Mitigation and Adaptation Studies

Class 10: Stock and Flow Models

Contents:

- Stocks and Flows
- Variables and Links
- Stock and Flow Models
- Tools

Stocks and Flows

Stock: a collection of discrete or continuous items.

Examples:

- a population of animals, people, plants, …
- money in an account, airplanes at an airport, cars on a road segment, …
- concentration of chemical elements in a medium (e.g., CO2 in the atmosphere), …
- water in a lake, energy in a battery, …
- Bytes used on a computer, …

The number of entities in a discrete stock or the quantity of a continuous stock is a "state variable".

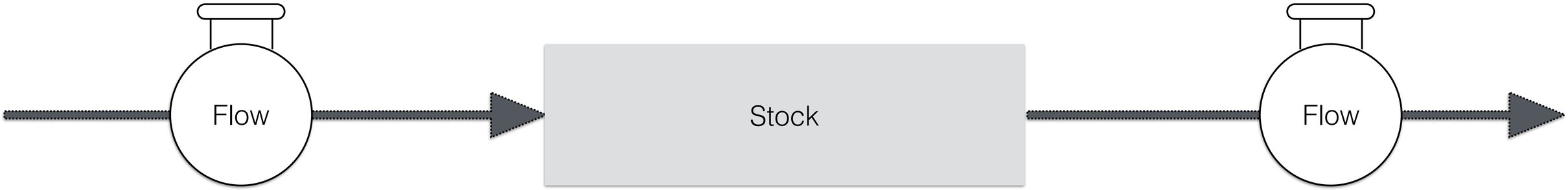
Flow: a movement of matter, things, energy, information, …

Examples:

- animals/people being born or dying, new plants growing, plants being harvested, …
- money spent, airplanes leaving or arriving, cars leaving a road segment or entering, …
- fertilizers put on a field, CO2 emissions,
- water running into a lake or out of it, energy taken out of a battery or put into it, …
- Information flowing into a computer or being removed.

Flows are the valves that control the movements between stocks.
They can be expressed as rate equations or differential equations.

Stocks and Flows



Stocks and Flows

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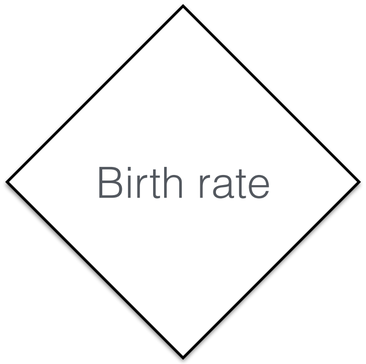
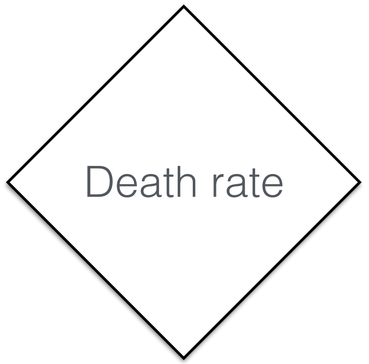
Variables and Links

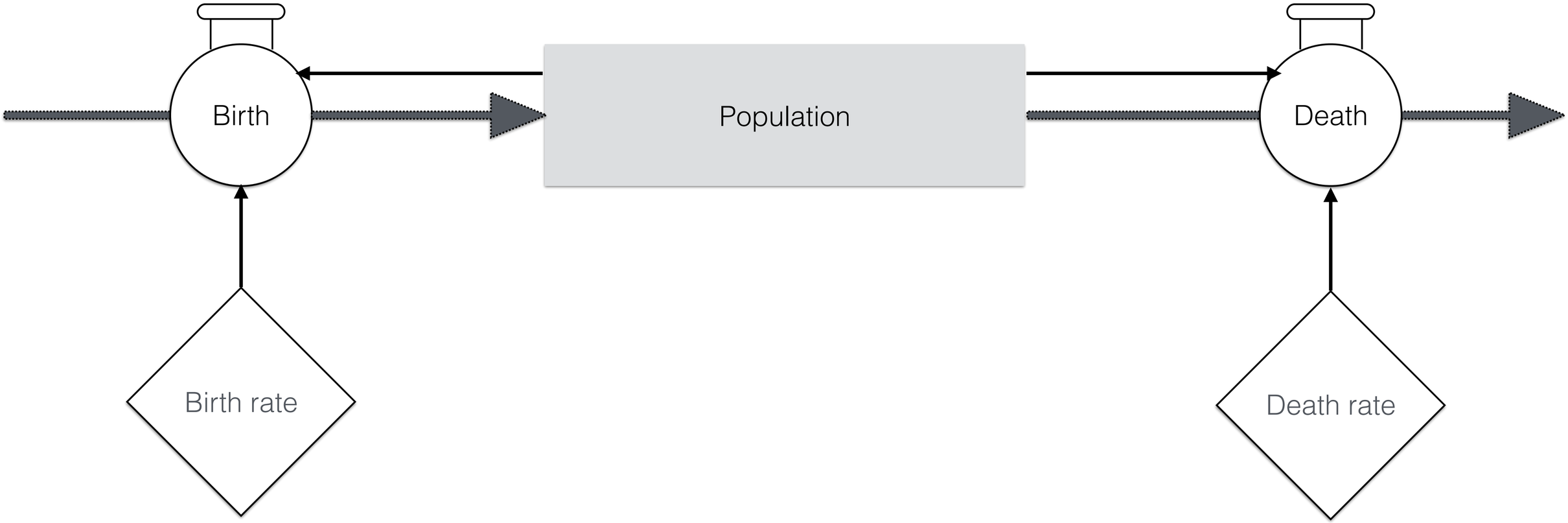


Variables:

- Birth rate
- Death rate



Variables and Links



Variables:

- **Birth rate**
- **Death rate**

Links:

- Birth = **Birth rate** * **population**
- Death = **Death rate** * **population**

Variables and Links

Variable: a quantity that can determine flows and stocks.

Examples:

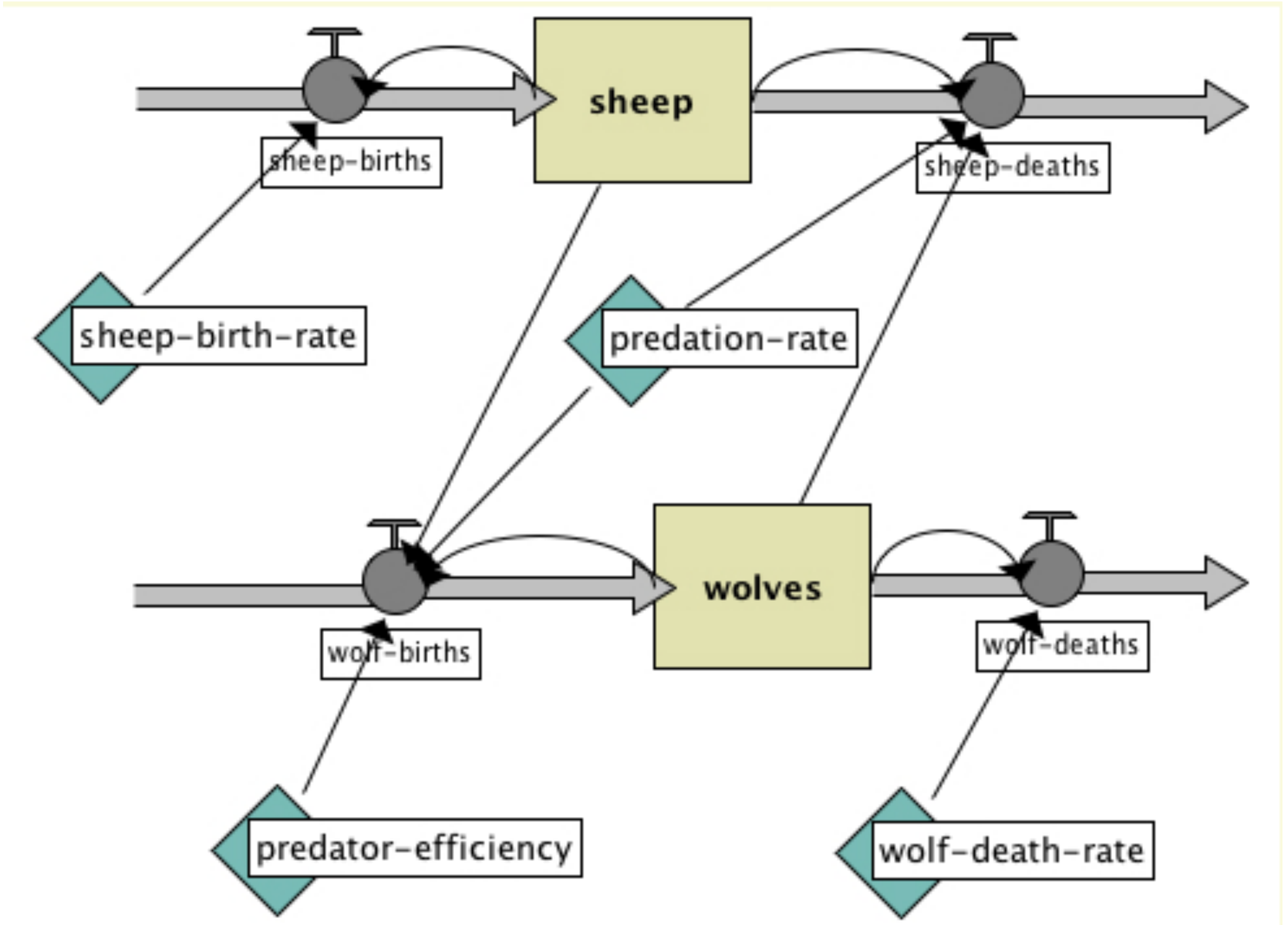
- birth rate, survival rate, death rate, predator efficiency, …
- energy efficiency, …
- absorption rate, …
- evaporation rate, temperature, salinity, …

Links: a connection that transmits a number from a variable, stock or flow to another stock or flow.

Examples:

- the flow “birth” depends on the variable “birth rate” and the number of population in the stock.
- the “death” of a prey population depends on the variable “death rate” and the number of prey population (stock), but also on the variable “predator efficiency” and the number of predators (stock).

Variables and Links



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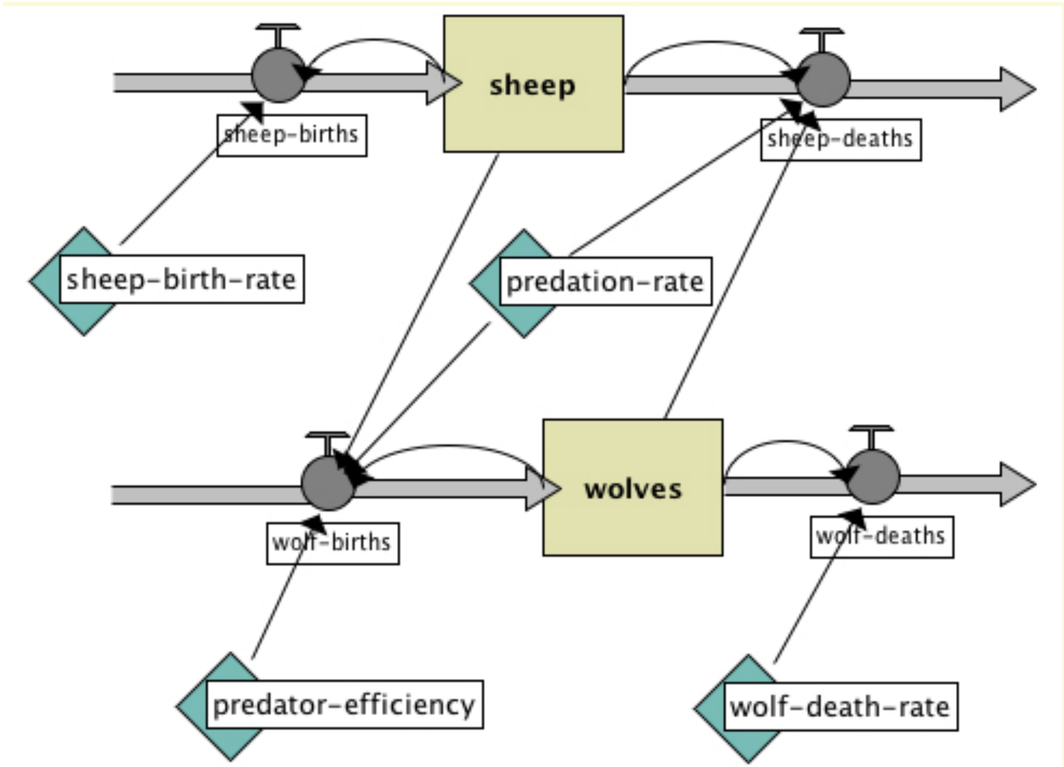
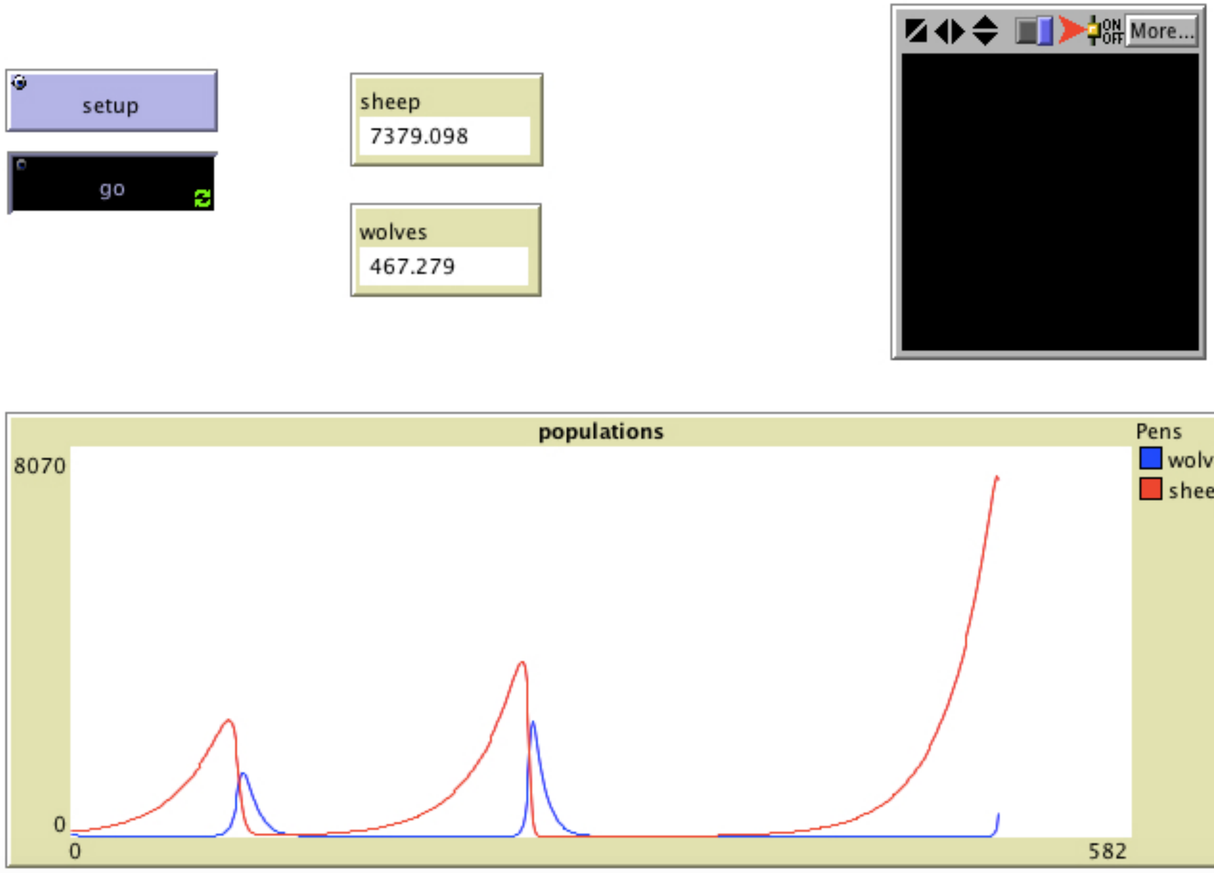
Stock and Flow Models





Stock and Flow Models

Model: Simplified abstract representation of reality designed to allow:

- explain causal relationships;
- study system characteristics;
- simulate (predict) system behavior under certain conditions.

Model levels:

- mental models: cannot capture relationships in complex systems;
- conceptual models: captures relationships between different system components;
- causal loop diagrams: Conceptual models that capture all relevant causal relationships including feedback loops
- mathematical, numerical, computational models: extensions of conceptual models; can be analytical models, simulation models, statistical models, box models, stochastic models, deterministic models, empirical models, theoretical models, dynamic models.

Stock and flow models and agent-based models are designed closely based on conceptual models.

Stock and Flow Models

A “good” model addresses the problem that it was designed to address.

Starting point: a well-defined question (with is a challenge for a wicked problem).

Three main goals for model design:

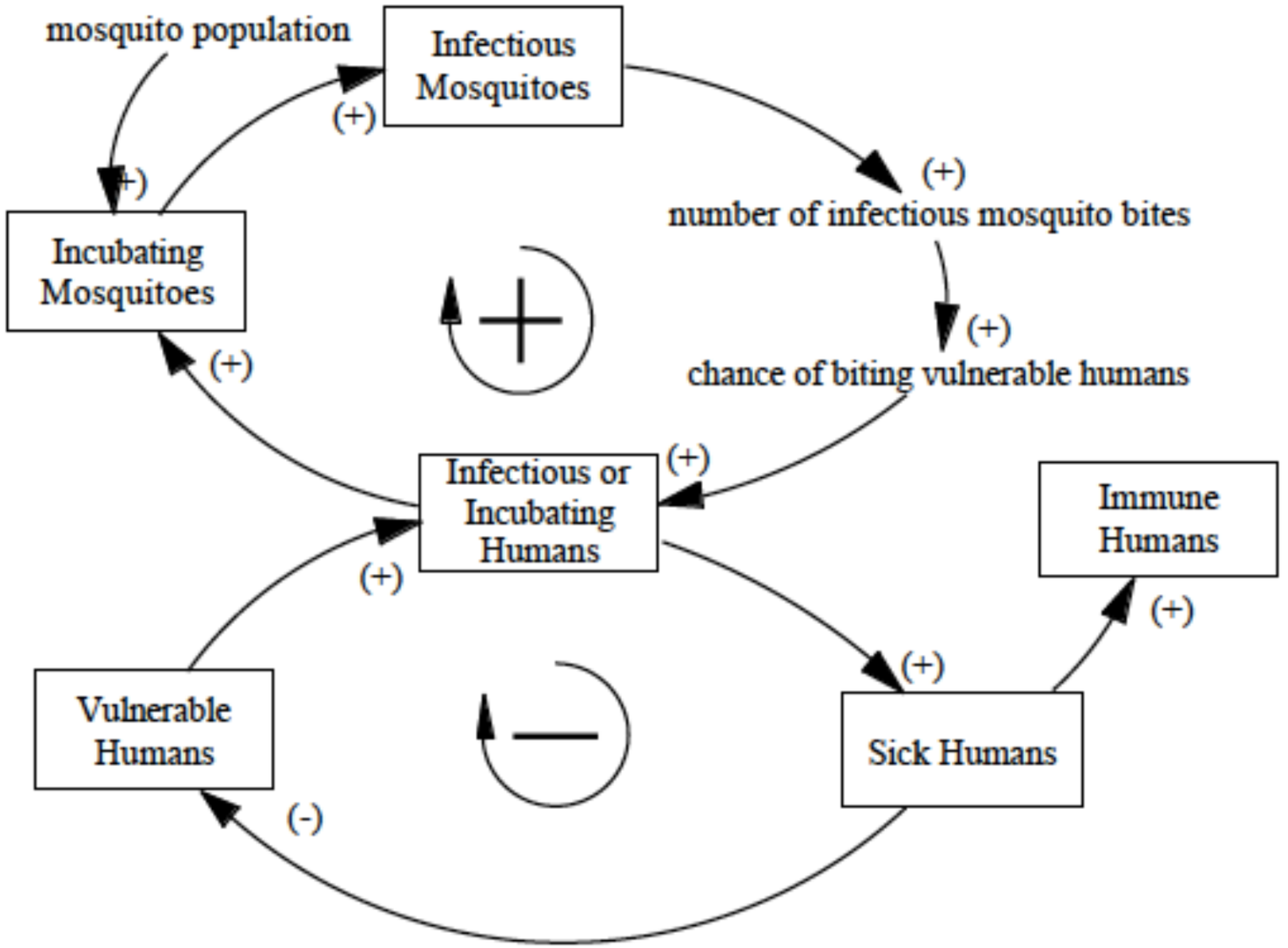
- Control: the ability to manipulate an experimental system and to quantitatively and precisely relate cause and effect.
- Realism: the extent to which the knowledge gain from the model is directly translatable to the real-world problem.
- Generality: the range of different types of systems the model can be applied to.

Stock and Flow Models

Eight steps:

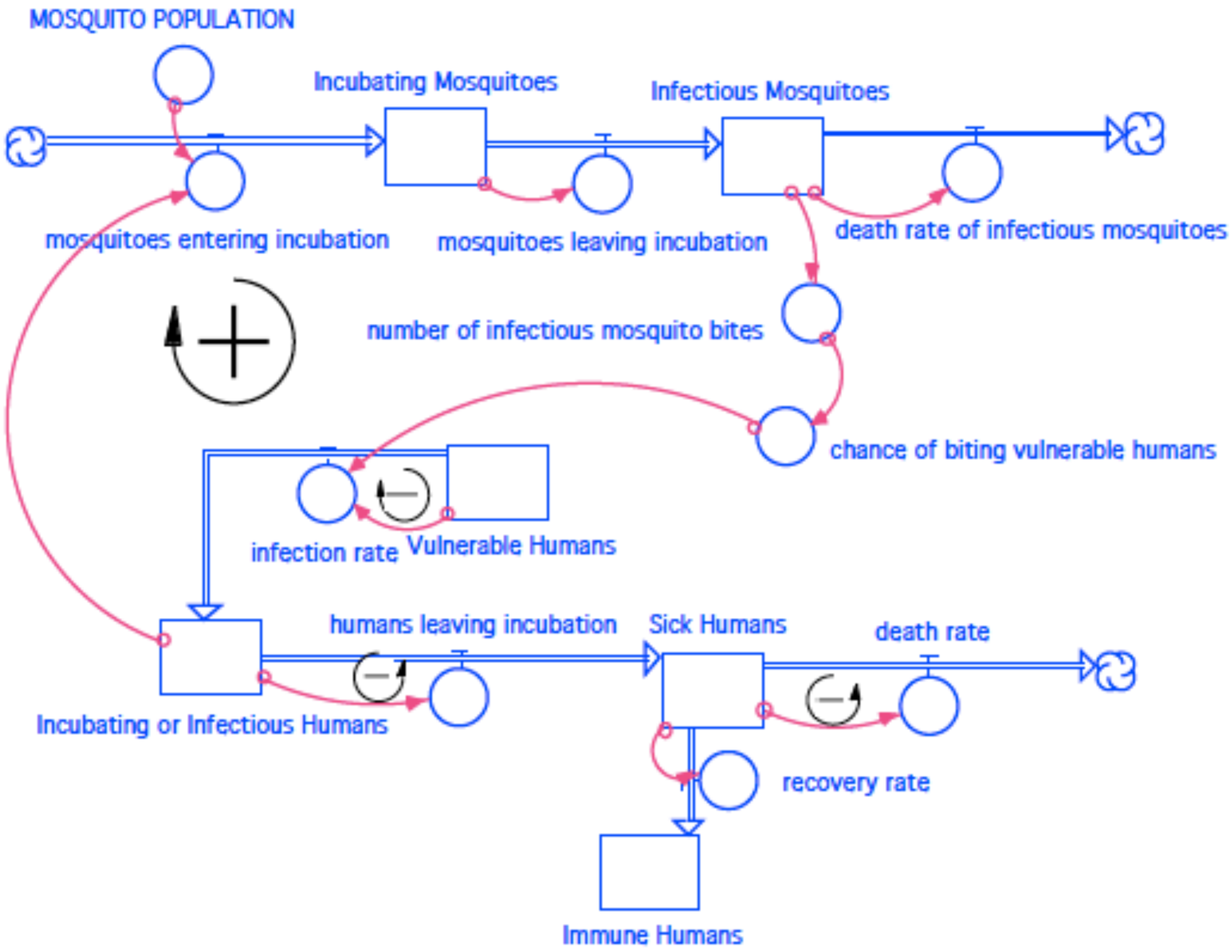
1. Identification of the problem
2. Conceptualization: develop conceptual model; preferably as conceptual loop diagram
3. **Formalization: translate the conceptual model into formulas (for a stock and flow model or agent-based model)**
4. Calibration: the process by which the model structure and coefficient values are altered within a range of observed values so that model output conforms to data observed in real systems.
5. Validation: use of independent dataset to test the models ability to predict dynamics under a different set of conditions.
6. Sensitivity analysis: values of model coefficients and initial conditions are systematically varied in order to determine which ones the model output is most sensitive to.
7. Simulations: An excellent approach for asking and answering what-if questions.
8. Translation: interpreting what findings from the modeling world mean for the real world.

Step 2



Basic mechanisms of yellow fever system

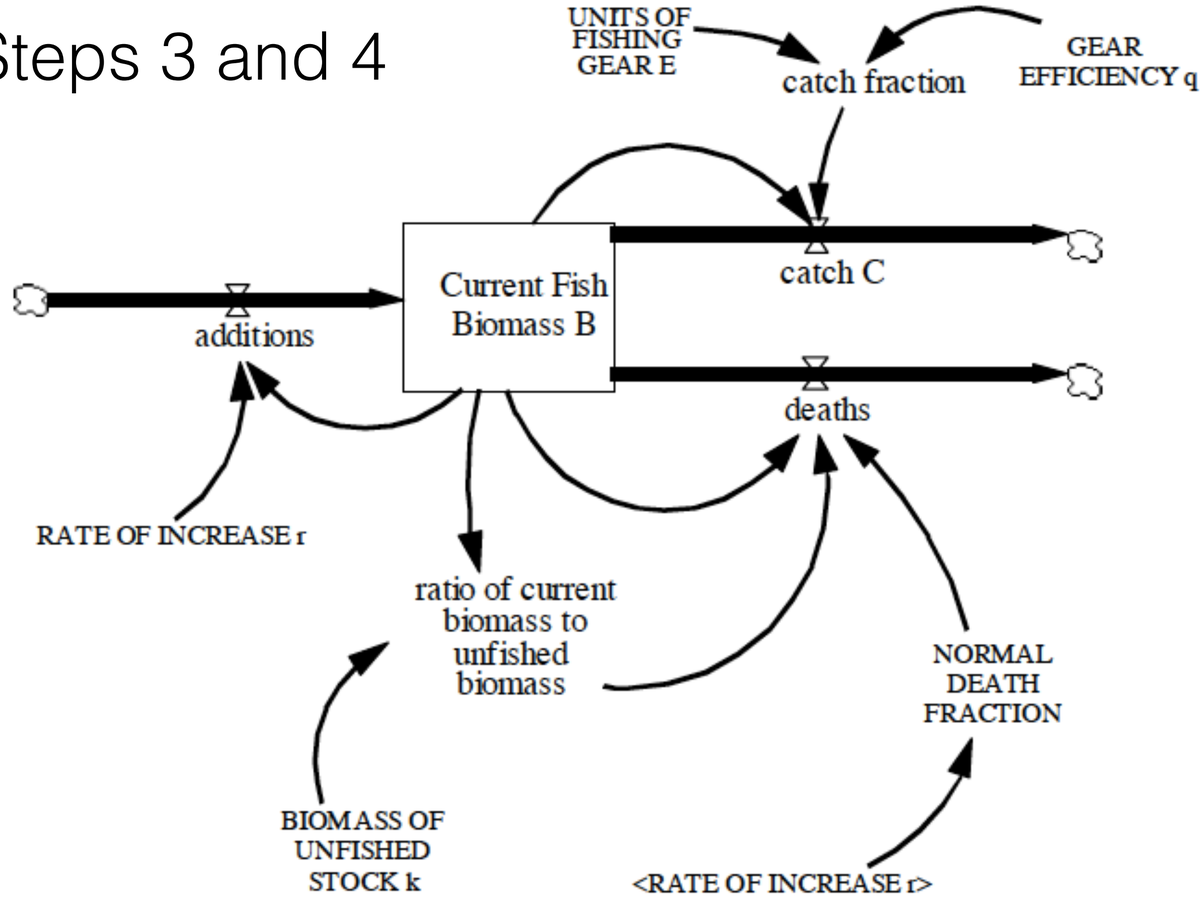
Step 3



Basic mechanisms of yellow fever system

Stock and Flow Models

Steps 3 and 4

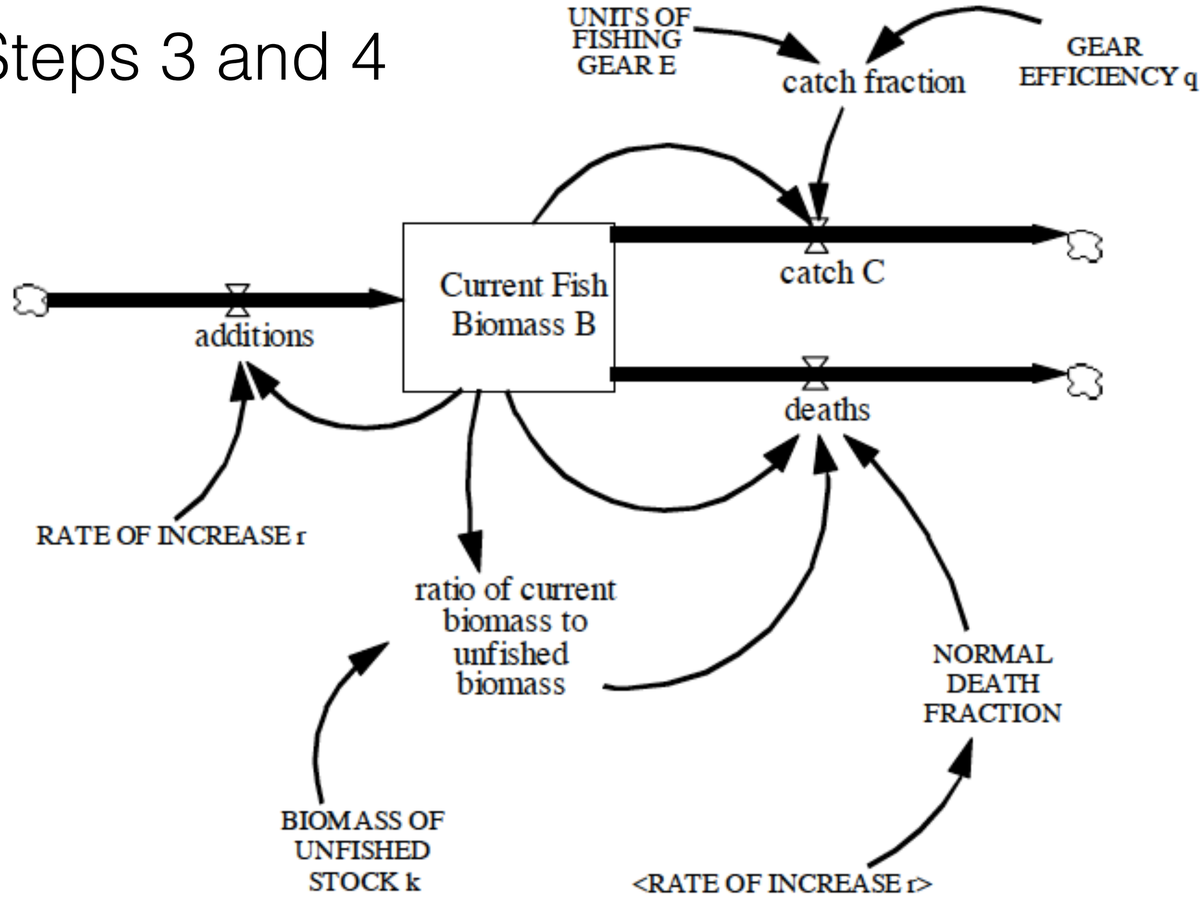


A system dynamics model formulation facilitates examination of model structure and assumptions. The rectangle labeled Current Fish Biomass B is a stock, or accumulation. The thick arrows are flows.

Dudley and Sonderquist, 1999

Stock and Flow Models

Steps 3 and 4



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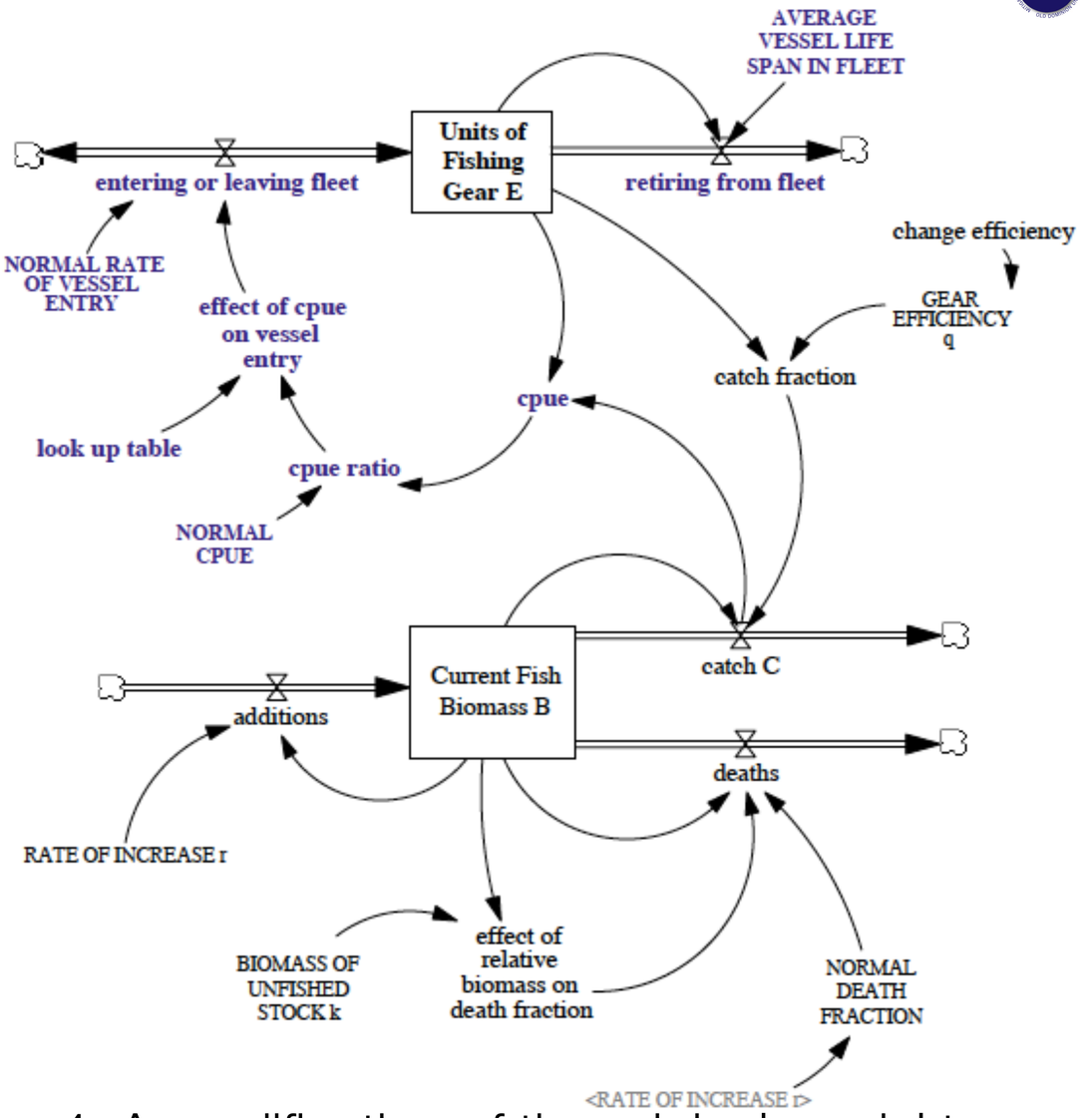


Figure 4. A modification of the original model to reformulate "Units of fishing Gear E" as a stock which grows more rapidly if cpue (catch per unit effort) is high.

Dudley and Sonderquist, 1999

urban areas with six million residents. It is also home to a remarkable wilderness. The Marjory Stoneman Douglas Wilderness Area preserves nearly 1.3 million acres of marine estuary, mangrove and cypress forests, hard-

est wilderness east of the Mississippi River.

Wilderness once encircled humans. Now we encircle it. Wilderness gives us a glimpse of what America once was.

Coe Visitor Center and Other Areas

Royal Palm	4mi	6km
Pinelands	7mi	11km
Homestead, FL	11mi	18km
Pa-hay-okee Overlook	13mi	21km
Mahogany Hammock	20mi	32km
Nine Mile Pond	27mi	43km
West Lake	31mi	50km
Flamingo Visitor Center	38mi	61km
Florida Bay Ranger Station	38mi	61km
Miami International Airport	45mi	72km
Shark Valley Visitor Center	50mi	80km
Gulf Coast Visitor Center	92mi	148km
Key West	135mi	217km

Message to Boaters

Do not use this map for navigation. Navigational Ocean Survey charts are essential for safe boating. Charts are available in most communities around the park and throughout the Keys. Knowing the draft (depth) and limits of your boat is critical, as is the ability to read and utilize nautical charts. • Keys and beaches in Florida Bay are closed to landings unless otherwise designated. • Commercial fishing is prohibited in the park. • To protect important sea grass beds, Pole/Troll Zones have been established and are subject to special regulation. • Recreational fishing requires a license in both fresh water and salt water. • A permit is required for backcountry camping.

Water Depths
- 0-3 feet (0-1 meter)
- 3-6 feet (1-2 meters)
- Over 6 feet (Over 2 meters)

- Hiking trail
- Unpaved road
- Wilderness Waterway and canoe trail
- Wildlife protection area (limited access)
- Lighted marker
- Canal and gate
- Pumping station
- Water detention area
- Picnic area
- National Park Service campground
- National Park Service primitive campsite
- Private campground
- Interpretive trail
- Marina
- Gas station
- Boat launch
- Food service
- Lodging

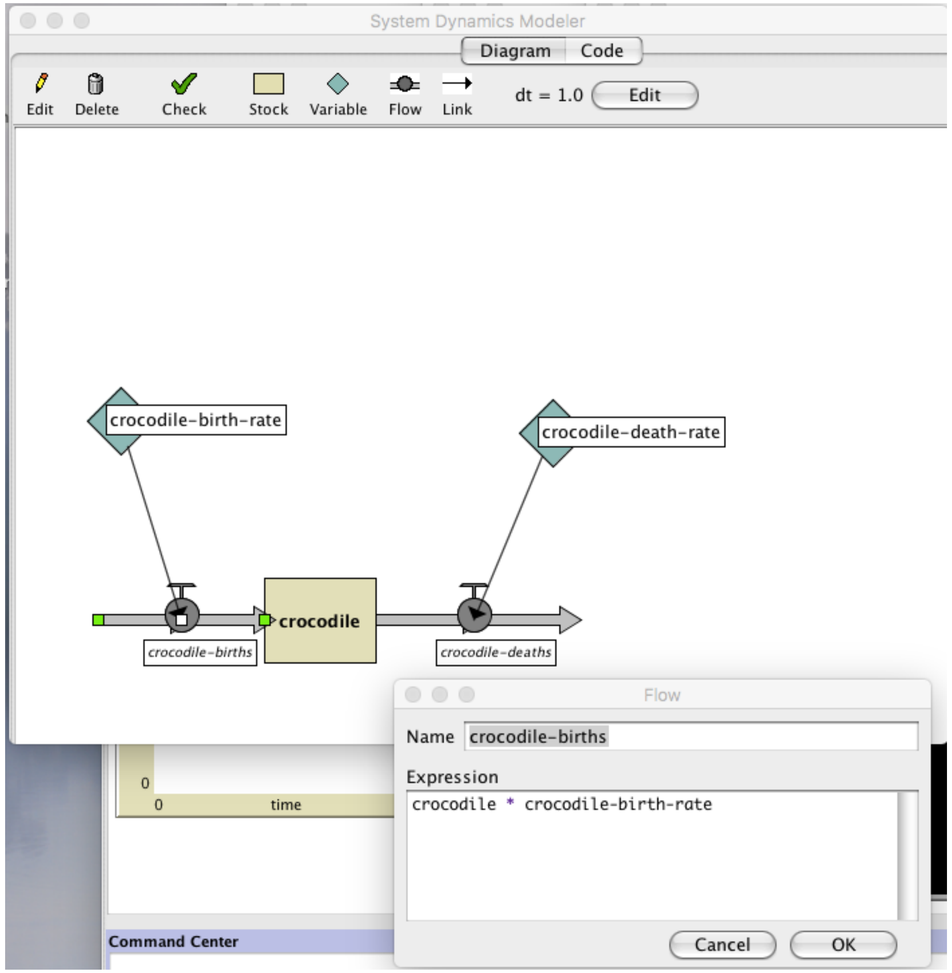
North

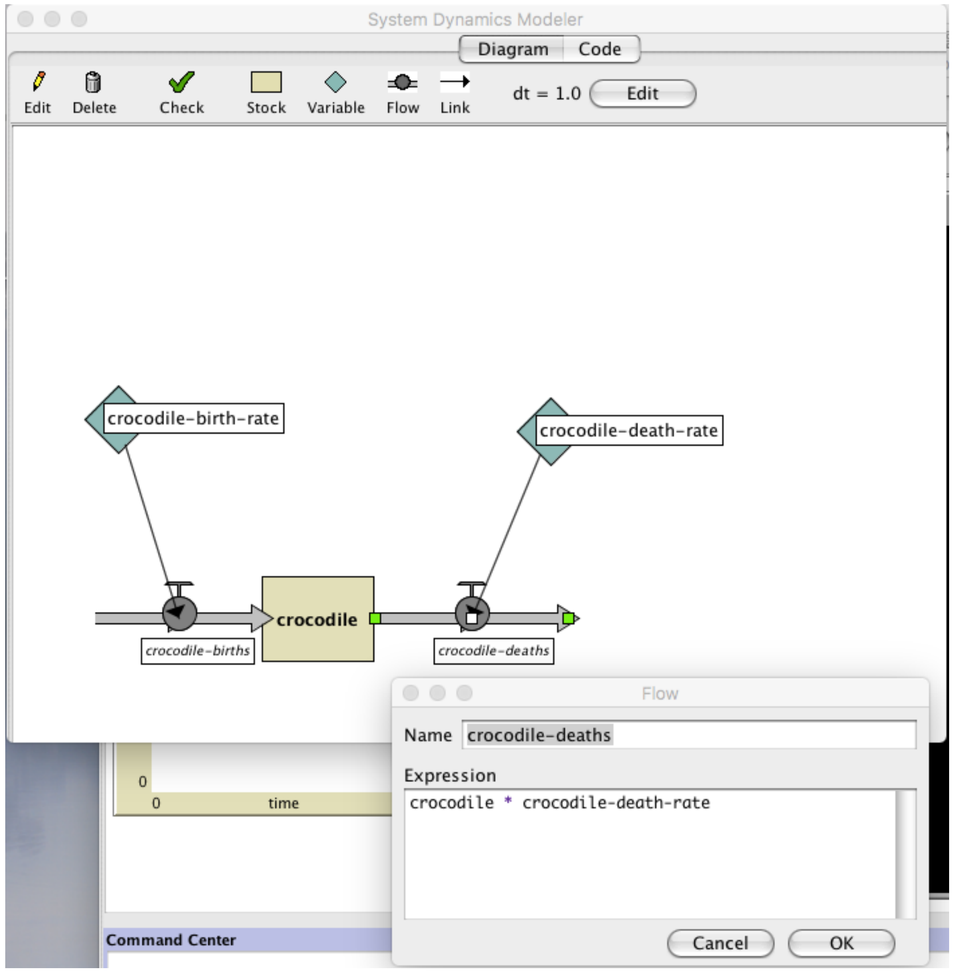
0 1 5 10 Kilometers

0 1 5 10 Miles

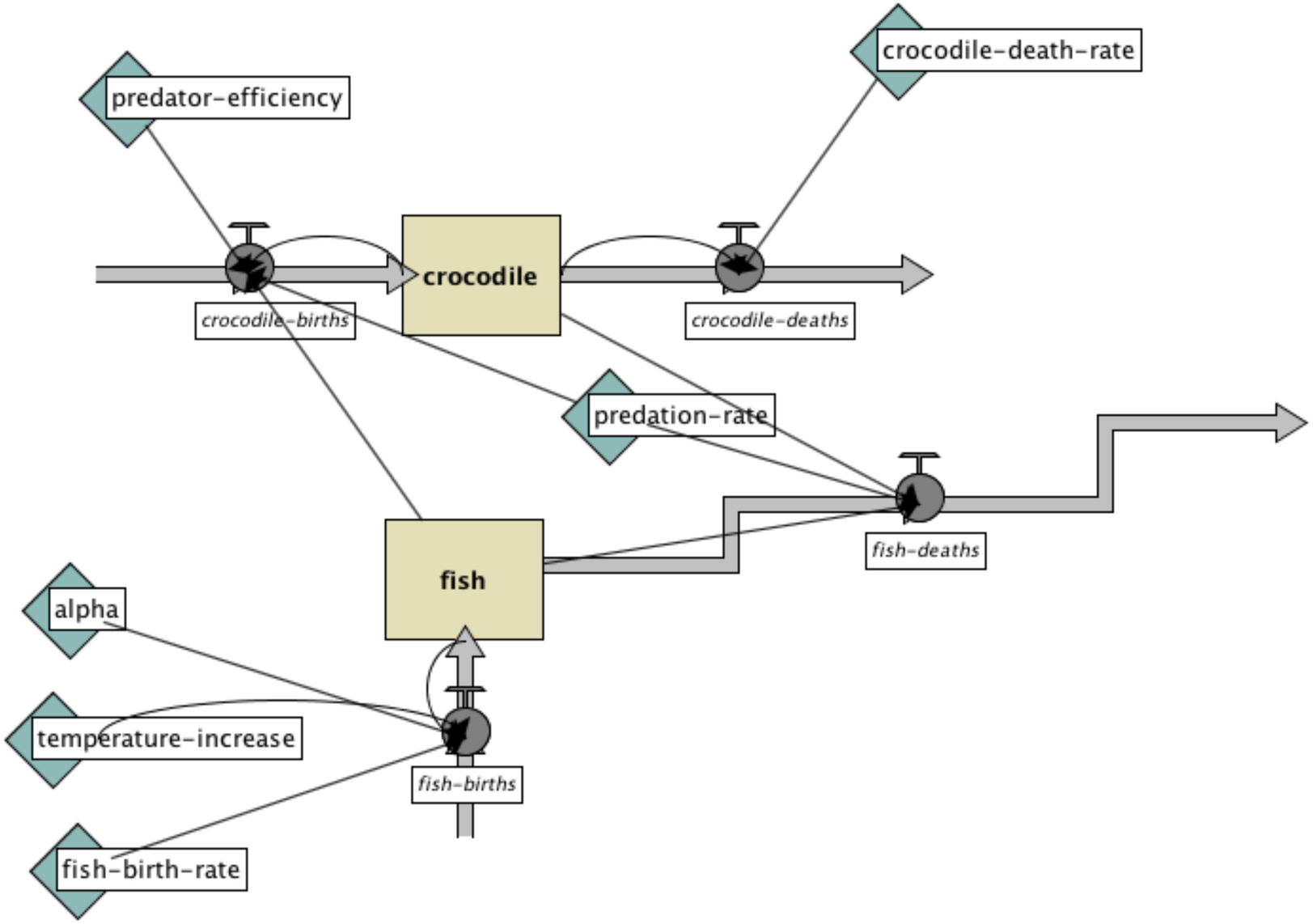
Stock and Flow Models

Stock and Flow Models

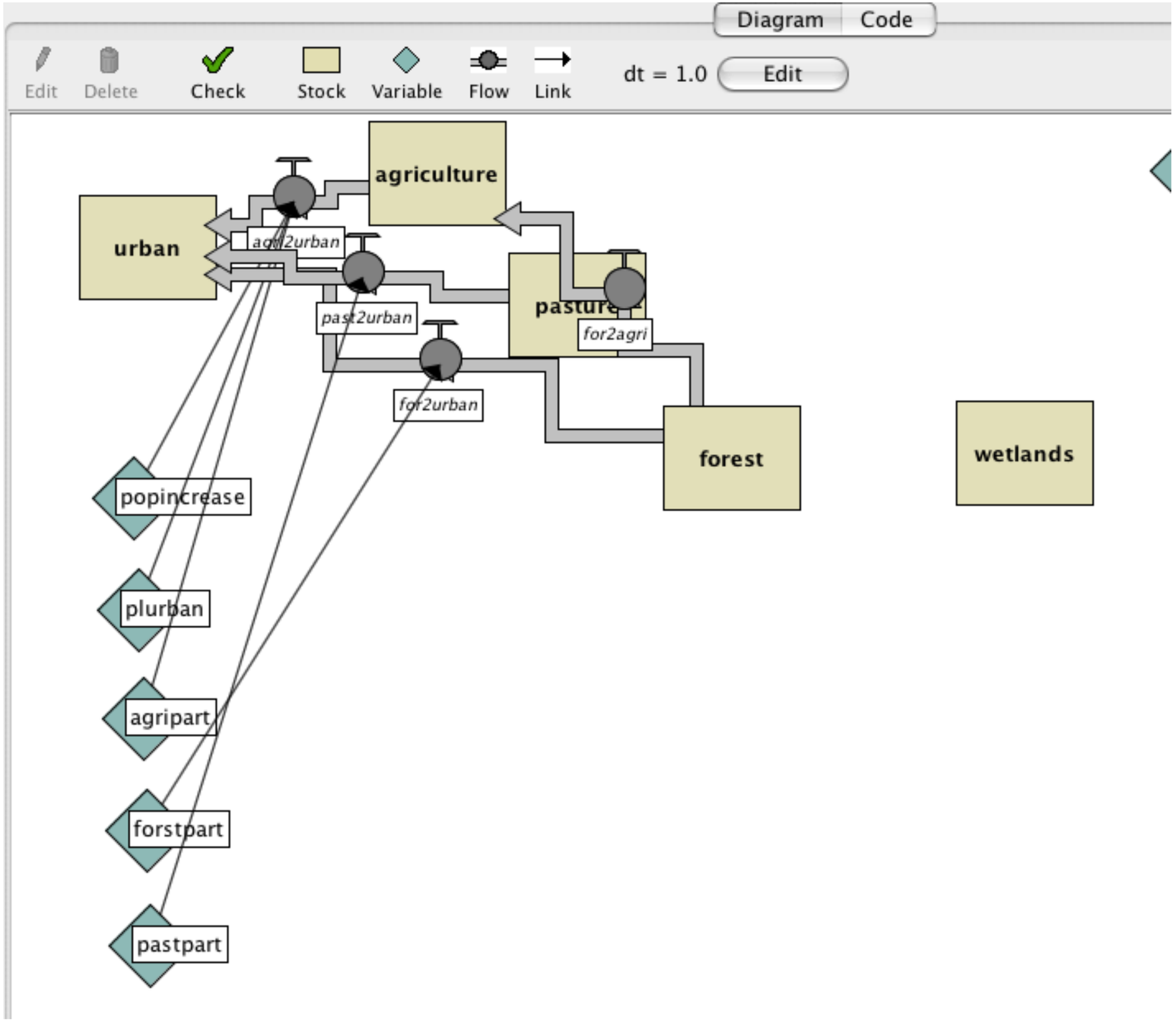




Stock and Flow Models



Stock and Flow Models



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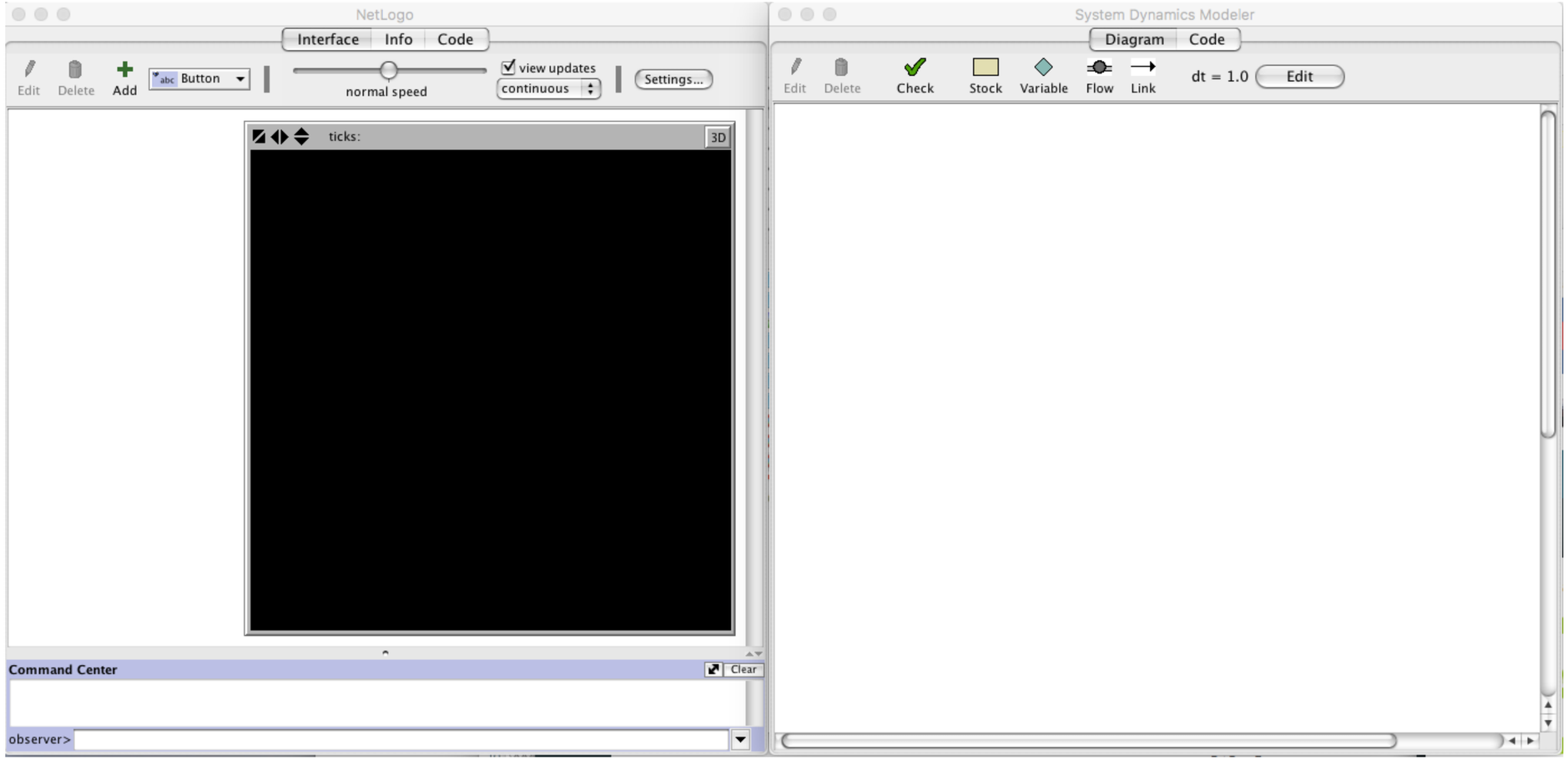
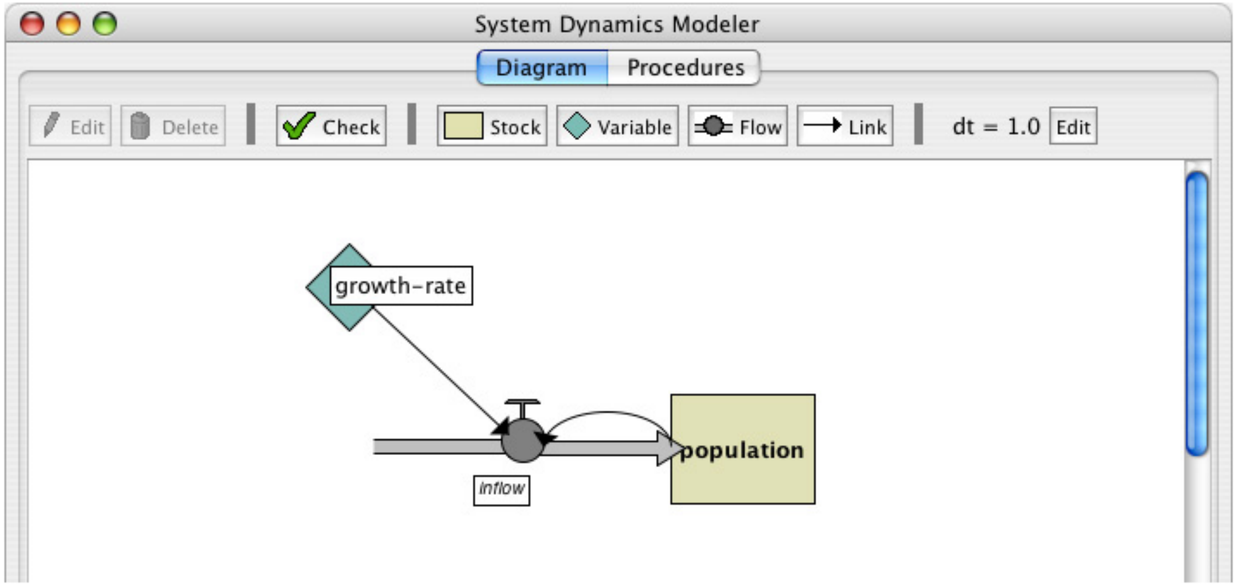
Tools

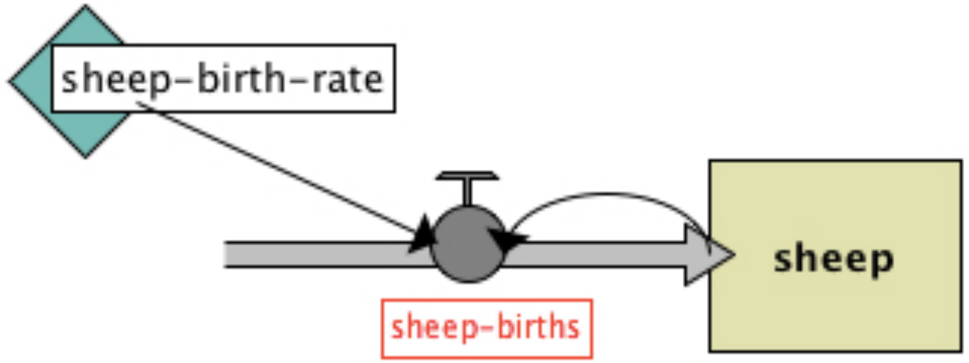
NetLogo:

The System Dynamics Modeler runs a stock and flow model over time with a discrete time step.
The time step can be adjusted to ensure sufficient time resolution.

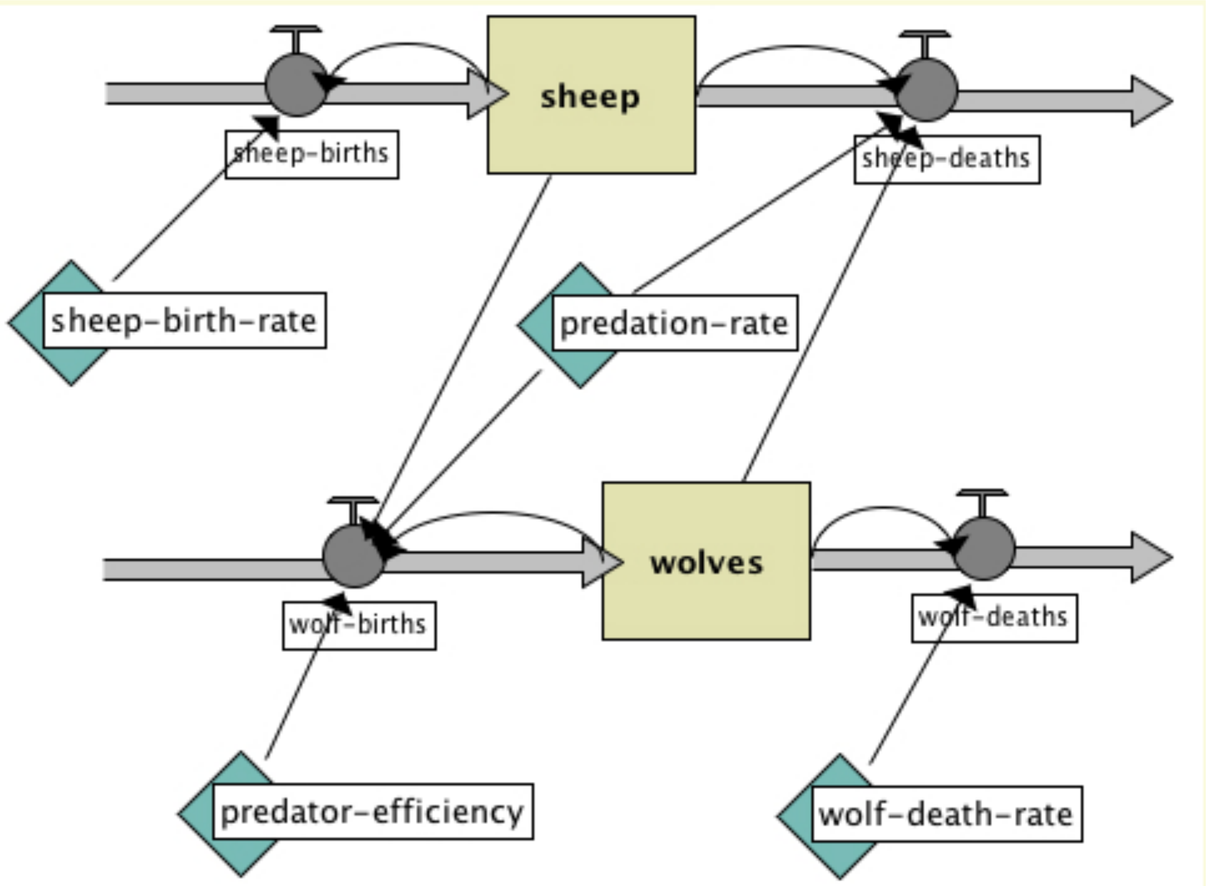


Tools


System Dynamics Modeler
Diagram
Procedures
Edit
Delete
Check
Stock
Variable
Flow
Link
dt = 1.0
Edit
growth-rate
population
inflow


sheep-birth-rate
sheep
sheep-births

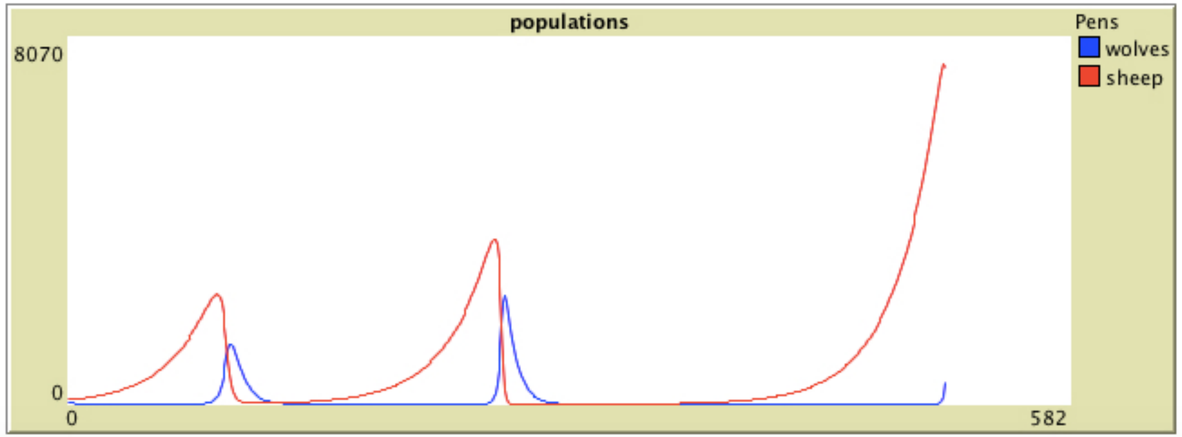
Tools


sheep
sheep-births
sheep-deaths
sheep-birth-rate
predation-rate
wolves
wolf-births
wolf-deaths
predator-efficiency
wolf-death-rate


setup
go


sheep
7379.098
wolves
467.279


More...


populations
Pens
wolves
sheep
8070
0
0
582

Tools

https://vensim.com/vensim-personal-learning-edition/

Vensim VENTANA systems, inc

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Vensim® Personal Learning Edition

Contents

1. Vensim PLE:
2. Vensim PLE Survey
3. Commercial Use
4. Download Vensim PLE at the Download page.
5. Vensim PLE Documentation (User's Guide)
6. Return to Software

Vensim PLE is a version of Vensim that has been designed to lower the barriers to the beginning system dynamics modeler.

Vensim PLE is fully functional system dynamics software that is **free** for personal and educational use, and comes complete with sample models, help engine, and Adobe Acrobat format PLE User's Guide. You can download Vensim PLE here.

Vensim PLE:

- Is free for academic and personal use.
- Has simplified menus and dialogs.
- Contains fewer option settings.
- Has a fixed tool set.
- Contains fewer model-building tools.
- Contains fewer of functions.