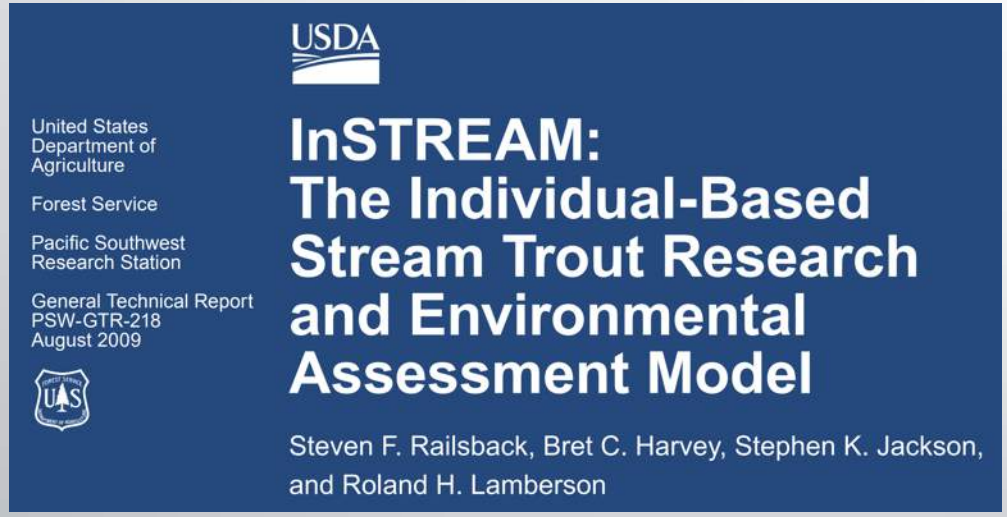
ABMs in sage and fish systems







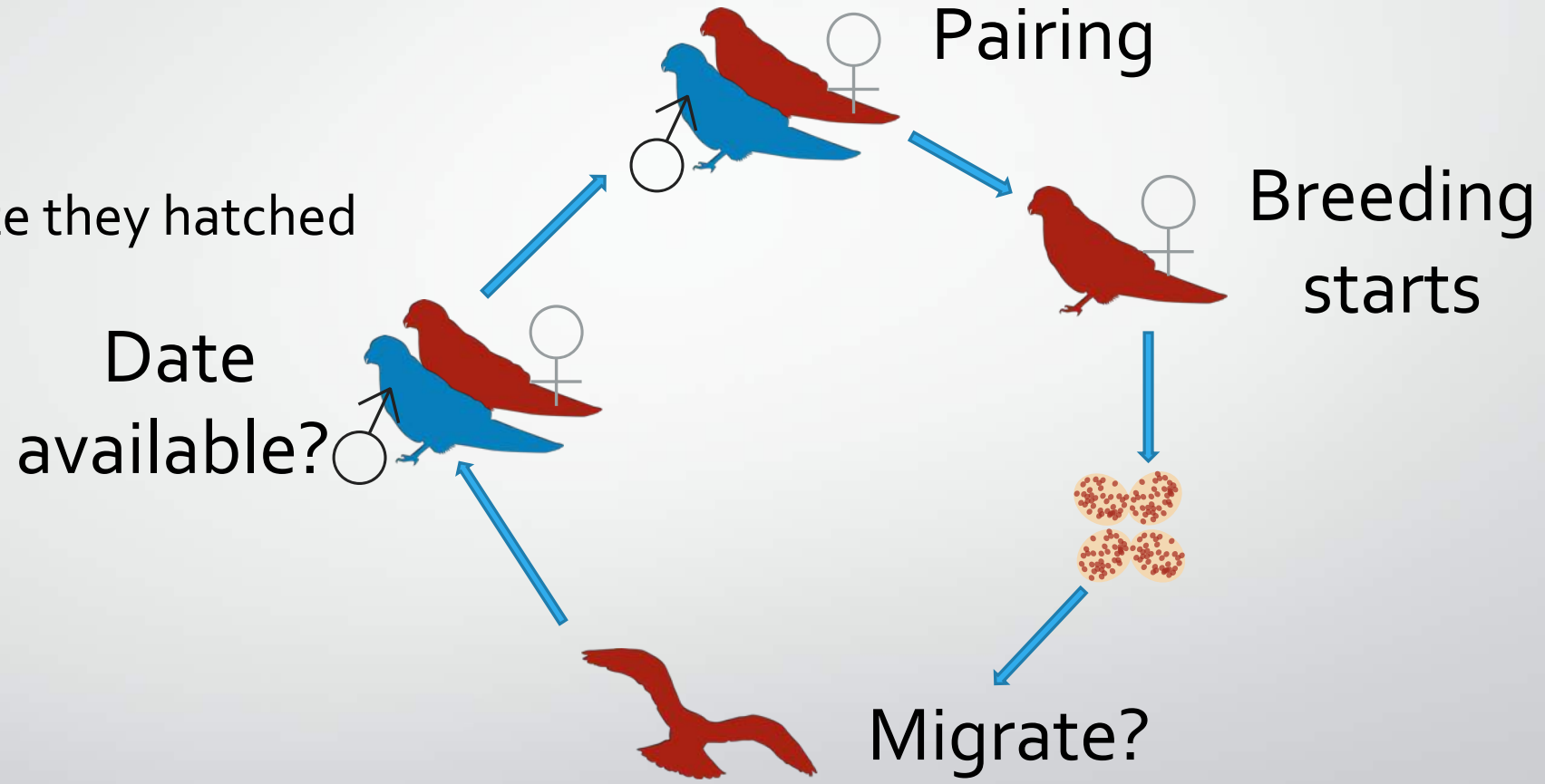
Challenges

- Computationally complex
- Integration of social-evolutionary-ecological processes

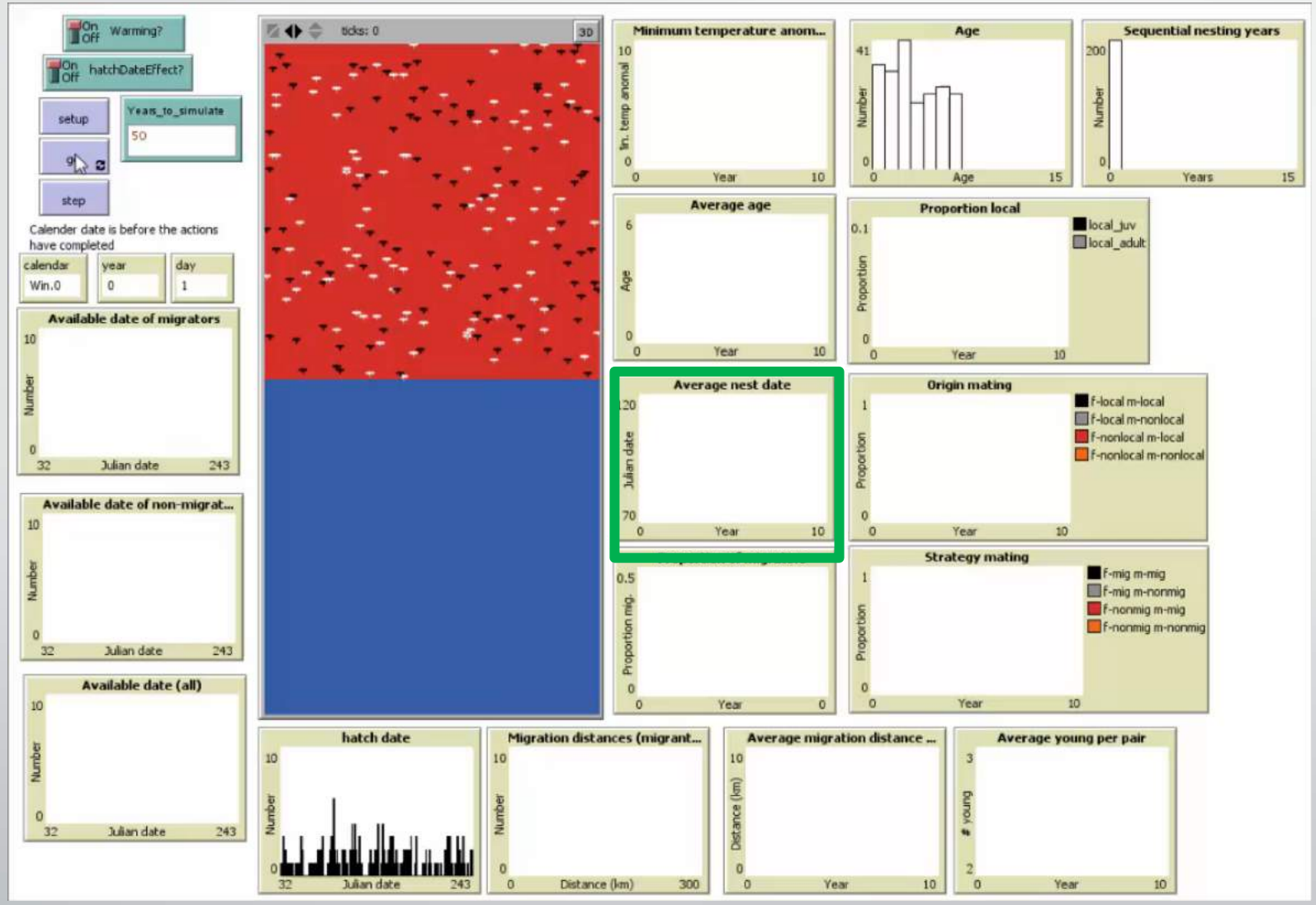
Example: model of kestrel annual cycle

Populate 200 kestrels:

- Sex
- Age
- Know the date they hatched

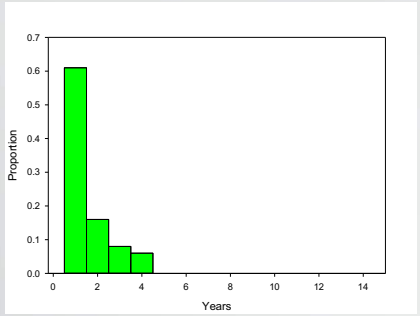


(Brown et al. in prep), (Strasser and Heath 2013), (Steenhof and Peterson 2009), (Steenhof and Heath 2013), (Steenhof and Heath 2009), (Ogonowski and Conway 2009), (Heath et al. 2013)


On Off Warming?
On Off hatchDateEffect?
setup
Years_to_simulate
50
go
step
Calender date is before the actions have completed
calendar
Win.0
year
0
day
1
ticks: 0
3D
Minimum temperature anom...
Age
Sequential nesting years
Average age
Proportion local
local_juv
local_adult
Available date of migrators
Average nest date
Origin mating
f-local m-local
f-local m-nonlocal
f-nonlocal m-local
f-nonlocal m-nonlocal
Available date of non-migrat...
Strategy mating
f-mig m-mig
f-mig m-nonmig
f-nonmig m-mig
f-nonmig m-nonmig
Available date (all)
hatch date
Migration distances (migrant...
Average migration distance ...
Average young per pair
Year
Age
Years
Julian date
Distance (km)

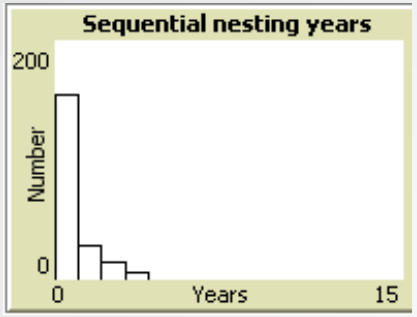
Validate by testing patterns

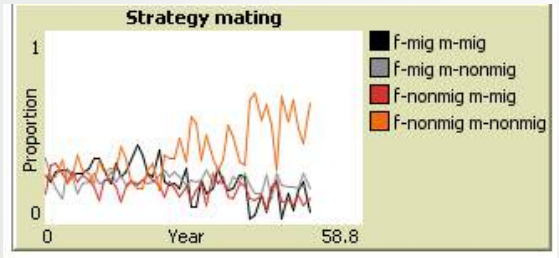
empirical



	Resident	Migrant
Resident	6%	10%
Migrant	10%	74%

model





Number of years nesting in study areas (Steenhof and Heath 2013)

Assortative mating (Anderson et al. 2016)

Experimental Design
What drives earlier nesting?

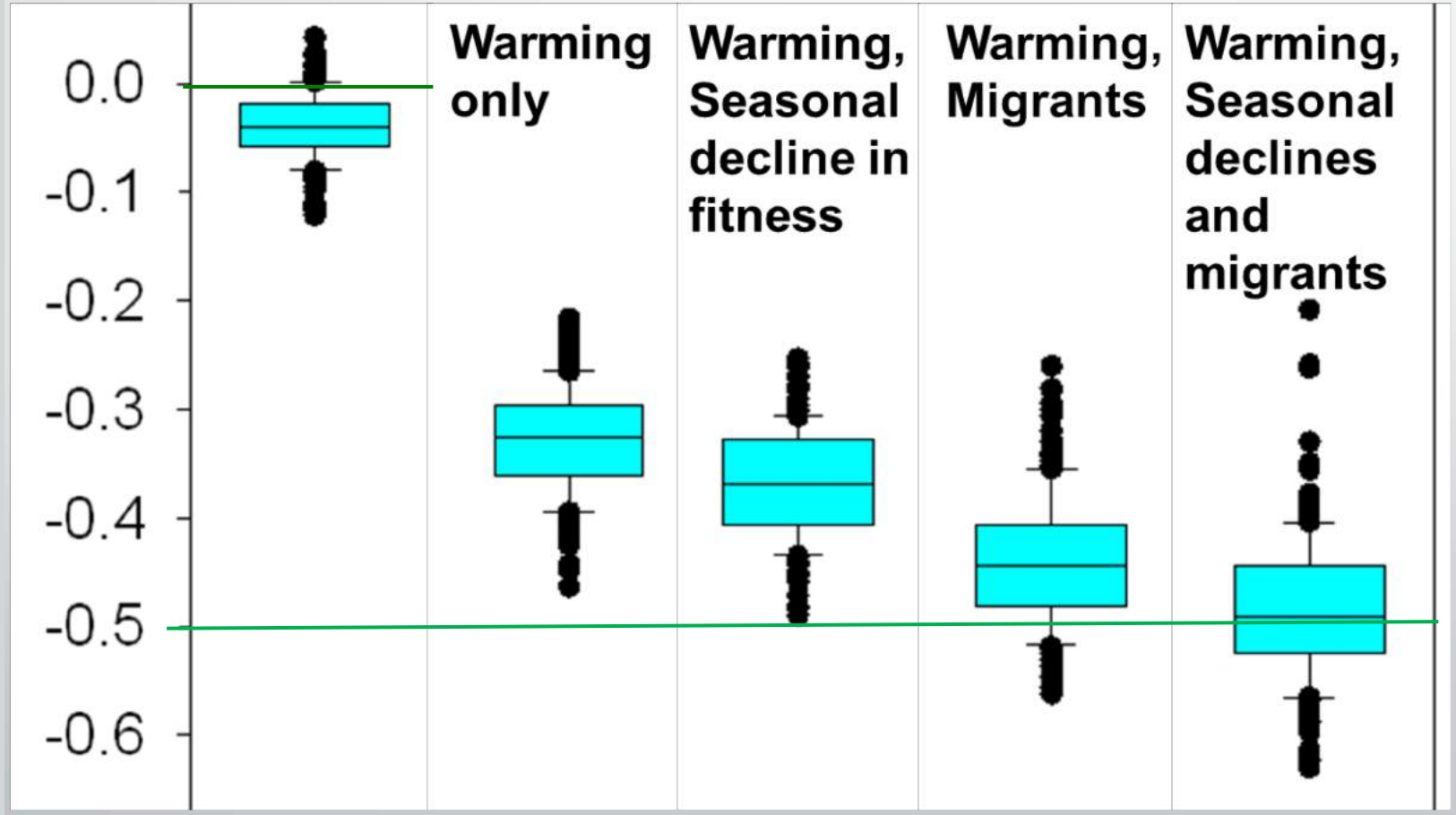
effects	Warming winter?	Migration?	Seasonal decline in local fitness?
no climate change	⊘	✓	✓
warming only	✓	⊘	⊘
seasonal decline in fitness	✓	⊘	✓
migration	✓	✓	⊘
full model	✓	✓	✓

- record changes in nest phenology over 50 years

Results

Change in nesting (day per year) over 50 years

No warming
Seasonal decline in fitness
Migrants



GEM3 ABMs

- Species specific for sagebrush and trout
- Portable framework for G2P2Pop
- Climate change forecasting
- Integration of soc_evo_eco processes
- Sage and Trout experts – lets start talking about the biology of your species!