Complex Dynamical Systems

A Series of Ten Lectures to the Ross Institute, 2011-2012

by

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Series Outline

1. Nov 2, Intro: Epiphany, What, Why, How

2. Nov 9, Grs. K, 1: Dynamical Systems (DS)

3. Nov 16, Grs 2, 3, 4: Complex Dyn Sys (CDS)

4. Nov 21, Grs 5, 6, 7, 8: NetLogo CDS Models

5. Dec 7, Grs 9, 10, 11: NetLogo CDS Models

Lec. 1: Introduction

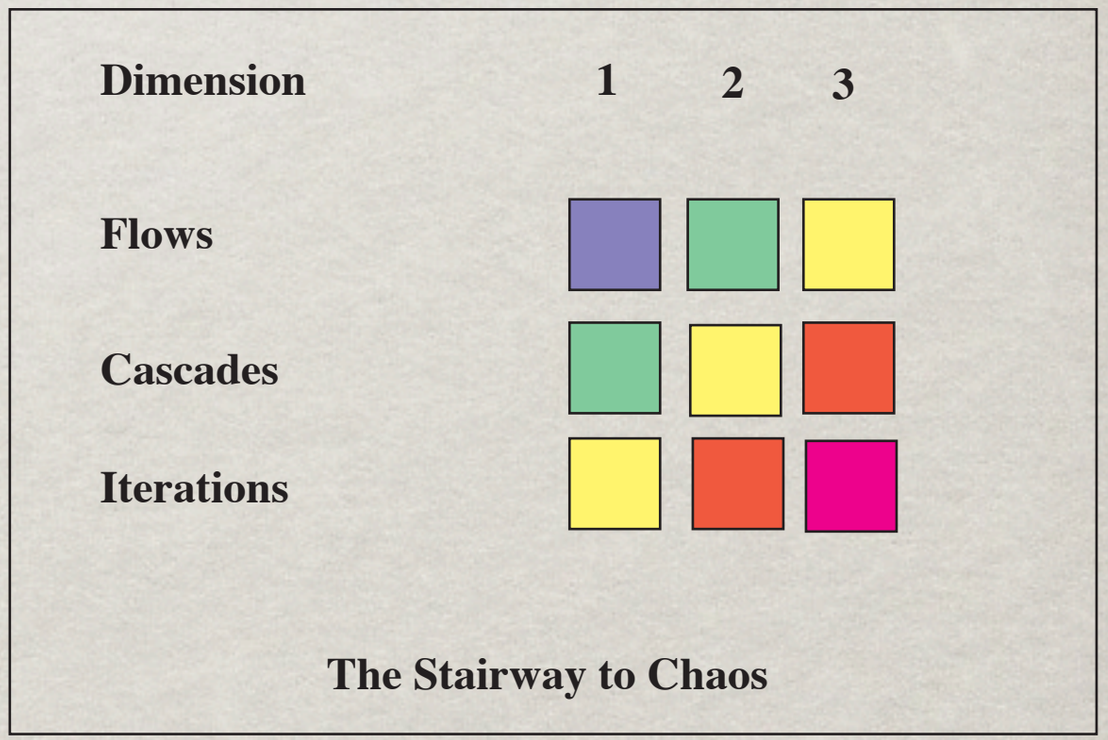
- A. My epiphany of the miracle year, 1972.
- B. WHAT: Systems thinking, General systems theory, cybernetics, system dynamics, and complex dynamical systems (CDS).
- C. WHY: The Spiral and World Cultural History as systems, systems thinking to understand the future.
- D. HOW: Foregrounding the systems of each grade with NetLogo (needs participation).

Lec. 2: Dynamical Sys.

- A. Stairway 2 Chaos
- B. Attractors, Basins, and Separatrices
- C. Schemes and Bifurcations
- D. Animated Examples

Stairway to Chaos

- Yellow:
  - First chaos for flows
  - For cascades
  - For iterations



Lec. 3: Complex DS

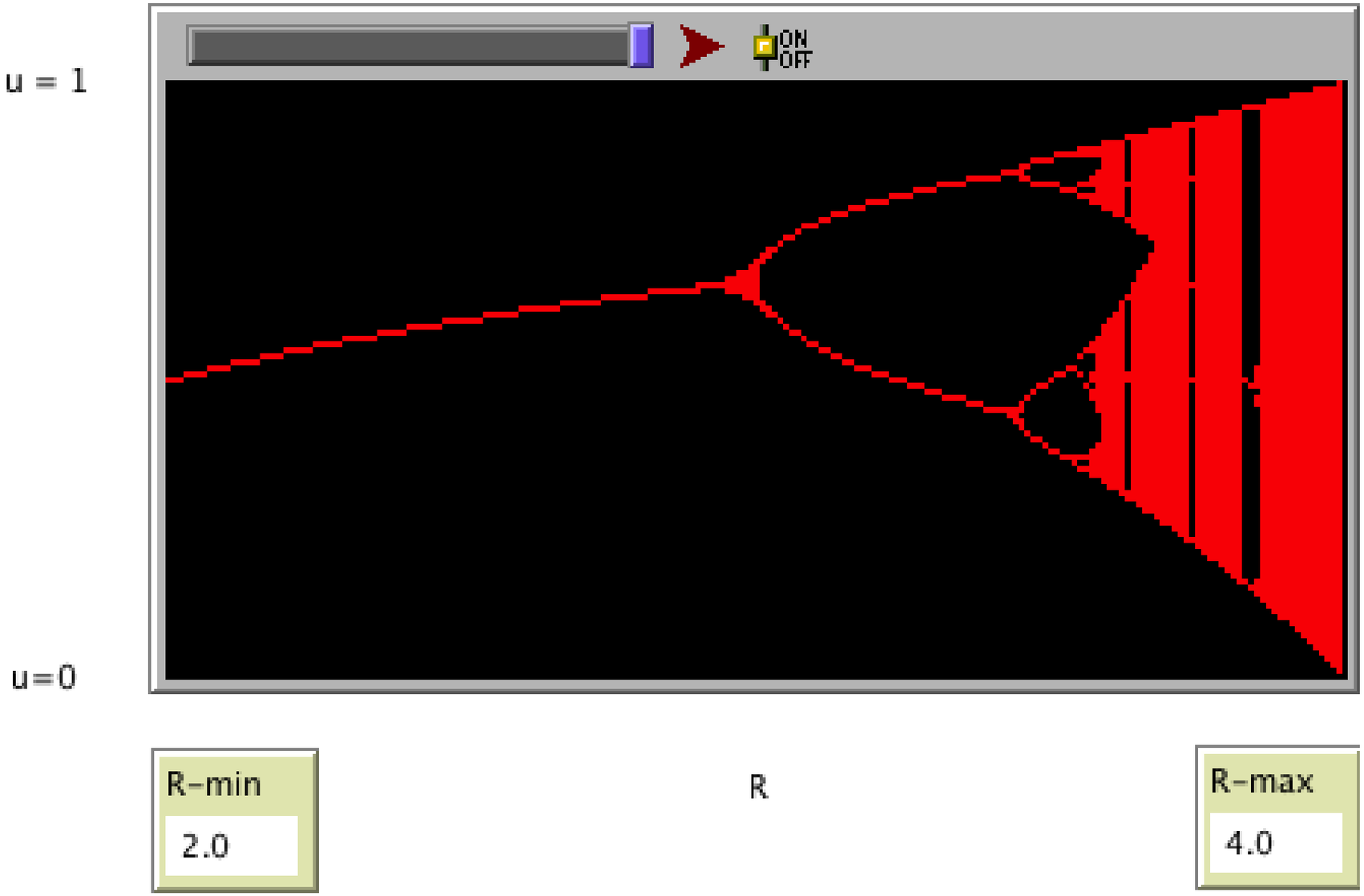
- Grade K: Logistic, Period doubling bifurcation
- Grade 1: Van der Pol, Hopf bifurcation
- Grade 2: Daisyworld (CDS)
- Grade 3: Wolves and sheep
- Grade 4: Rabbits, grass, and weeds

Systems Thread Map
Ross Institute/Ross School

	Description from Bill's notes FROM ORIGINAL DOC, 2000	**Ralph's Notes (NetLogo Models)**
Kindergarten The Division of Unity	CREATION, VAST ELEMENTAL FORCES Creation myths; *Enuma Elish,* Genesis 3, Singularity of the Big Bang, Dyadic cycle of light and dark; Spectrum of Colors, Child	Logistic family
Grade 1 Patterns	PATTERNS IN NATURE AND ART The Dyadic System; Creator and Creatures, Earth and Sky, Sun and Moon, Night and Day Parents	Logistic family, period doubling bifurcations Van der Pol family, Hopf bifurcation
Grade 2 Systems	COHERENT WORLD SYSTEMS Patterns in motion; Pulse of life; high tide/low tide; weather—sun & rain, clouds in the sky; light and leaves, flowers, Solar System I	Daisyworld (NetLogo)
Grade 3 Human Systems	HUMAN BODY, HUNTING BAND Shelter, Ice Age Art (Venus of Lespugue), Musical Scales in Ice age flutes; Culture/ Nature; Human Trade; Gathering/foraging; The Market 1, the Family, Shamanism	Wolf-Sheep (NetLogo SD)
Grade 4 Agricultural Systems	EARLY NEOLITHIC SOCIAL SYSTEMS 2,000,000 to 10,000 BCE From nomadic transhumance and foraging to Agriculture; Ceremonial Centers, Shift from Shamanism to religion; Human Trade, The Market II, Farm	Rabbits-Grass-Weeds (NetLogo)

Grade K: The Division of Unity

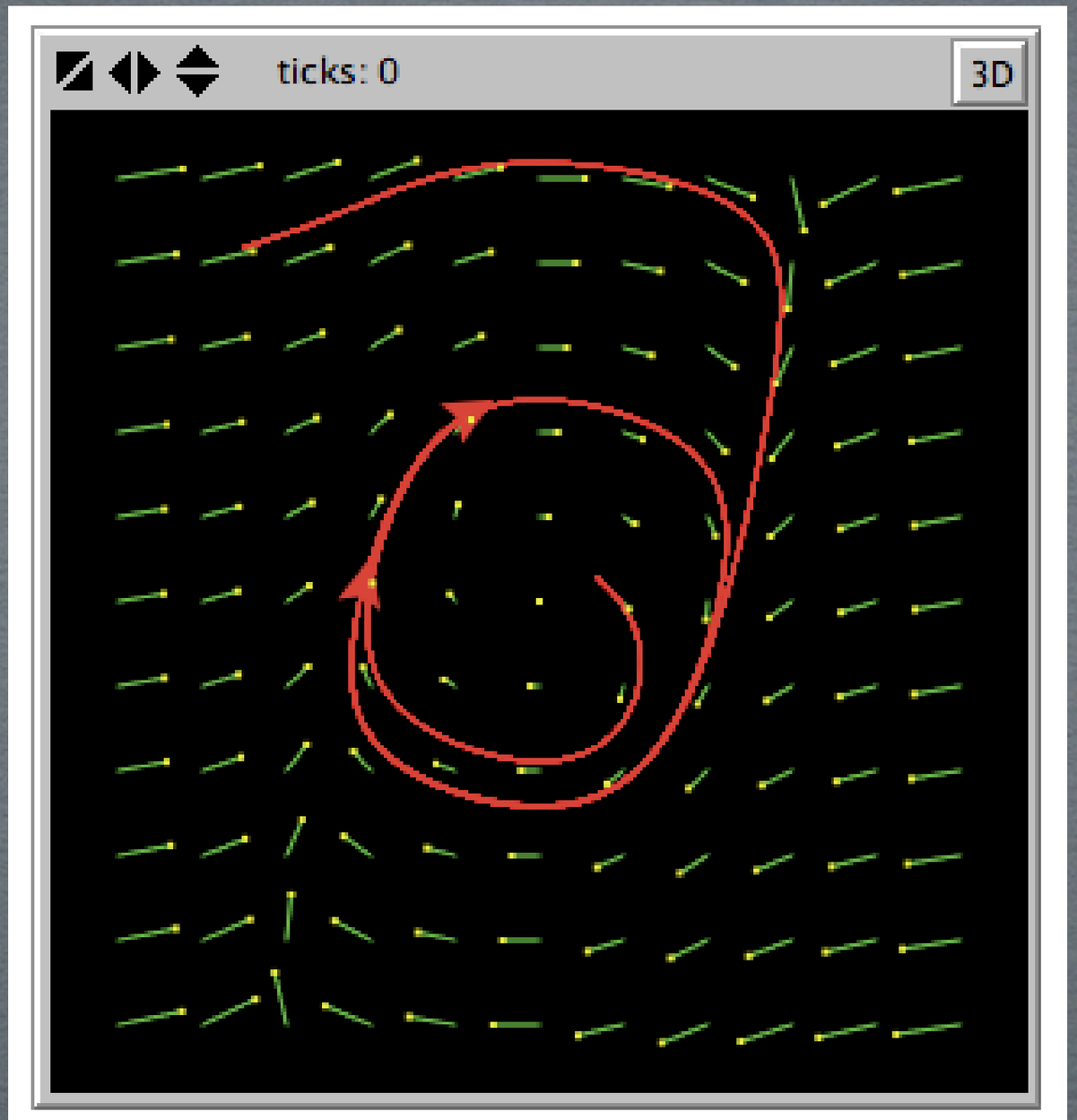
Logistic Scheme: Period Doubling Bifurcation (Dynamical Scheme)



Logistic Response

Grade 1: Patterns

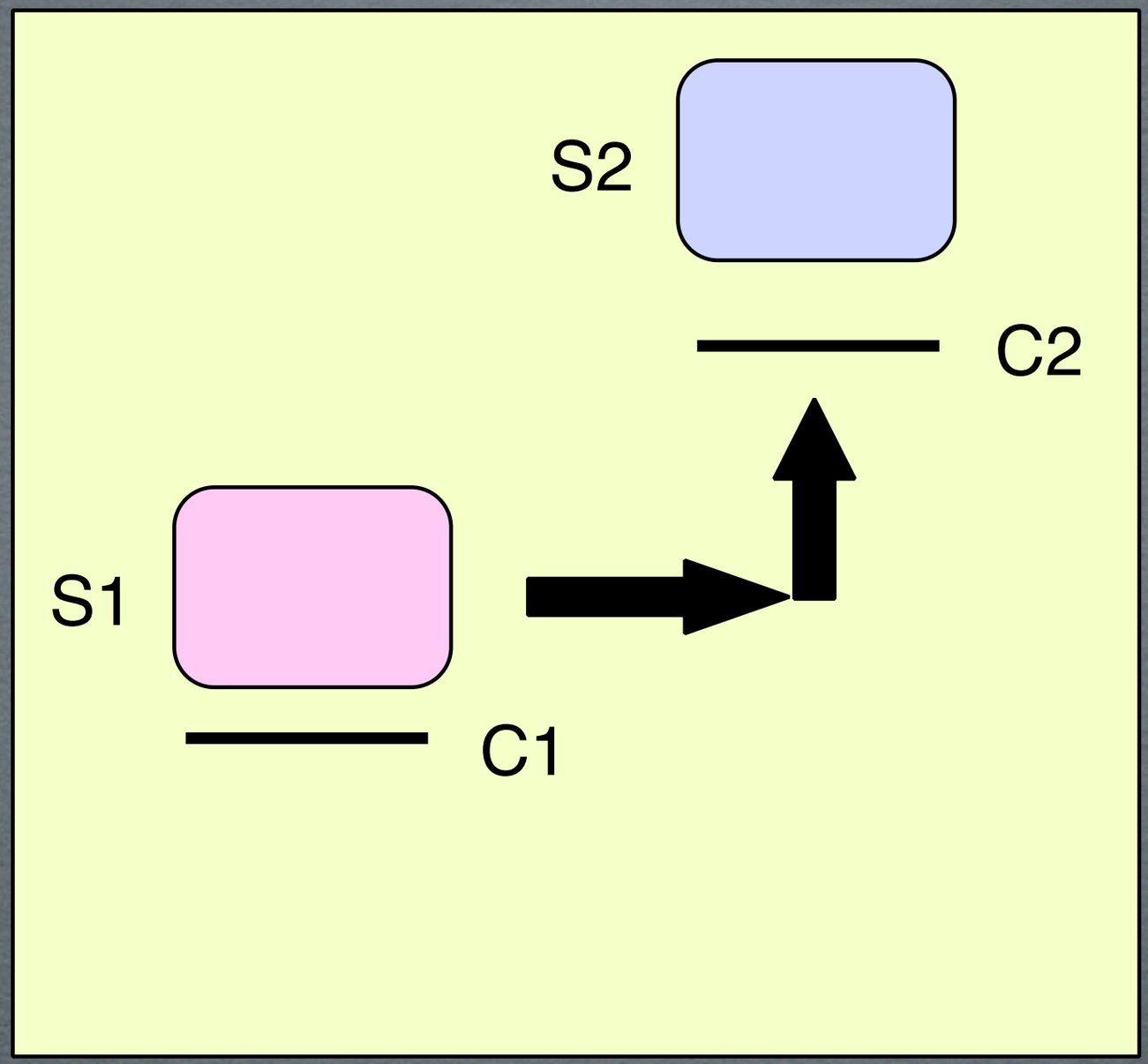
Van der Pol Scheme: Hopf Bifurcation



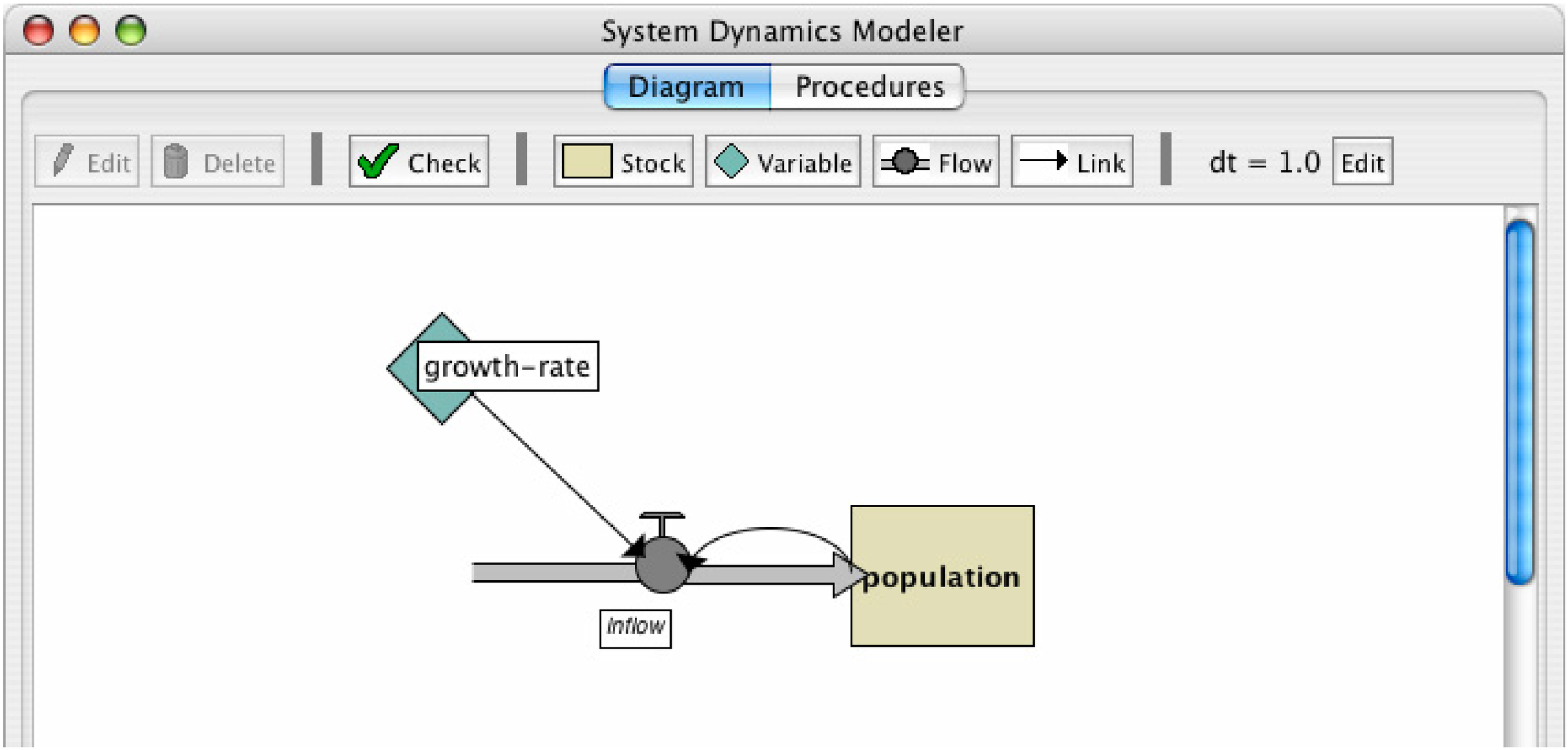
Periodic Attractor

Grade 2: Systems

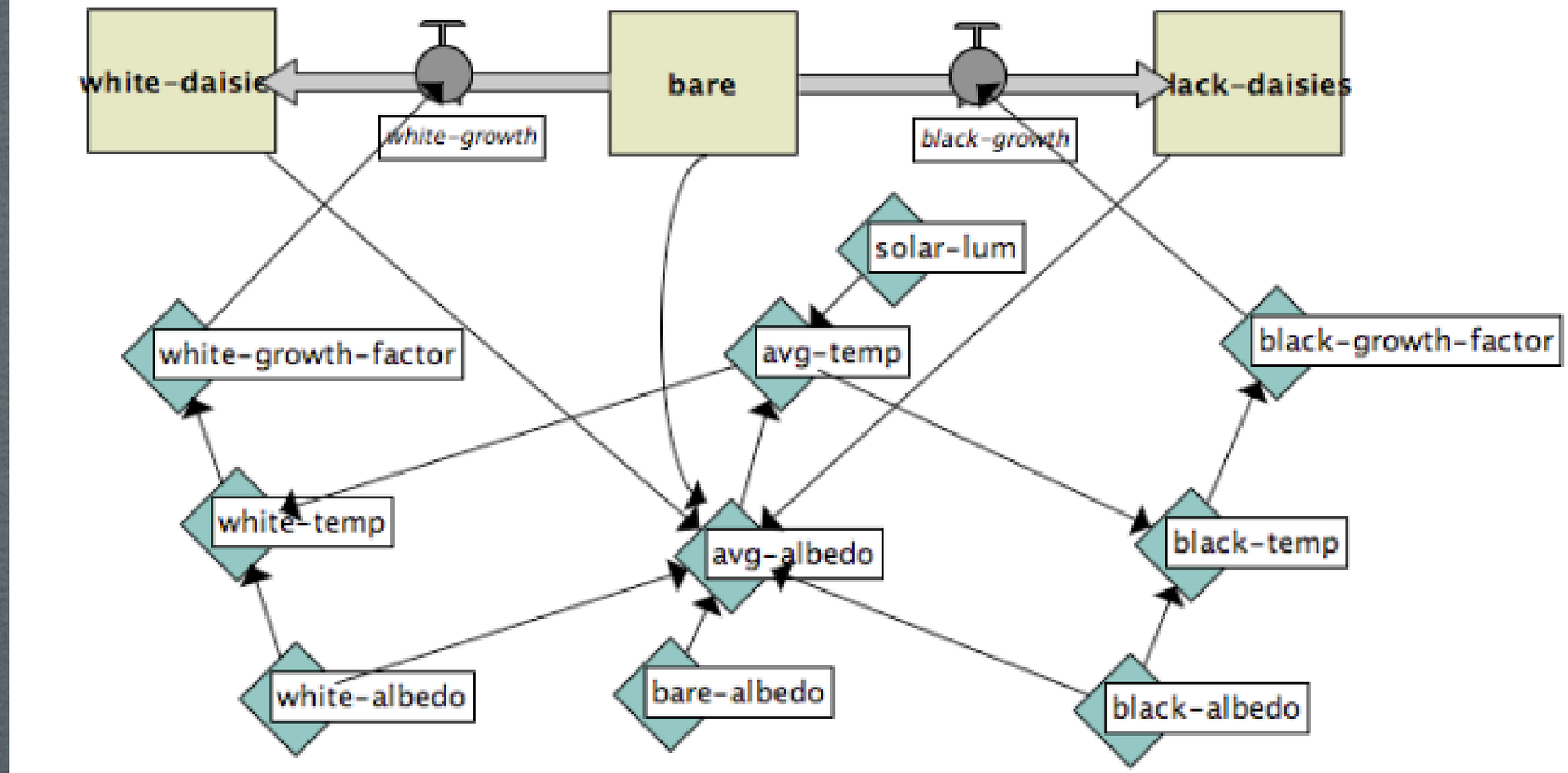
Daisyworld (CDS)



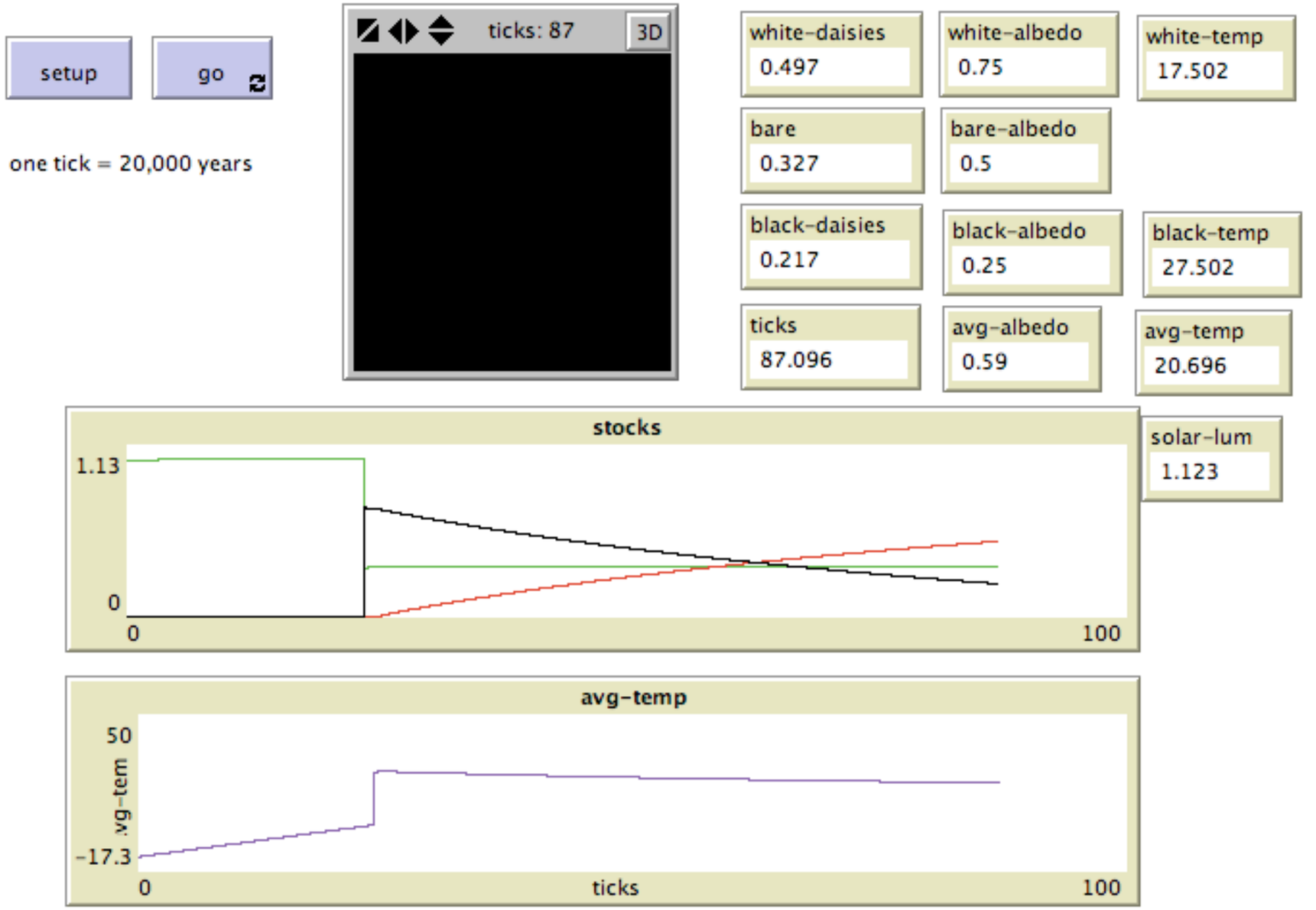
CDS Link



A Node, SD Style



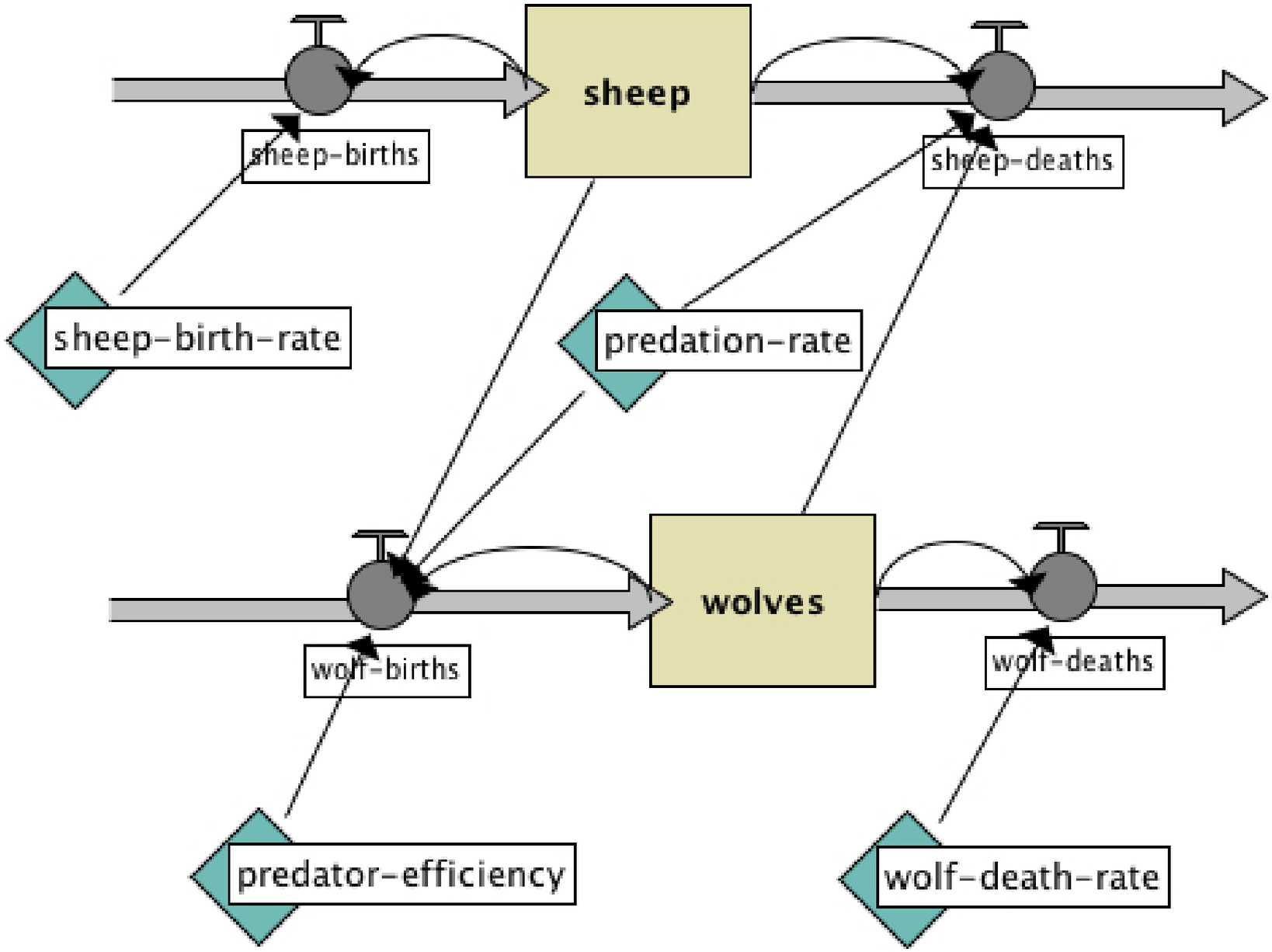
Daisyworld Diagram System Dynamics



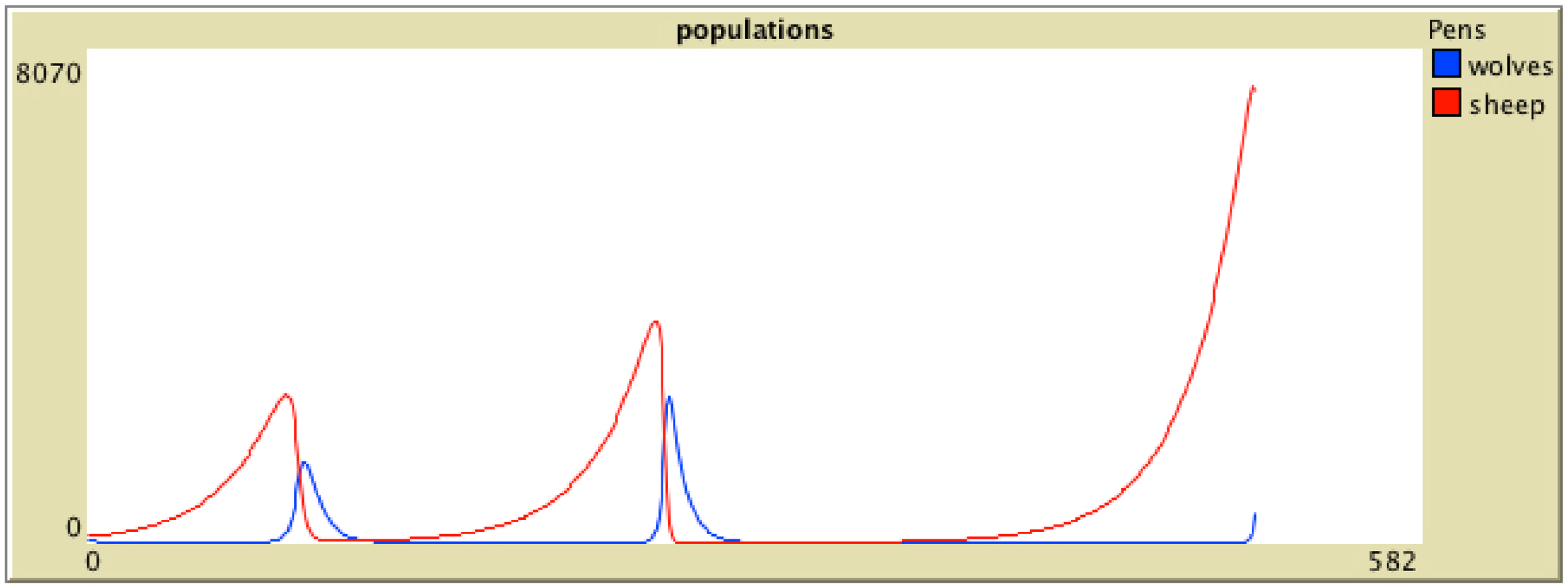
Daisyworld NetLogo GUI

Grade 3:
Hunting Band

Wolf-Sheep
Predator-Prey



NetLogo SD Model



Periodic Attractor

Homework #3 (do 1)

- Adapt the Daisyworld model:
  www.vismath.org/research/gaia/
  to a system from Grade 2.
  (Adapt means -- interpret the nodes and links.)

- Adapt the NetLogo Wolf-Sheep model to a system from Grade 3.

- Adapt the NetLogo Rabbits-Grass-Weeds model to a system from Grade 4.

End of Lecture Three of Ten