# Learning and Teaching System Dynamics Modeling A 20 Year Journey

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# Before 1990

## A typical Modeling Exercise: Modeling Human Growth

**THE QUESTION**

What type of growth pattern is exhibited in the early years (pre-adult) of an average person?

| Age (years) | Weight (pounds) |
|---|---|
| 1 | 21.6 |
| 2 | 27.2 |
| 3 | 31.9 |
| 4 | 36.4 |
| 5 | 40.0 |
| 6 | 45.9 |
| 7 | 51.4 |
| 8 | 57.3 |
| 9 | 62.1 |
| 10 | 68.3 |

**Analysis:**

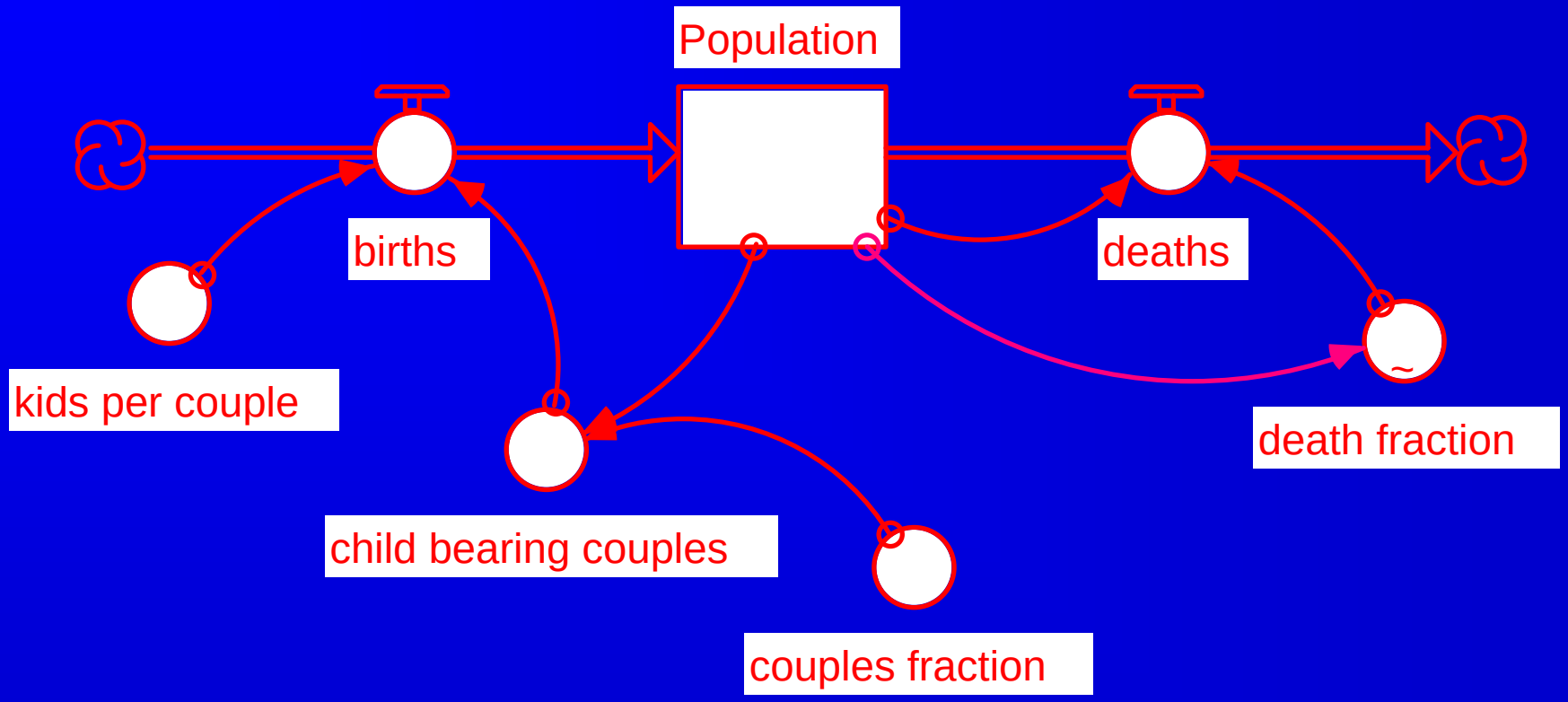
1.Write the equation :

_____

2. a. Use your model to predict the child's weight at 5.5 years and at 50 years.

b. How confident are you in your answers?

# 1990 NCCE Workshop




Analysis:

1. What is happening to the death rate over time? The population?
2. What are some of the limitations of this model?

# Getting Off the Ground

- Purchased STELLA, started experimenting in programming and in advanced algebra classes.
- Wrote 2 in-district grants (one in 1990, other in 1991)
- STACY$^{N}$ Project at Stanford (1991)
- Meet Ed Gallaher (1991)
- Systems Thinking in Education Conference (Tucson, March 1992)
- Franklin High School starts full year modeling class
- Write NSF CC-STATDUS grant (awarded May 1993)

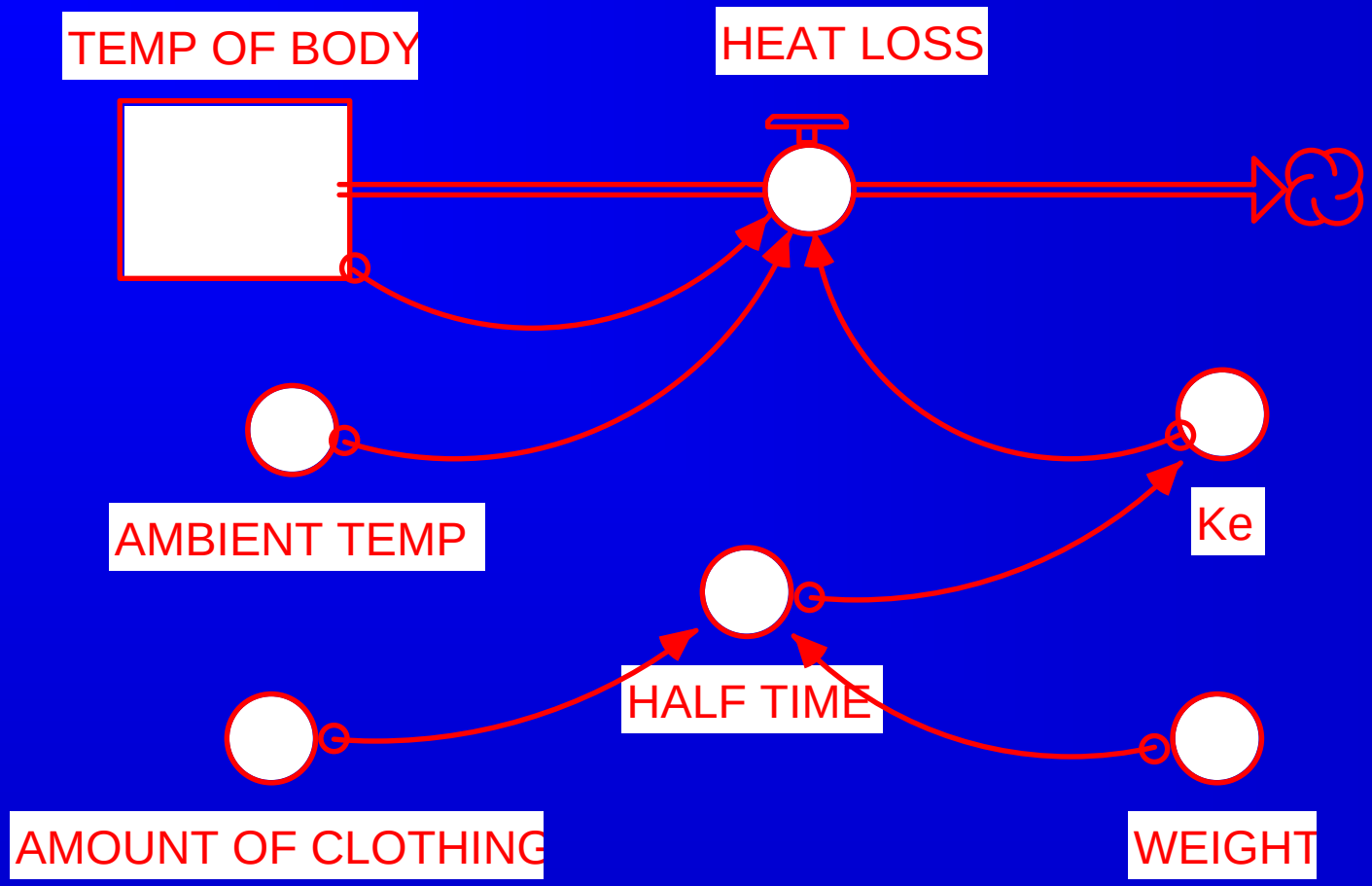
# Focus on Building Models

"Old mental models and decision habits are deeply ingrained; they do not change just because of a logical argument." JF

**"Coming to an understanding of systems must be a participative experience. Computer modeling allows an accelerated vicarious experience. …immersion in such active learning can change mental models."**
**Jay Forrester**

# Early Models

## Student Model #1 (1993)



# Early Models

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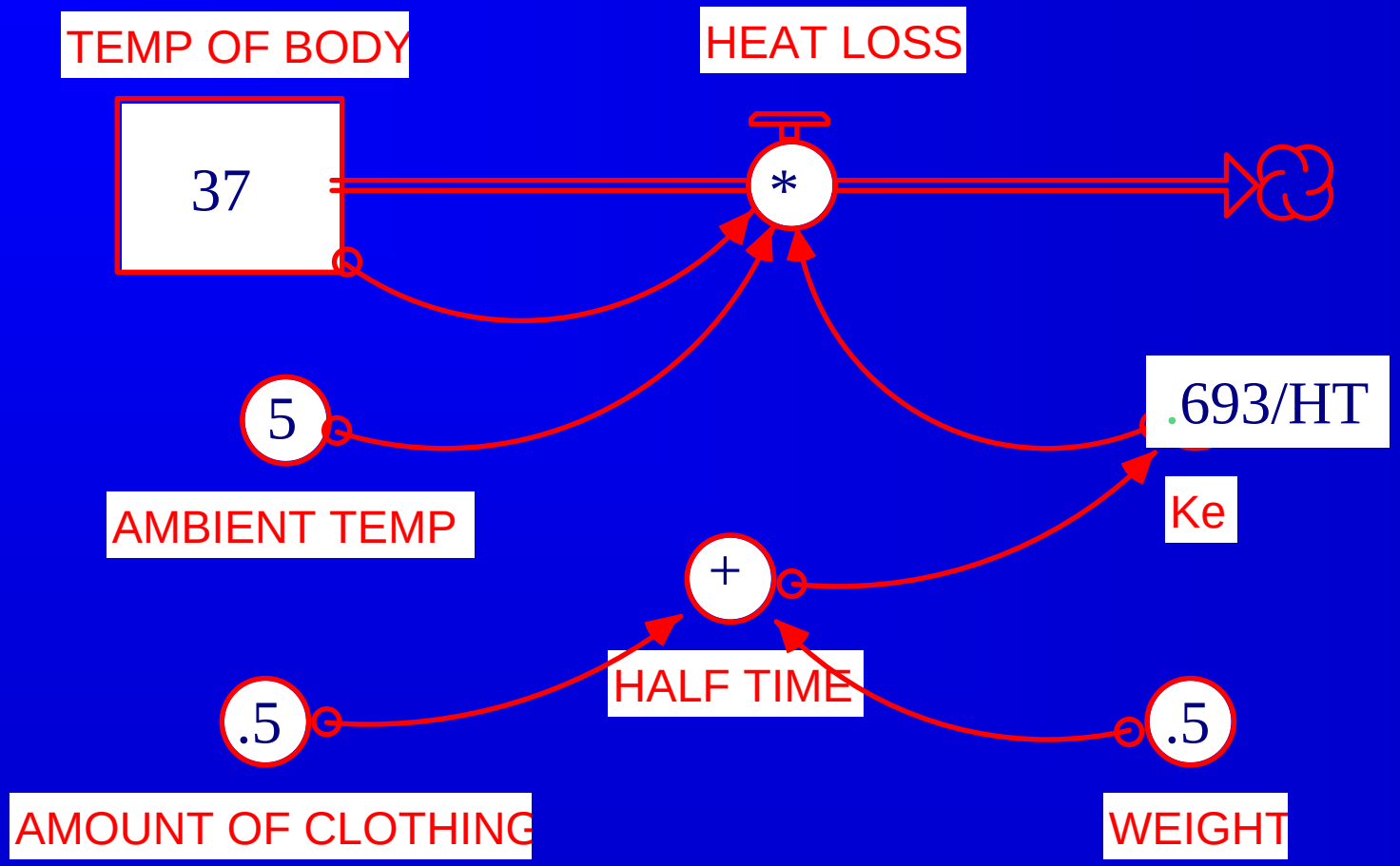
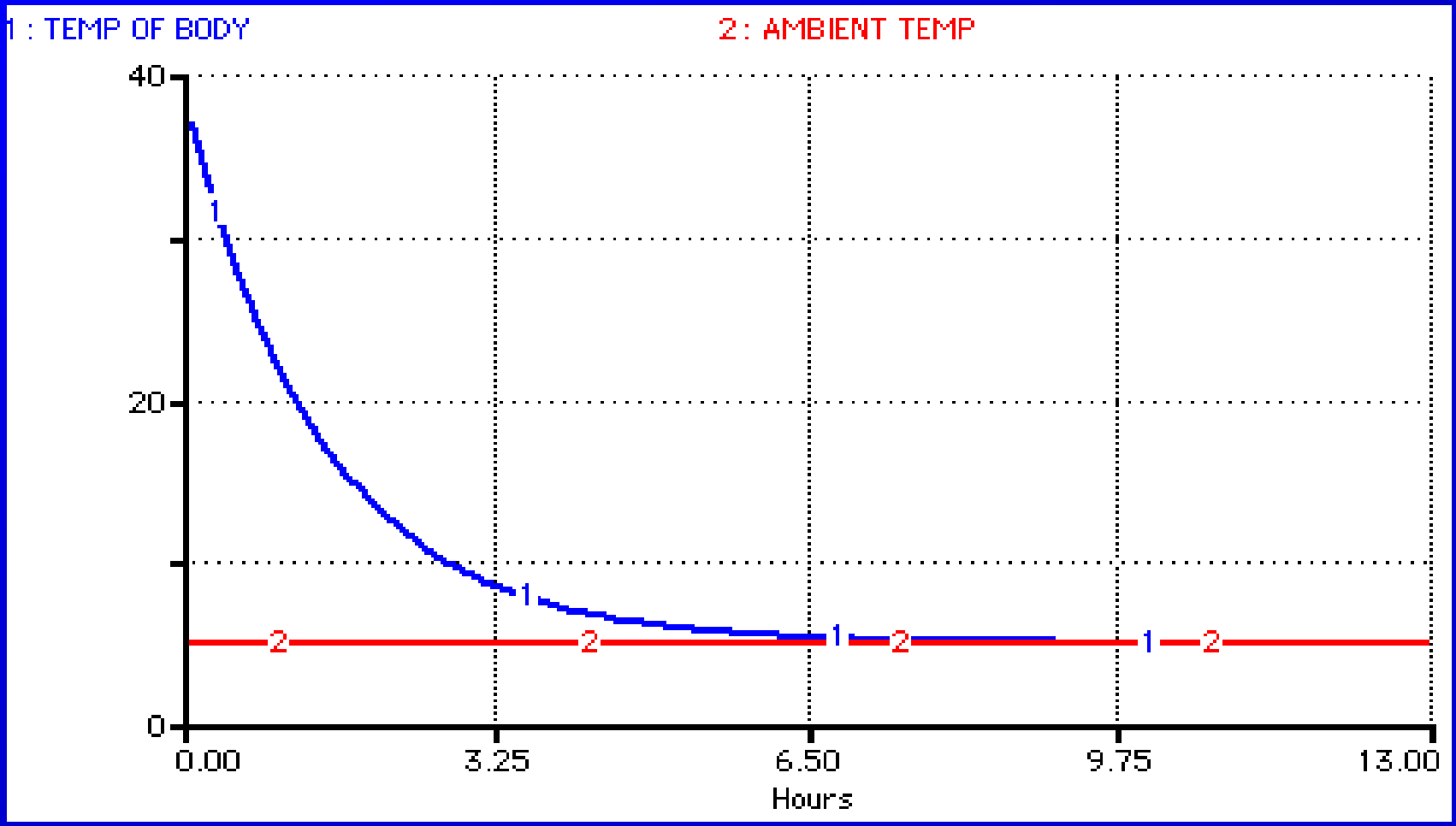


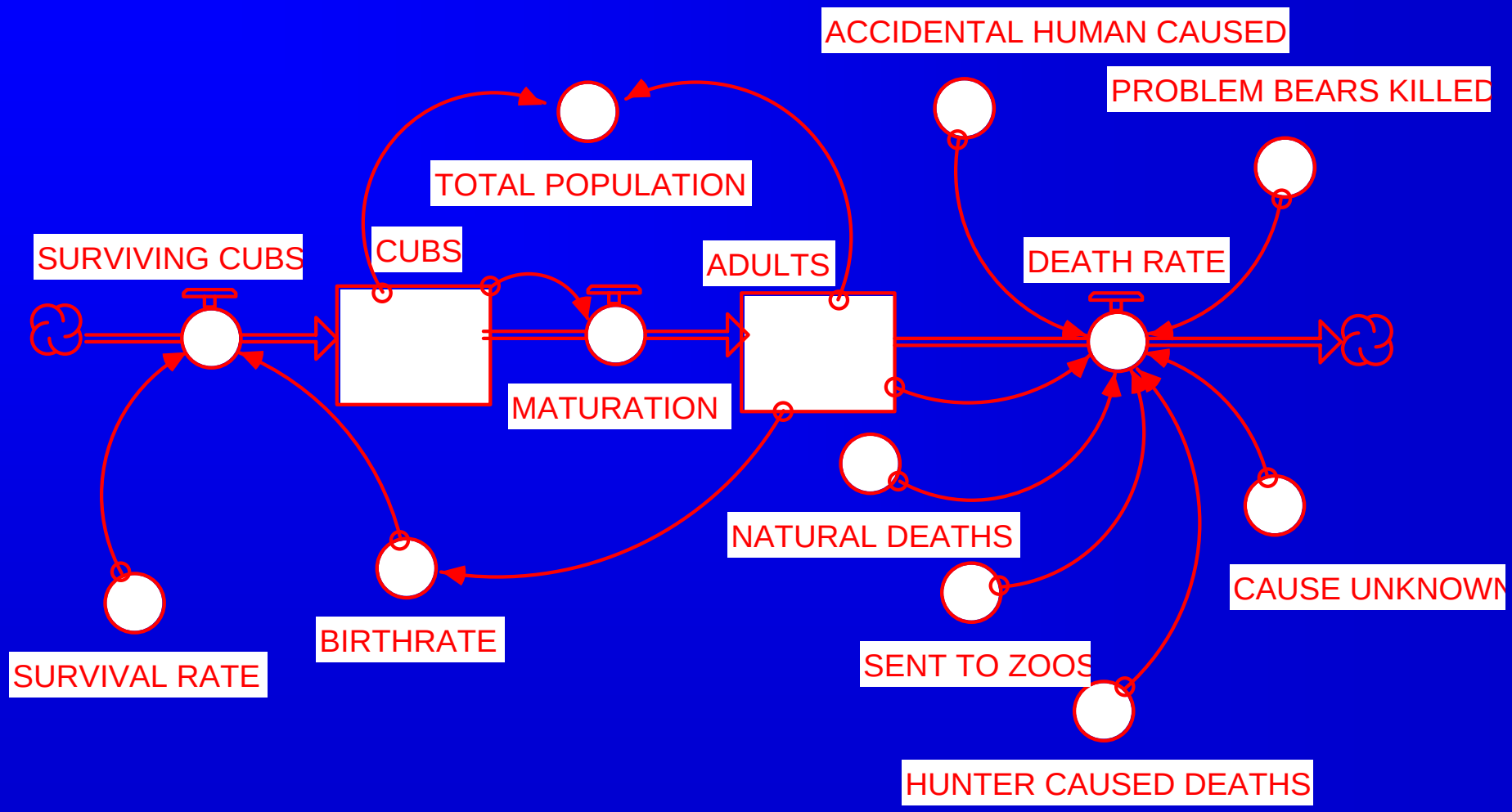

Documentation, but no paper.

Very simple model.
Problem with units.

# Early Models Student Model #1 (1993)



# Student model #2 (1993)



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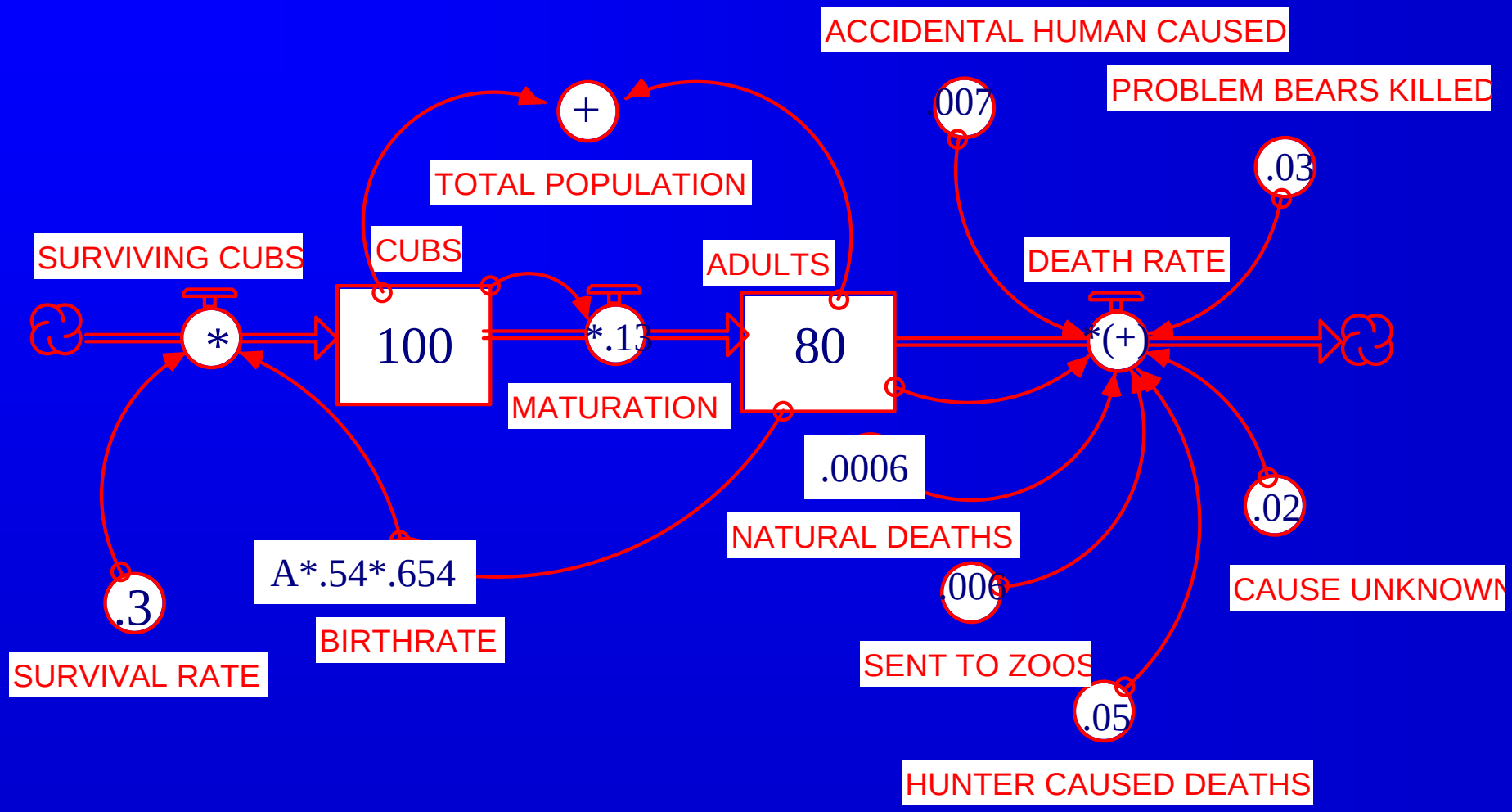
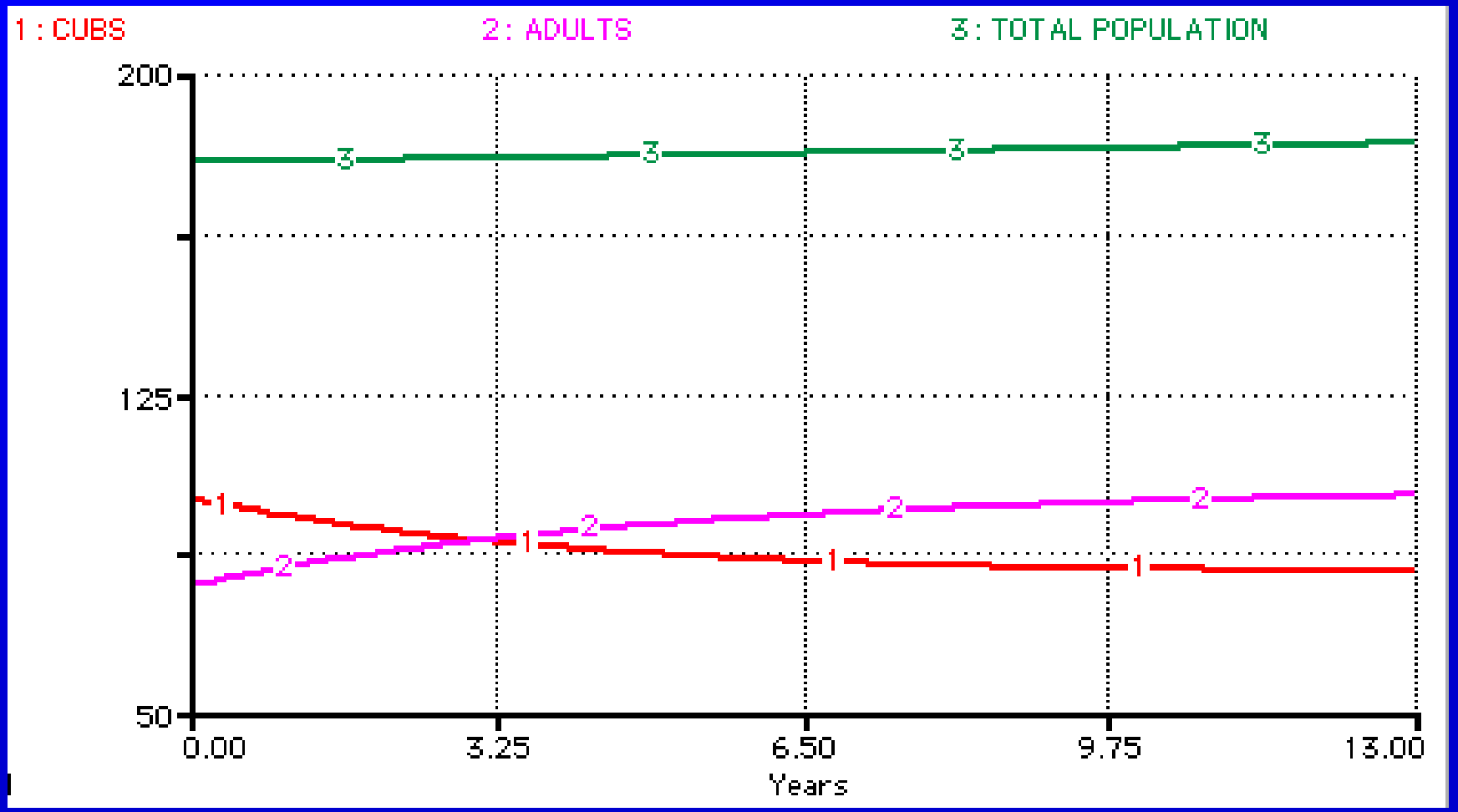
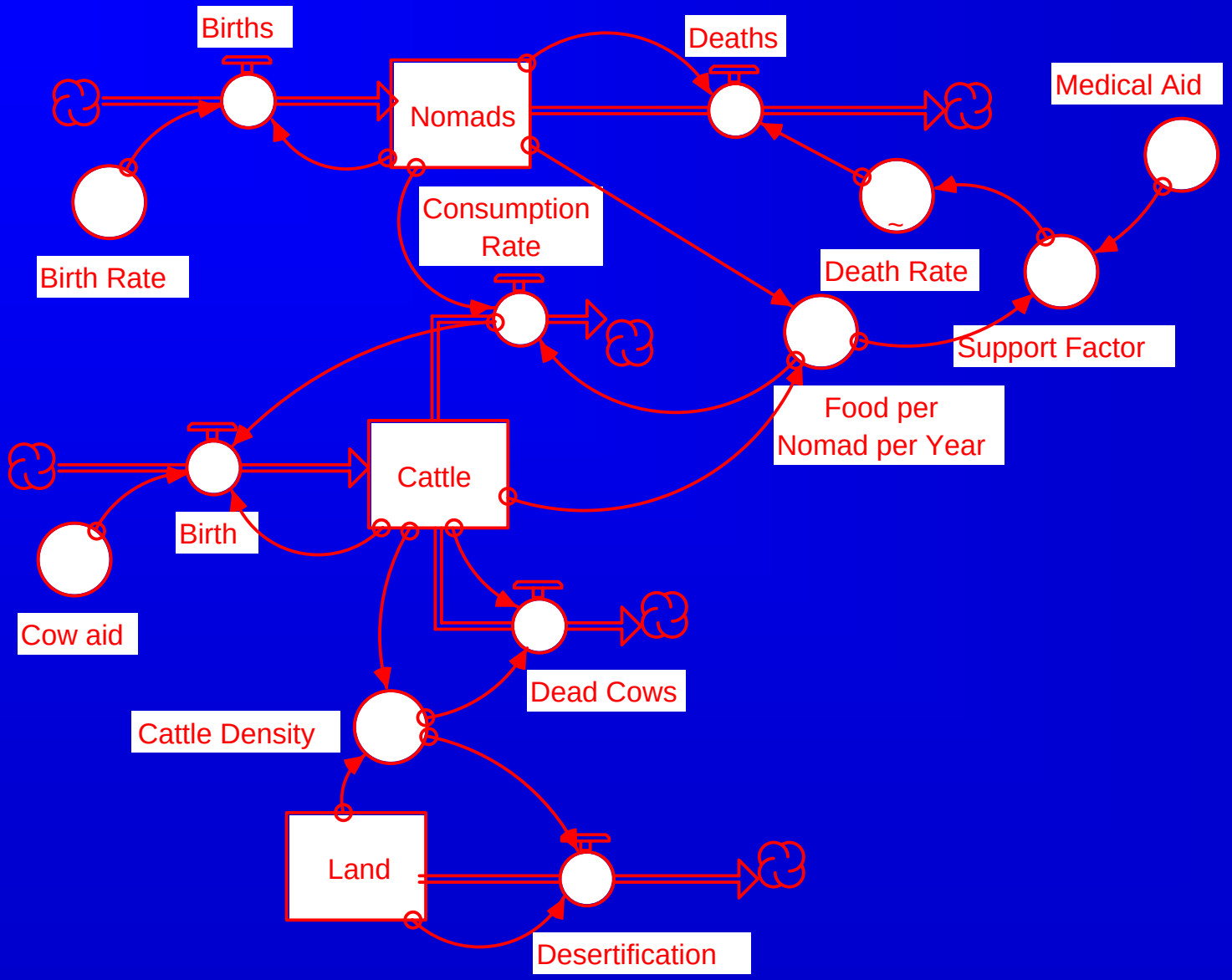



Dead buffalo syndrome.

# Student model #2 (1993)



# Teacher group model (NSF Grant 1993)



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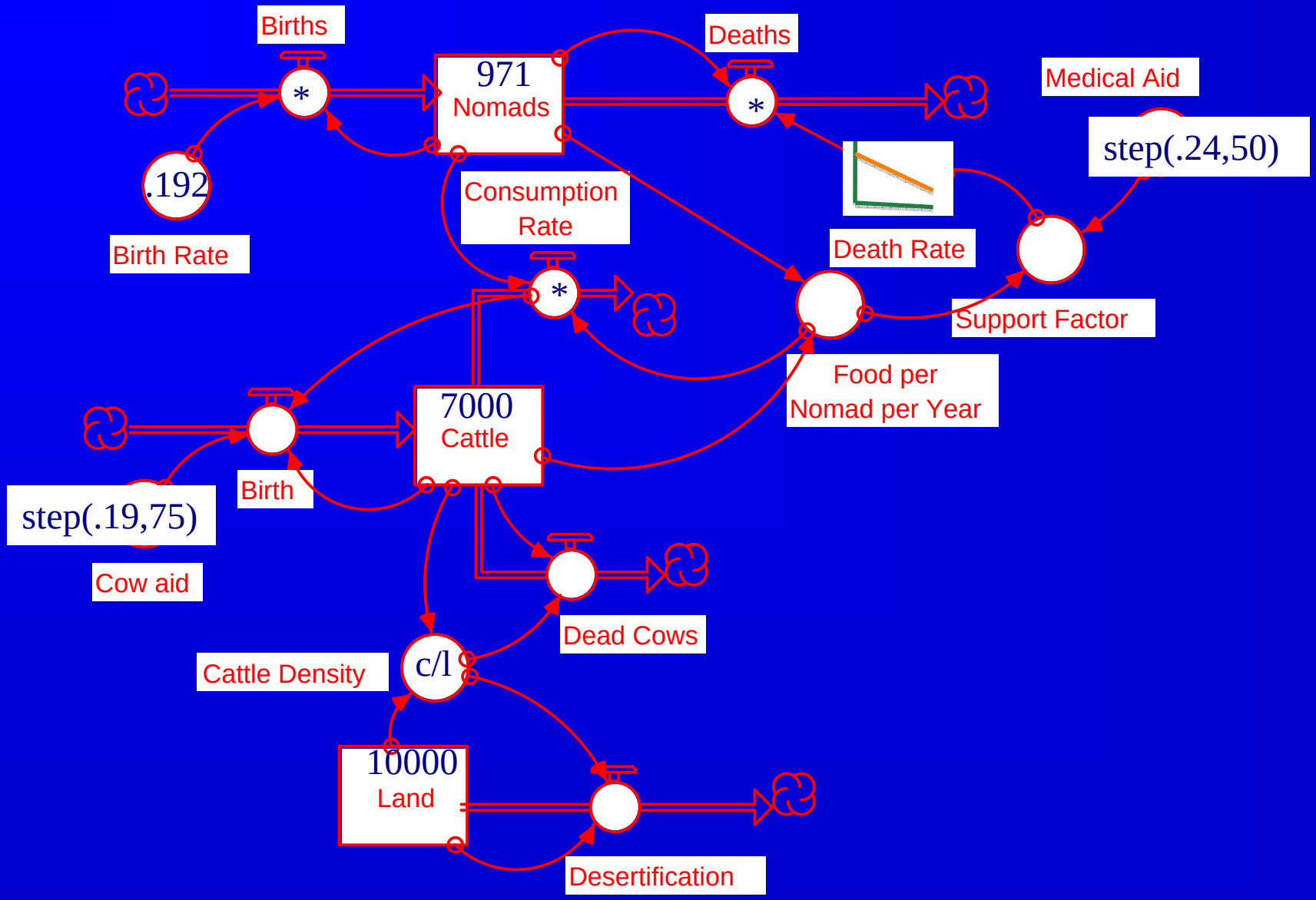

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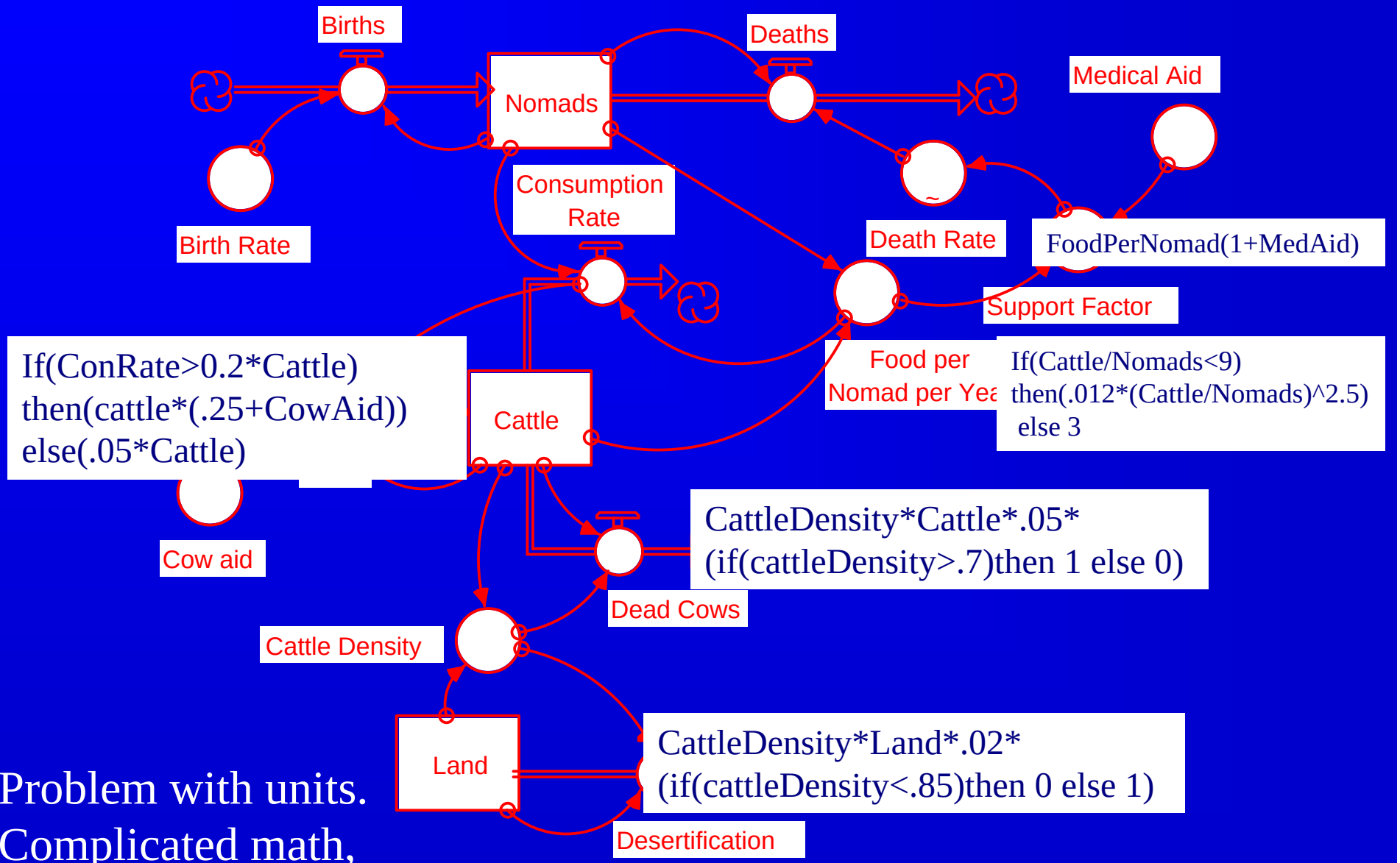



Problem with units.
Complicated math, hidden.

# Help From Our Friends

- **Steve Peterson** – NSF grant speaker & mentor
  - "It's not about the numbers."
- **George Richardson** – Workshops for core team
  - Dimensionless multiplier, SD process, …
- **Barry Richmond** – Workshops for core team
  - Models of non-physical processes, students share learning
- Regular attendance at ISDC (starting 1994)
  - Observing SD professionals & making connections

# How We Learned

- Time to meet & talk – core NSF training team
  - Cross-discipline, some rotating members.
  - Ed Gallaher, Tim Joy, Wayne Wakeland
    - SyM*Bowl -> SyM*Fest
    - Outline for a modeling paper
- Regular attendance at CLE K-12 ST/SD Conference
  - Sharing ideas
  - Teaching each other

# SyM*Fest

- Barry Richmond increases involvement
  - Reads some student papers
  - Presents to students
  - Software & T-shirts
  - Trains teachers
    - System

      Citizen

# SYST&MS Project

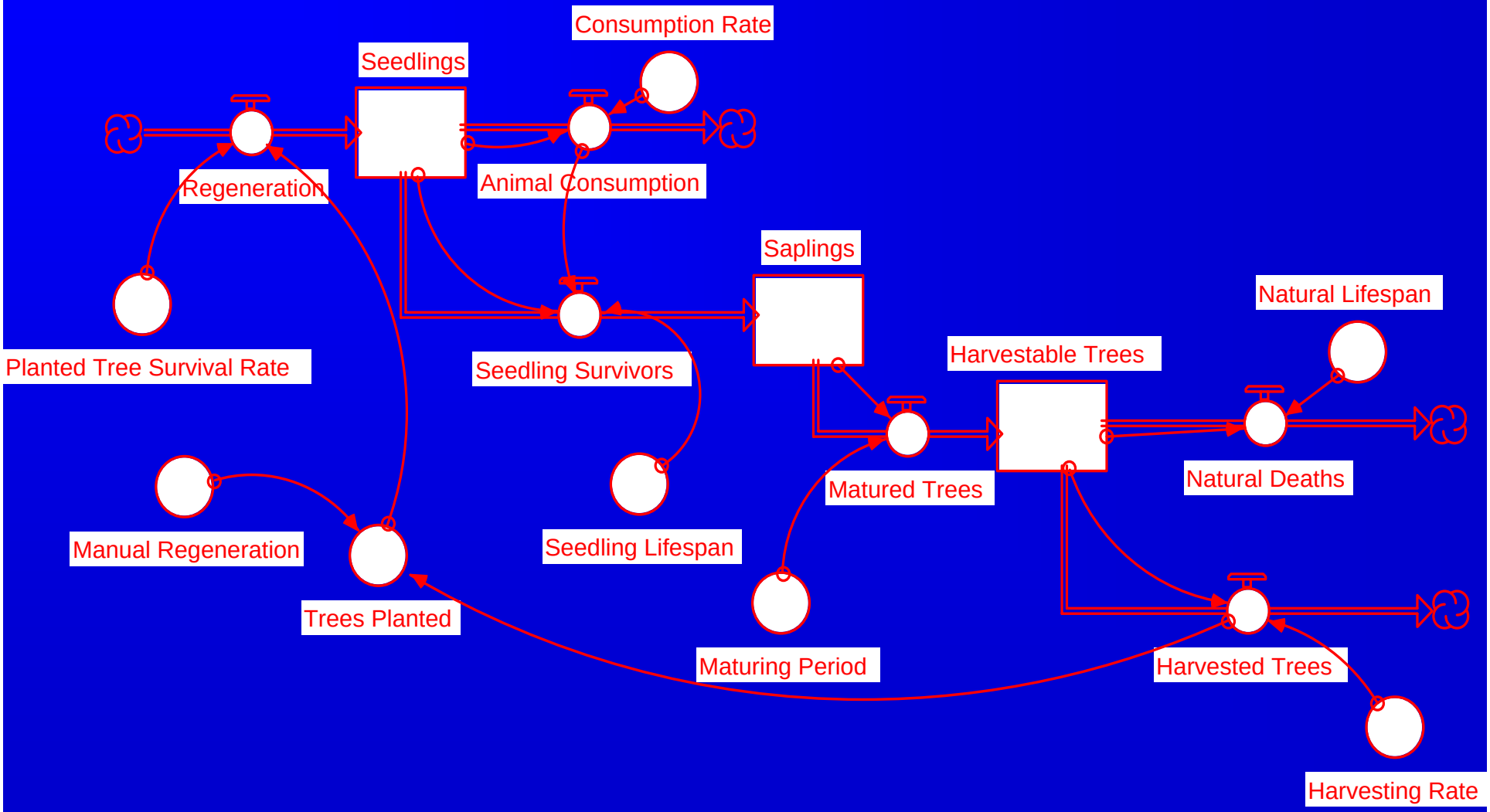
- Receive Intel ***Innovation in Teaching*** Award/Grant (1996)
  - Start SYST&MS Project
    - Attract upper level students to Franklin High School
  - Expand number of modeling classes
    - 3 first year classes, 1 second year class
    - Increase number of modeling teachers to three

# NSF CC-SUSTAIN Project

- NSF CC-SUSTAIN grant awarded (1997)
  - Expand teacher SD training to other parts of US
    - Include some middle school teachers
    - Release time (1/2 time) to administer grant
- Obstacles
    - Lack of comprehensive curriculum
    - Teachers need support after the workshop, but very difficult to support remote locations

# Models Improve

## Student Model (1999)



# Models Improve

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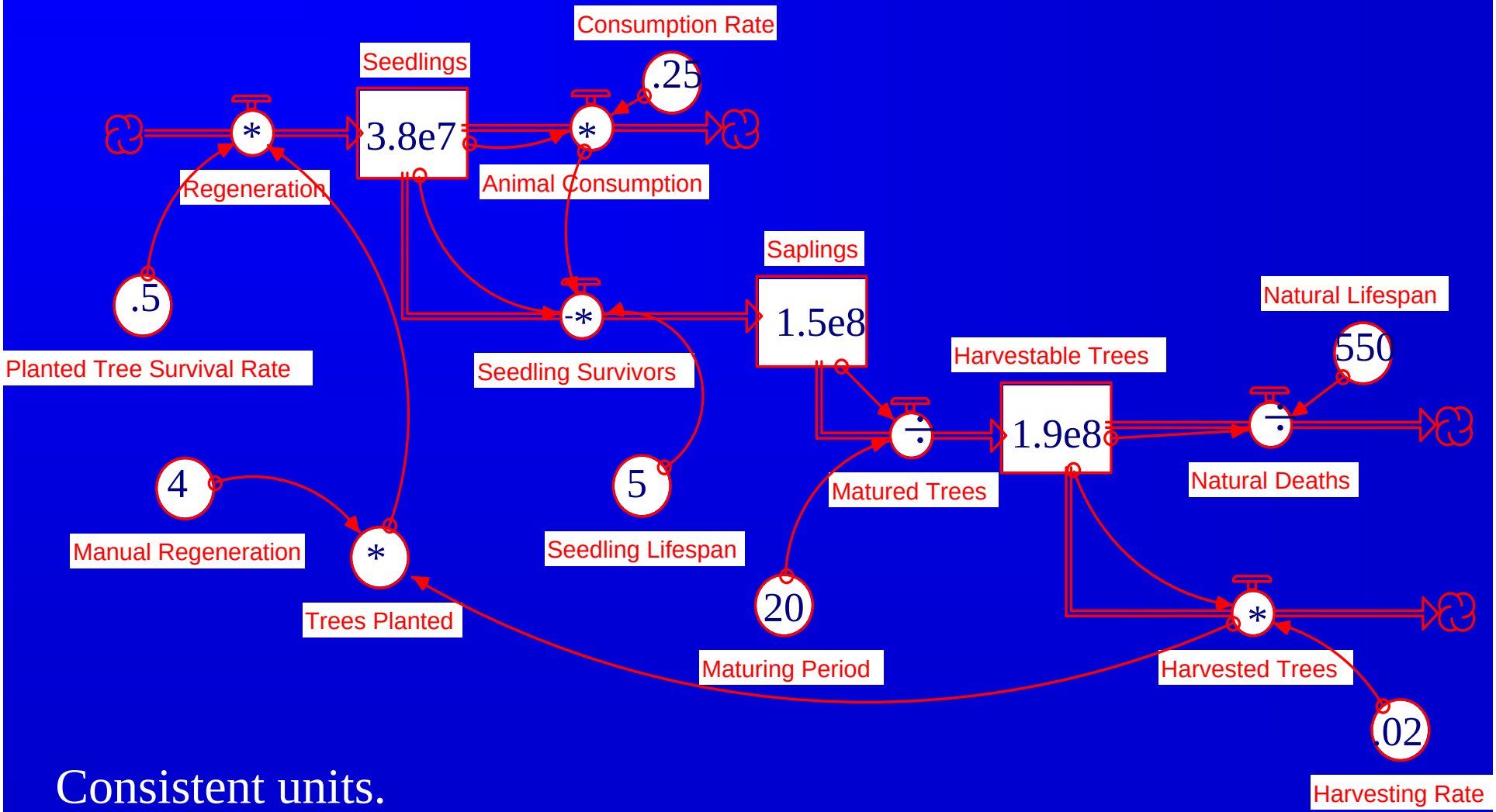



Consistent units.

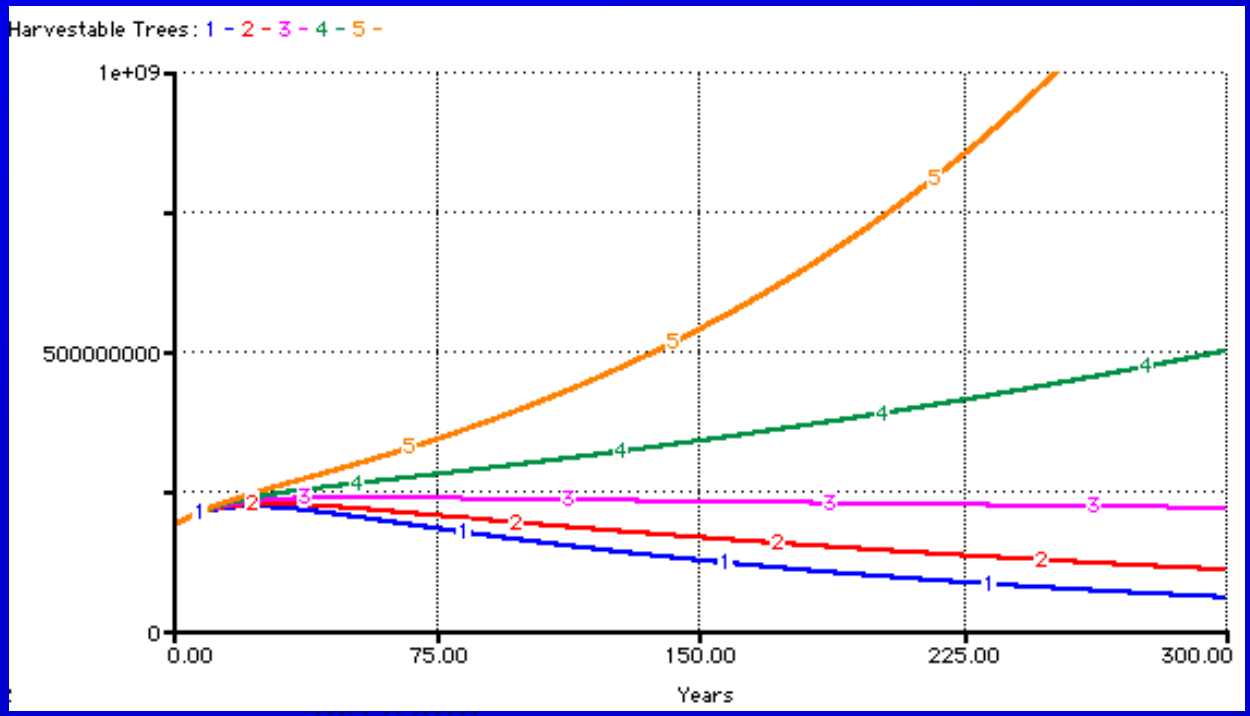
Surprising leverage pt.

# Models Improve Student Model (1999)

Out of all the tested variables, animal consumption proved to be the most viable leverage point. According to our results, efforts to reduce animal consumption could be the most important action taken to save forests, even more important than lowering harvest rates.

Animal consumption

0.25 -> 0.05



# Student Reflection Franklin High School (1999)

# Move to Wilson High School

- Two SD teachers move from Franklin to Wilson High School
  - Two SD teachers remain at Franklin but do not want to continue the effort to recruit students
  - SYST&MS Project dies at Franklin after one more year
- Wilson High School
  - Teaching SD and programming during the same class period, until 2008.
  - New hire continues SD modeling class.

# SD Learning Continues

- Delays, Journals and auto-check Unit Consistency
  - Help from Debra Lyneis

# A quote from a student journal

"China's one child policy… was introduced to combat overpopulation, but… the policy has led to selective abortions …which leads to gender imbalanced generation… There are also not enough young people to sustain and support the economy built by a burgeoning population. This … could impact economic growth and China's position as an emerging power. In addition, there will likely be issues as a generation without siblings … comes of age. "

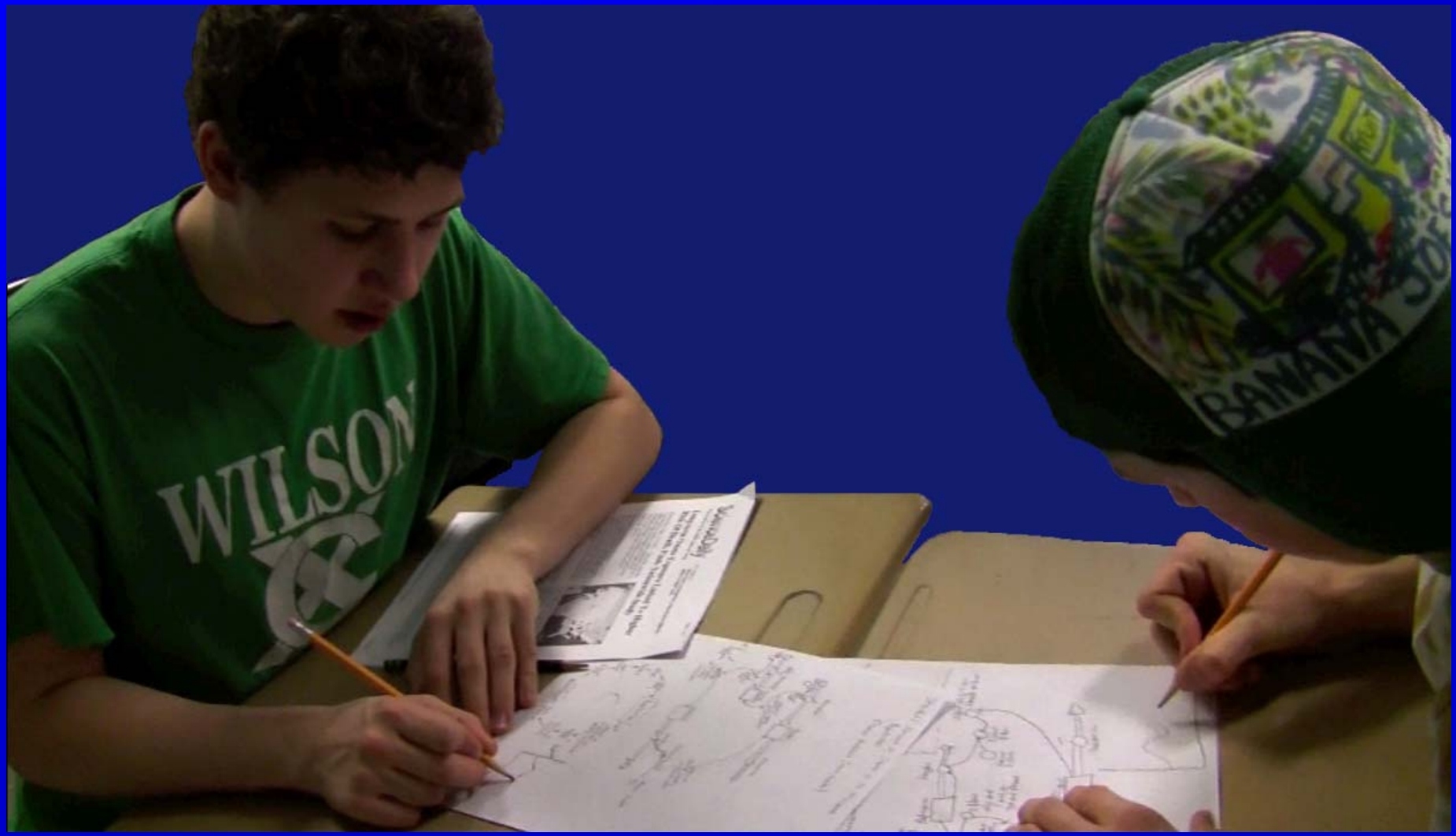
Kate L. (age 15)

# SD Learning Continues

- Delays, Journals, auto-check Unit Consistency
  - Help from Debra Lyneis
- Take WPI System Dynamics classes
- Oscillations, segment dynamic hypothesis, start model in equilibrium, extreme value testing, systematic parameter testing, policy testing required

# Student Thinking Improves

Systems in the news



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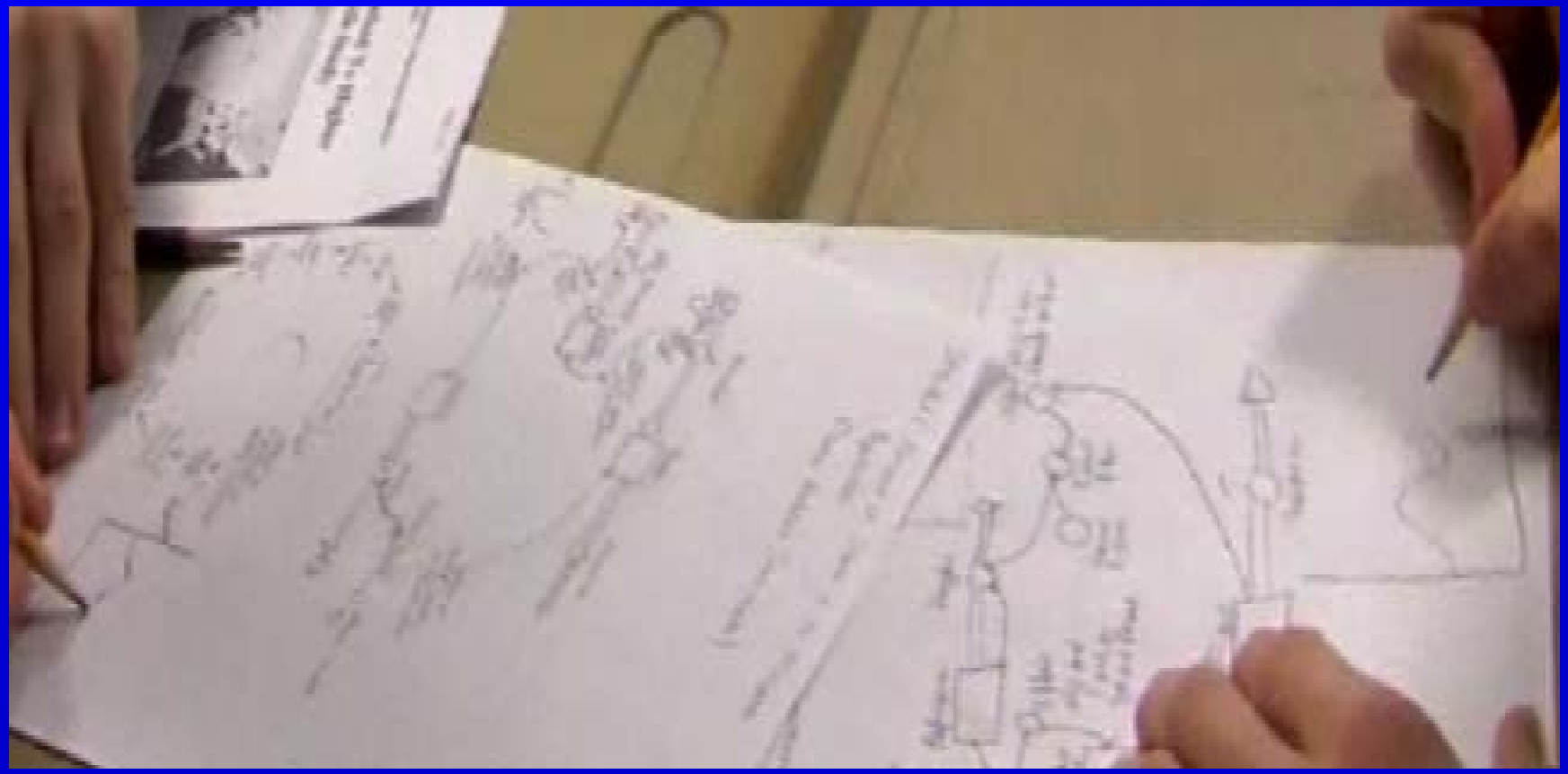
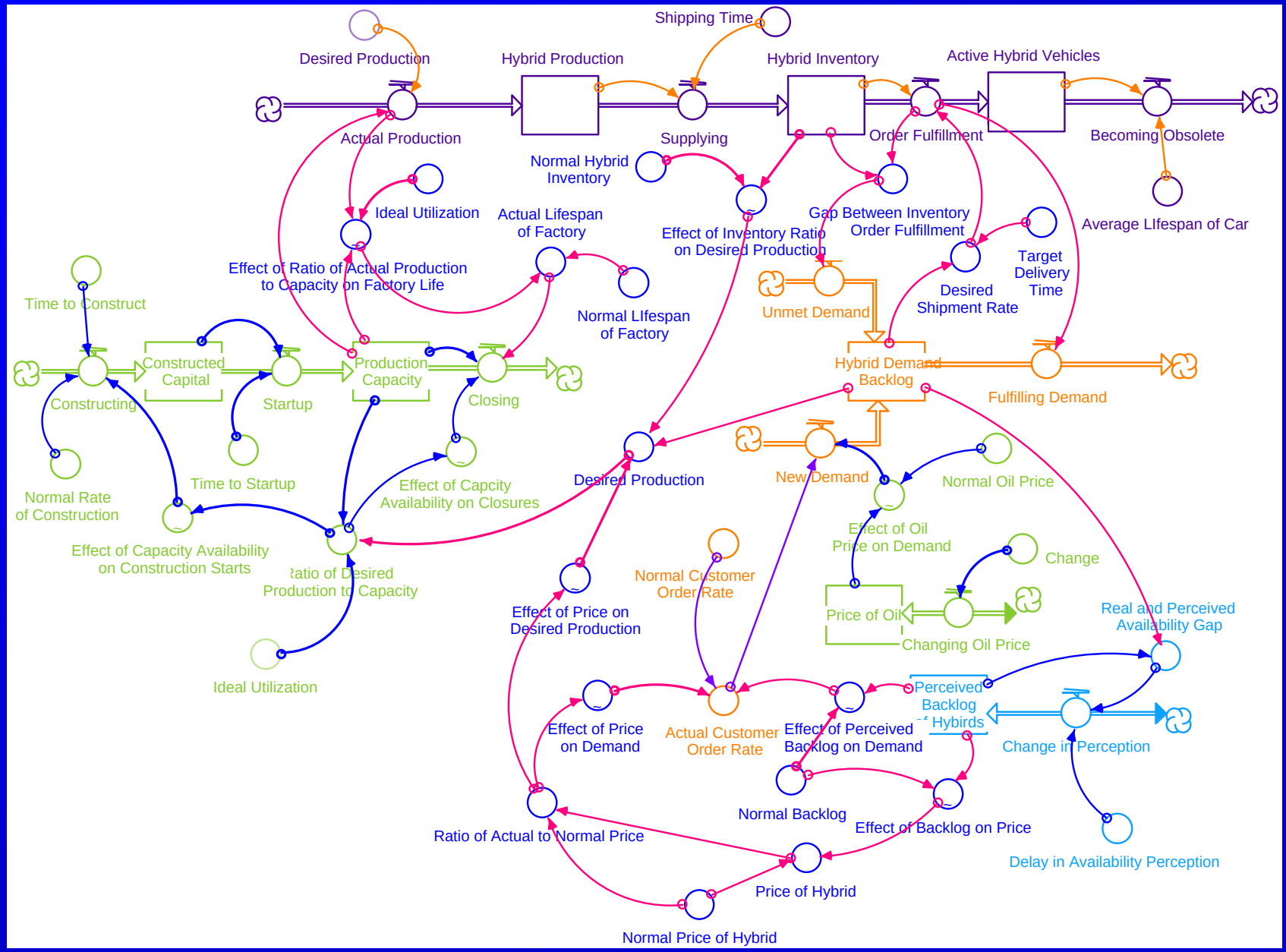


# Student Models Continue to Improve

# Hybrid Cars Student Model (2007)



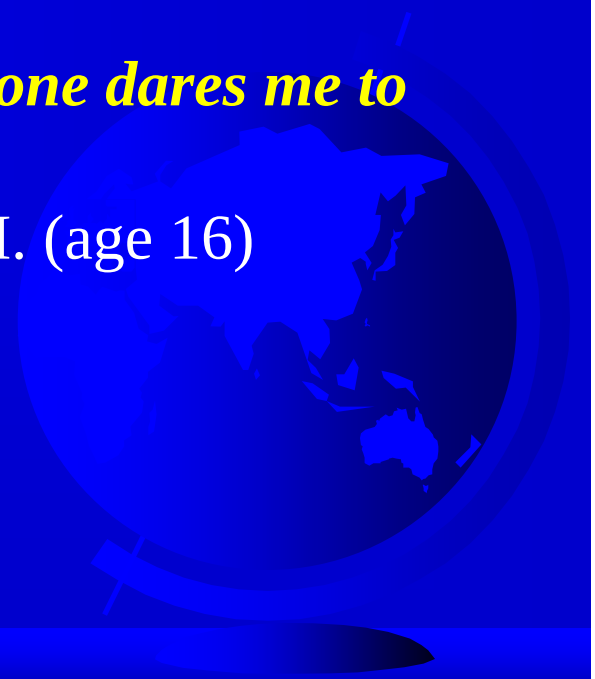
# Student Presentation – Joseph Kibe

# Student Reflection

"In other classes, I am often asked to posit logical solutions to problems or am given the solutions reached by other people. Using models of complex systems I can test out my own theories and confirm those of others instead of faithfully accepting them as fact.

***Where other classes ask me to memorize, this one dares me to explore.***"

Tommy H. (age 16)



# Students Care About Local and World Problems

How do breaches affect airport security?

How Can We Improve the Blood Donation Process in the United States?

How Devastating Is An Invasive Species?

How Can the United State's Social Security Program Be Sustained?

What Could Bird Flu do to a Human Population?

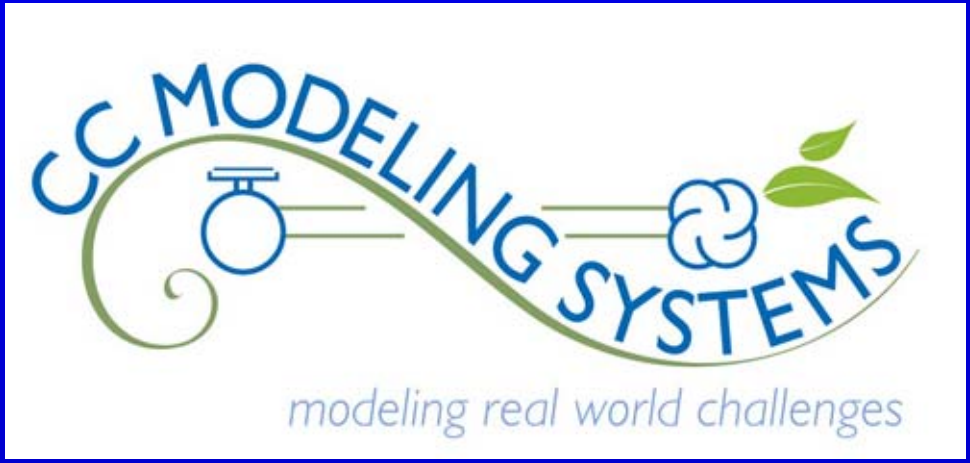
How Much do Carbon Emissions Need to be Reduced in Order to Stop Global Warming?

How Does Colony Collapse Disorder Affect the Almond Industry?

Does Having More Children Keep People Poor?

# CC Modeling Systems

- View Student Work
  - model diagram, paper, video presentation
- Link System Dynamics to National Education Standards
- Resources and Research

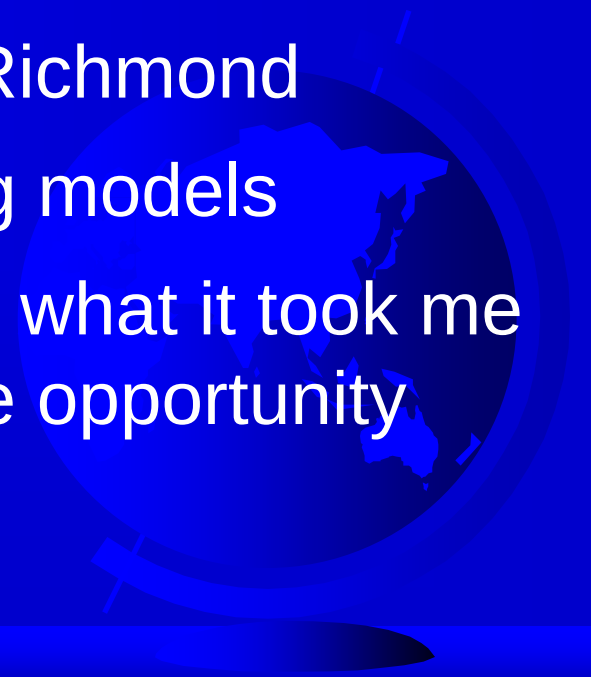


# Lessons Learned

- Start somewhere ST …….. SD
- “Always work toward a simulate-able model”

  George Richardson
- Work in a group, if possible
- “Make the learning available to others”

  Barry Richmond
- Learn the correct method for building models
- Teachers can learn now in 9 months what it took me 20 years to learn - but they need the opportunity



# Lessons Learned

- **Kids can do this.  They will amaze you!**
- **Your children deserve to learn this in school**

**Only you can make that happen**

- We need the help of **Parents** and the **informed public** to **promote the inclusion of ST/SD in schools** to make this happen.

It will not happen from within the schools

# Modeling Dynamic Feedback Systems:
## *A Different Way to Think*

***"We cannot solve our problems with the same thinking we used when we created them."*** *— Albert Einstein*

# Thank You