Learning by Doing

A Path to Creating Original Modeling Projects

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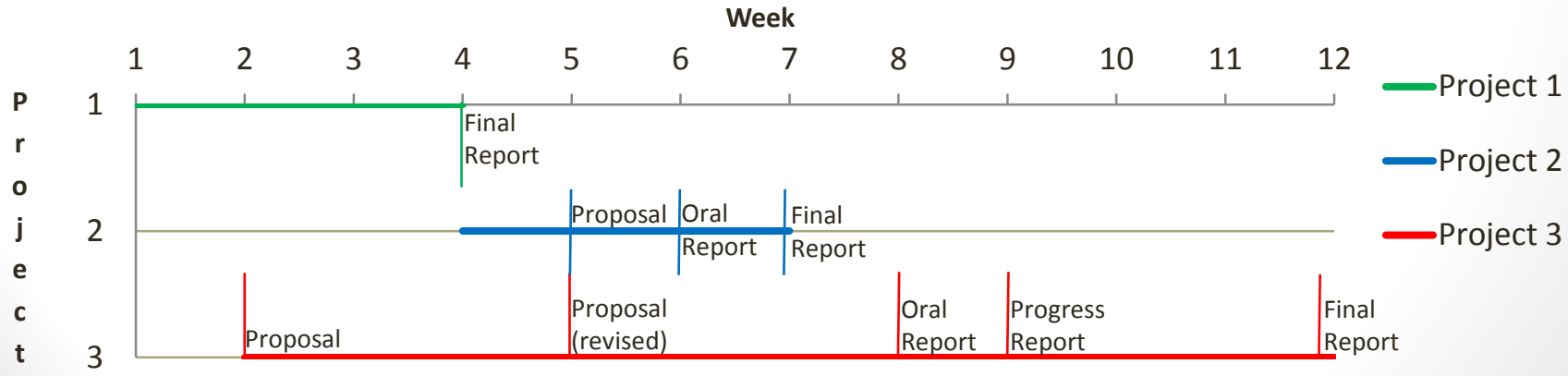
Overview

- The best way to learn system dynamics thinking and modeling is by "doing" it through hands-on learning:
  - Project 1 – Modelling the Kaibab Plateau
  - Project 2 – Replicating classic or instructional models
  - Project 3 – Developing an original modeling project



Methodology

- Emphasis on practicing model building towards producing an original modeling project

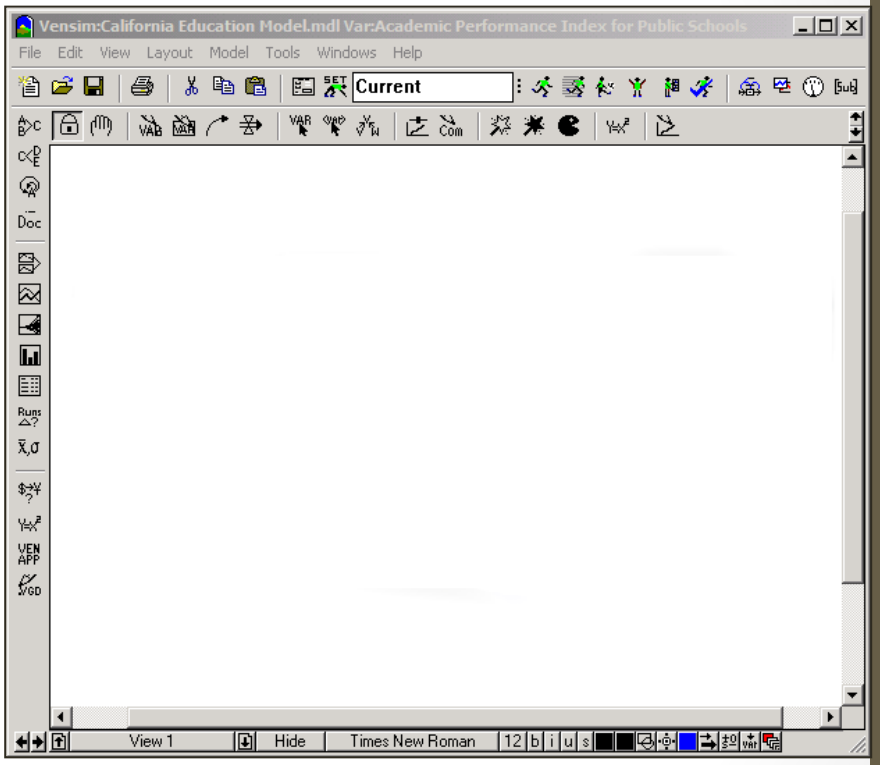
- Students are guided through the following progression
  - Kaibab Plateau model – Understand the scenario and develop the model
  - Replication model – Understand and develop classic or instructional system dynamics models
  - Original model – Develop a model based on a self-selected problem

- Project progression (for the replication and original modeling projects)
  1. Conceive a project
  2. Submit a written proposal
  3. Present the proposal orally
  4. Present a progress report orally
  5. Present a final oral and written report

- Learn by
  - Doing – Student volunteers use the software in class
  - Practicing – Students are provided with tutorial videos via Camtasia
  - Experimentation – Students self-learn through trial and error

Using Vensim

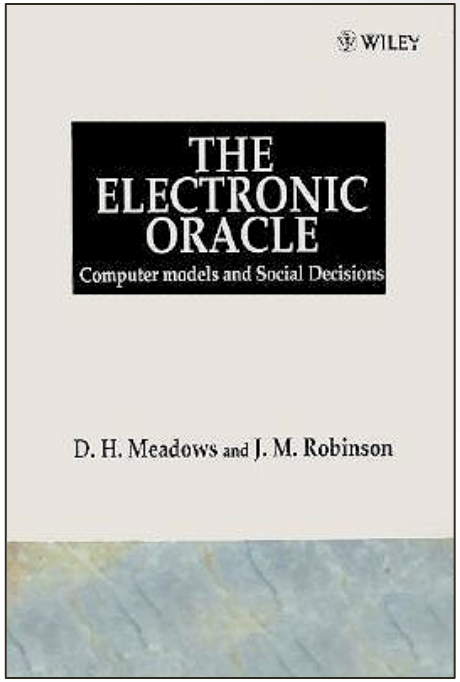
- Vensim PLE is the software tool used for modeling
- Vensim manuals are used to self-learn
  - Instructor comments are provided as supplements
- Vensim models and model documentation are used for replication
- Focus
  - Mastering Vensim is not the focus of the class; Vensim is a tool to learn and practice system dynamics modeling
  - Developing skills in crafting and presenting projects is the focus

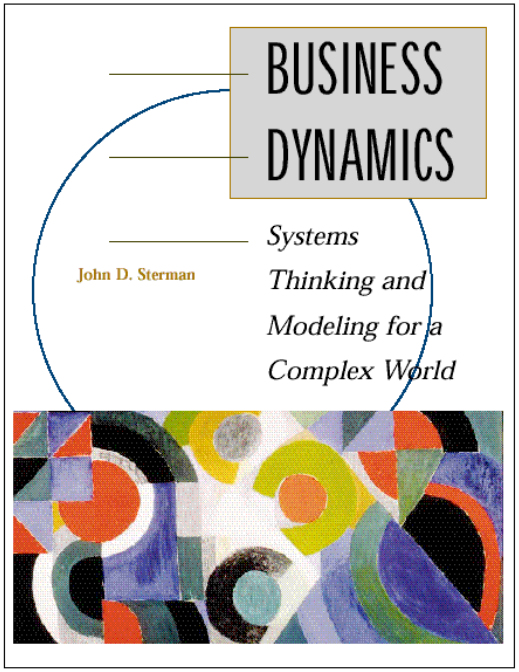


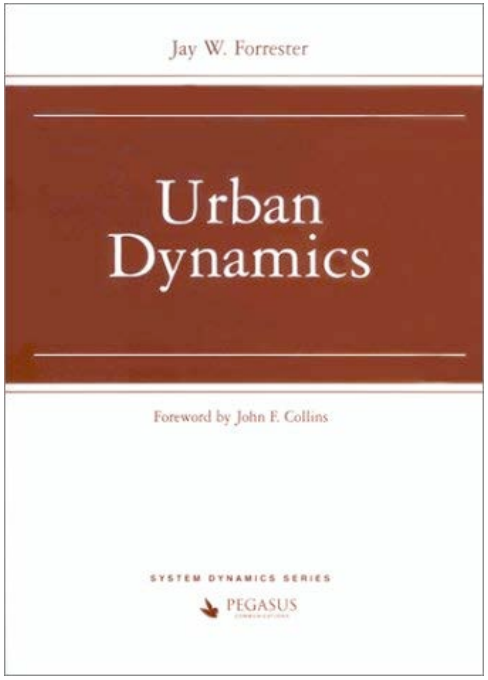
Texts

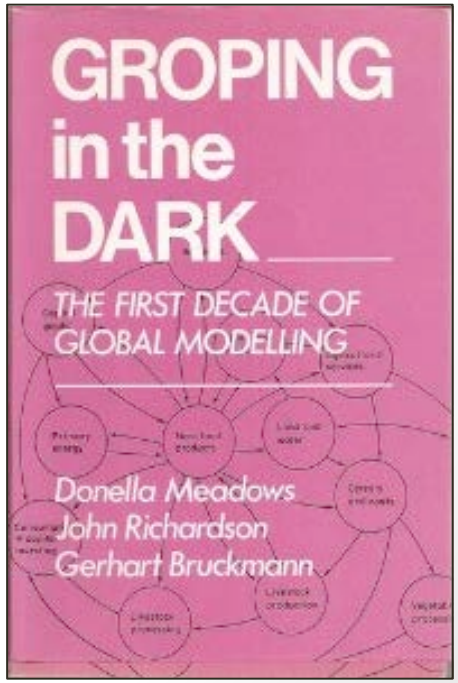
This is a practice course, not a reading one, but readings supplement and provide context for the modeling practice

- Vensim – Vensim manuals









Kaibab Plateau Modeling Exercise

- Goal
  - Develop a common technical language for the class using a model that is simple and "concrete"
- Timeframe
  - Three weeks (6-9 hours in class) from first lesson to final project submission
- Purpose
  - Not to build the model correctly, but to understand why the model is constructed the way it is

Source: http://www.fs.fed.us/wildflowers/regions/southwestern/KaibabPlateau/images/kaibab_plateau_map_lg.gif

Kaibab Plateau Modeling Exercise

- Methodology
  - Sector-by-sector model construction, with each sector building on the previous
    - Deer
      - Population
    - Lions
      - Population with predation added
    - Food
      - Growth with consumption and regeneration added
  - Model is constructed in class
  - Completed model sectors are provided as a ‘check’ for students

Kaibab Plateau Modeling Exercise

- Reference Mode

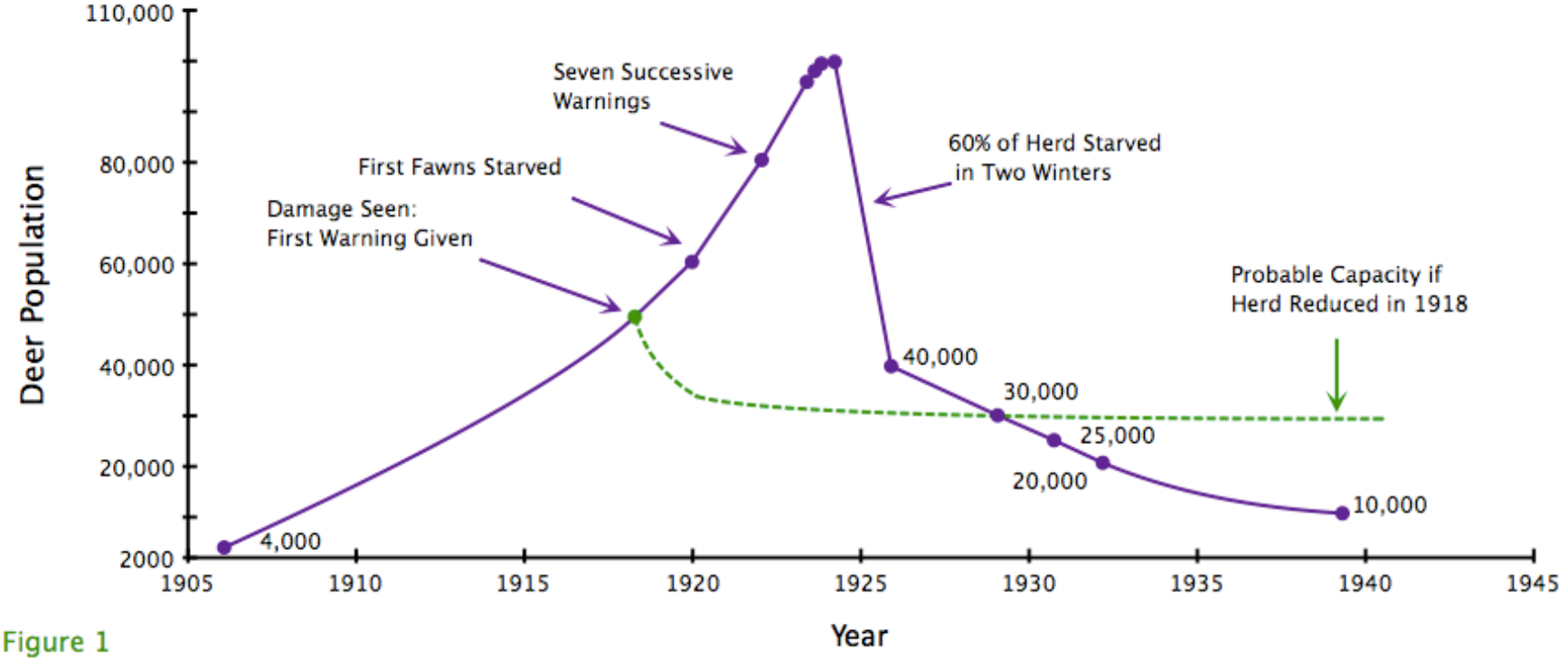
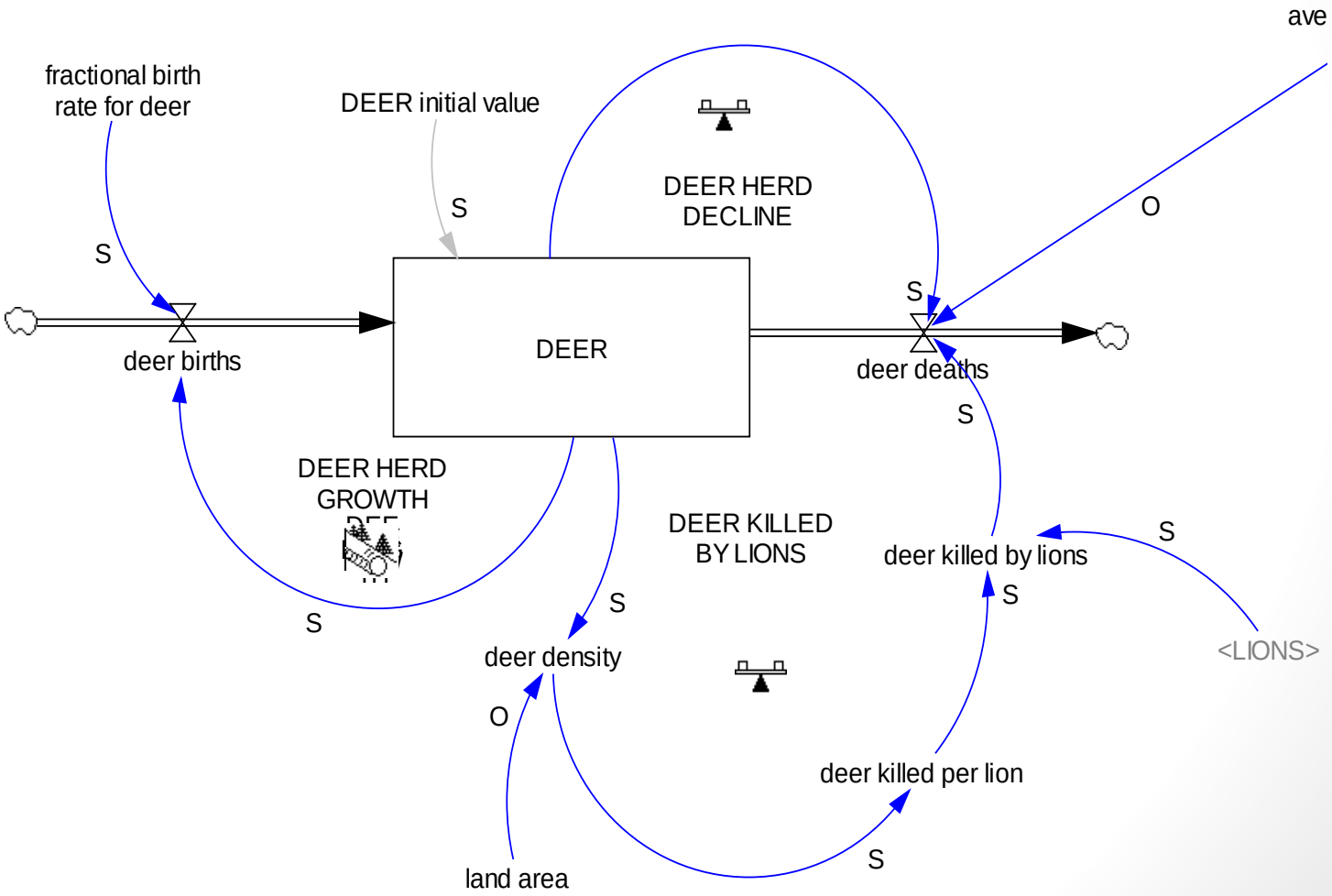


Figure 1

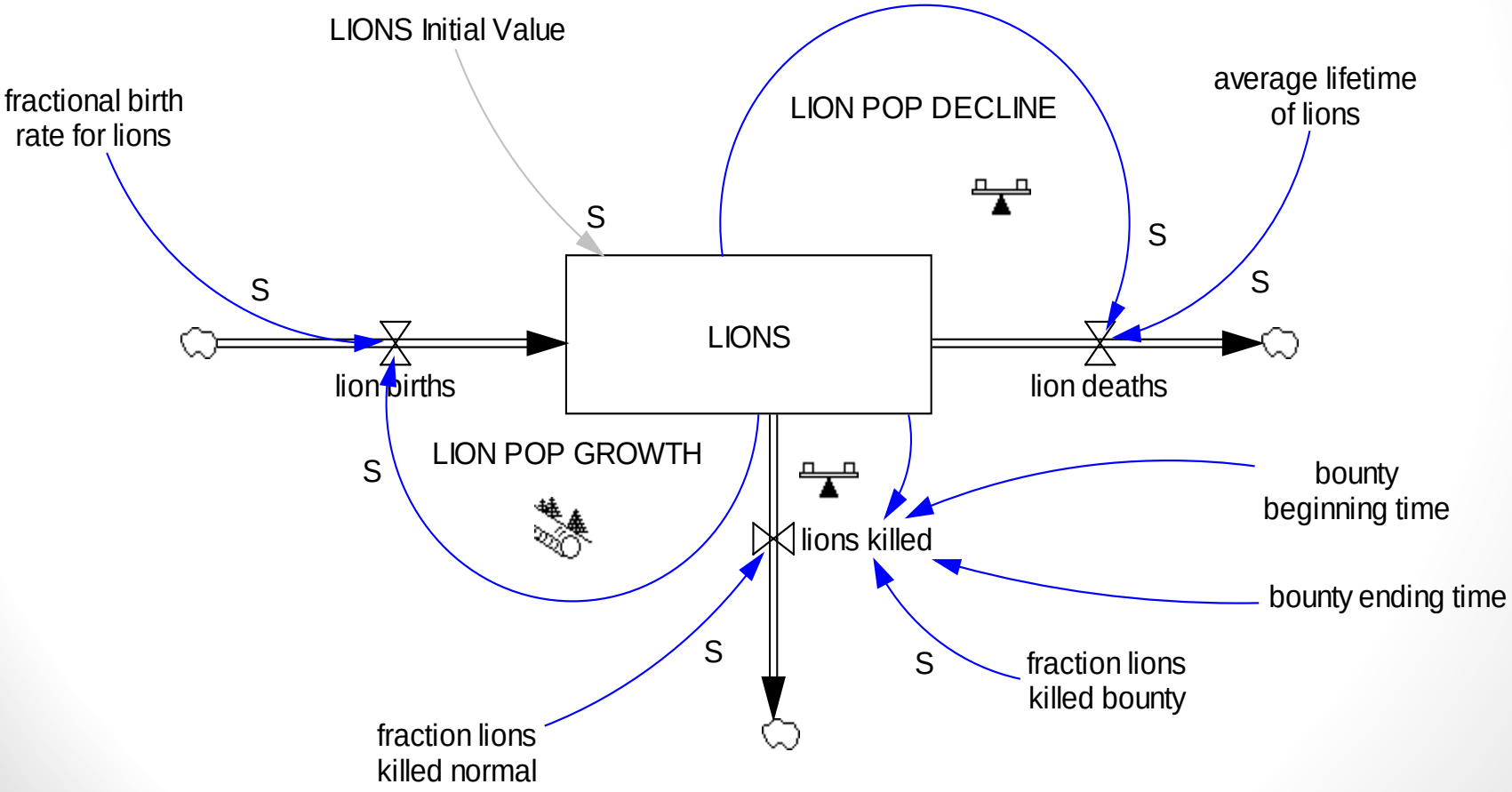
Kaibab Plateau Modeling Exercise

- Deer Sector



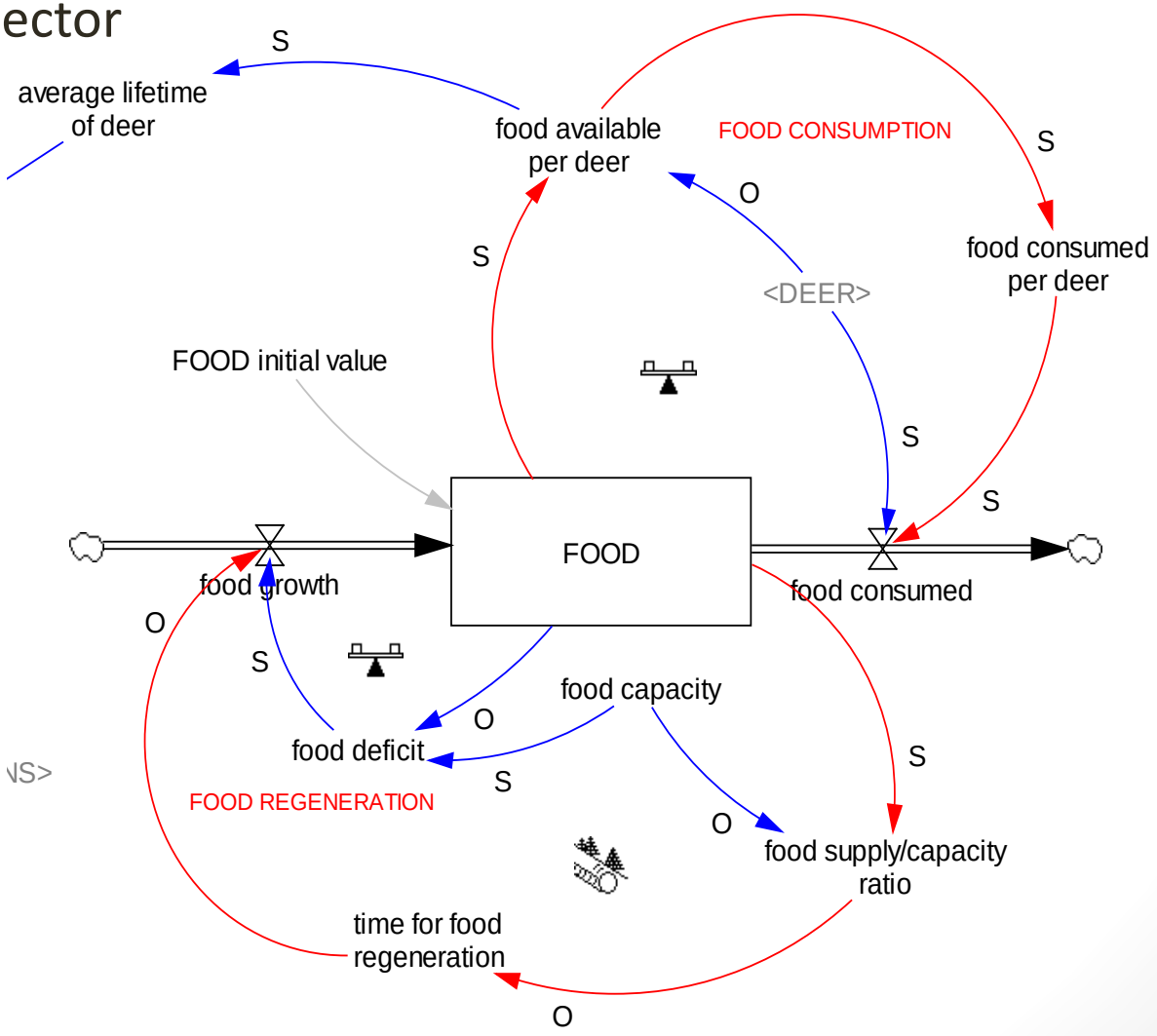
Kaibab Plateau Modeling Exercise

- Lion Sector

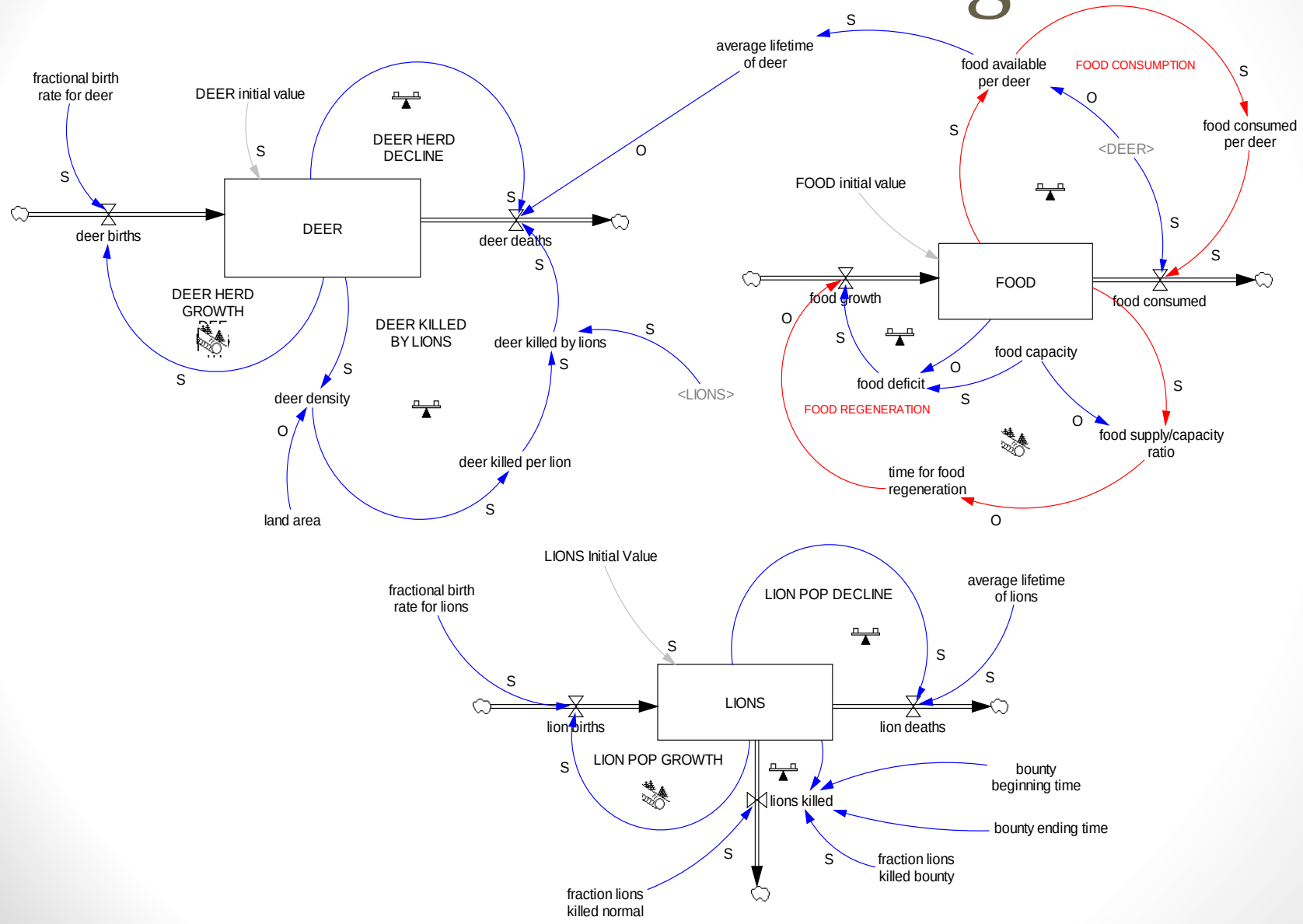


Kaibab Plateau Modeling Exercise

- Food Sector



Kaibab Plateau Modeling Exercise



Kaibab Plateau Modeling Exercise

- Advantages of Using Kaibab Plateau Model
  - Policy problem
    - Presents a policy intervention
    - Multiple stakeholder views
  - "Concrete" variables in a real-world context
    - Deer, lions, and vegetation
  - Clear reference mode
    - Data readily available
    - Shift in loop dominance
    - Cannot be re-created until model is completed
    - Closed (endogenous) system
  - "Classic" structures
    - Simple ecosystem
    - Population dynamics
      - Growth and regeneration
      - Overshoot phenomena
      - Example of sustainability
  - Allows for various policy intervention scenarios

Kaibab Plateau Modeling Exercise

- Demonstration (10 minutes)
  - Classroom teaching
  - Self-learning
  - Video recording

Replication Modeling Exercise

- "The training wheels are off"
- Goal
  - Replicate a classic or instructional system dynamics model while learning about new functions in Vensim
- Students choose a model based on their original project (samples)*
  - Business/Management
    - Capacity and Market Growth
    - Financial Modeling and Risk
    - Project Dynamics
    - Workforce, Inventory, and Oscillation
  - Other
    - Growth of a Field
  - Population
    - Population Dynamics
    - Urban 1
    - World 2

* These are selected by the instructor(s) based on student interest

Replication Modeling Exercise

- Methodology
  - Model context / background is given in class
  - Model is replicated outside of class
  - Additions, extensions, or adaptations are made to the model to fit student interests
    - Replicate the reference mode
      - Structure
        - Sectors
      - Content
        - Functions
        - Equations
    - Extend the model or create a policy intervention
  - Expands the domain for model diversity and policy and sensitivity analysis

Replication Modeling Exercise

- Demonstration (10 minutes)
  - Classroom teaching (replication document)
  - Self-learning via Vensim exercises

Original Modeling Exercise

- Are students capable of creating and presenting a policy-relevant system dynamics model?

- Goal
  - Develop an original model building upon knowledge gained from the Kaibab and replication projects
  - Create a quality project that can be used as a point of departure as a
    - Thesis/dissertation
    - Credential

- Students select a problem based on their interests
  - Problems are chosen in any field or subject

Original Modeling Exercise

- Student topic areas (samples)
  - Education
    - What explains the gap in academic performance between students from middle-income and low-income school districts in the USA?
  - Energy
    - What is delaying shifting to renewable energy in Singapore?
  - Finance
    - How did speculation create volatility in the housing market in Denmark?
  - Governance
    - What are the key factors affecting road accident fatalities in Delhi?
  - Population
    - What are the causes of declining fertility in Singapore?
  - Urban Dynamics
    - What are the economic factors that have caused net migration over the last three decades in Sri Lanka?

Original Modeling Exercise

- Demonstration (10 minutes)
  - Coaching
  - Self-learning and model development

Guest Speakers

Cities – Prof. K. E. Seetharam

NUS HIGH SCHOOL of Math & Science

Education – Deputy Principal Goh

Engineering – Prof. P. C. Lui

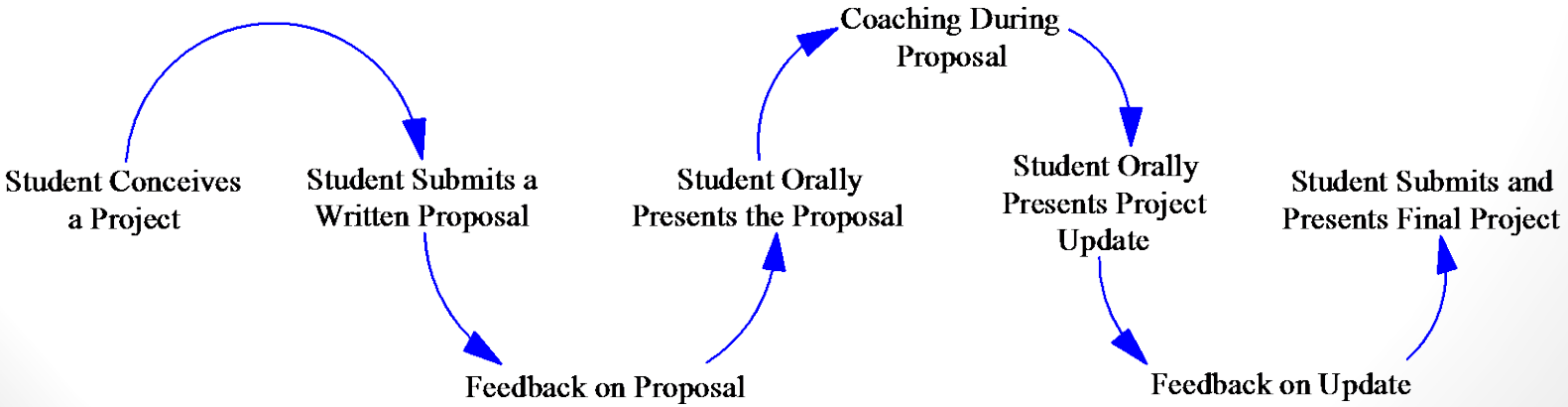
Health – Prof. Jim Thompson

Foundations of System Dynamics – Prof. George Richardson

Vensim – Prof. Bob Eberlein

Coaching and Feedback

- Evaluations
  - Project
    - After each project is complete
  - Students
    - Proposal via oral and written reports
    - Interim via oral report
    - Final via oral and written reports



Coaching and Feedback

- Presentations
  - Emphasis is placed on quality presentations and presenting system dynamics information to those outside the field

- Support
  - Group Work – Working in groups is encouraged for mutual support and discussion of the material
  - Coaching – Regular coaching is provided on replication and original projects
  - Support
    - Office hours – Three sessions per week
    - Modeling – Encourage regular practice in Vensim

Benefits of this Approach

- Direct Immersion
  - Students start modeling on the first day of class and are modeling until the end of the semester
- Building Process
  - Students progress from copying a model, to replicating and expanding a model, to creating one
- Modular Structure
  - Each element can be separated from the other and re-organized per the needs of the teachers and students, and time constraints

Alternate Approaches

- Drawbacks
  - Time and Workload Commitment
    - Requires significant time from students and teachers
    - Coaching is key, but requires time for feedback and discussion
  - Immersion
    - Students are expected to work outside of class and keep up with the technical and theoretical aspects

- Alternatives
  - Introduction
    - Use a common game as an introduction, e.g. the Fish banks or beer game
  - Replication
    - Follow the Kaibab Plateau modeling exercise with two replication models of increasing complexity
    - Select a larger variety of models of increasing complexity for students to replicate
  - Original Project
    - Remove the original project
    - Focusing on technical learning rather than an original project

An Evolving Process

- Changes that we are implementing
  - Documentation
    - Develop, complete, and standardize teaching material
  - Replication
    - Select a larger variety of models for students to replicate

- Student comments for future implementation
  - Pacing
    - Spread projects more evenly to distribute workload
  - Vensim
    - Earlier education on more Vensim functions

Conclusion

- Proven
  - Long track record of quality student modeling projects
- Flexibility
  - Methodology has a common starting point but highly flexible in the progression through the intermediate (replication) and advanced (original) projects
- Feedback
  - Students appreciate consistent, detailed feedback
  - Gives confidence in replicating and modeling
- Systems Thinking
  - By modeling from the beginning of the class, students become more deeply grounded systems thinkers than if trained in systems thinking alone