Introduction to System Dynamics

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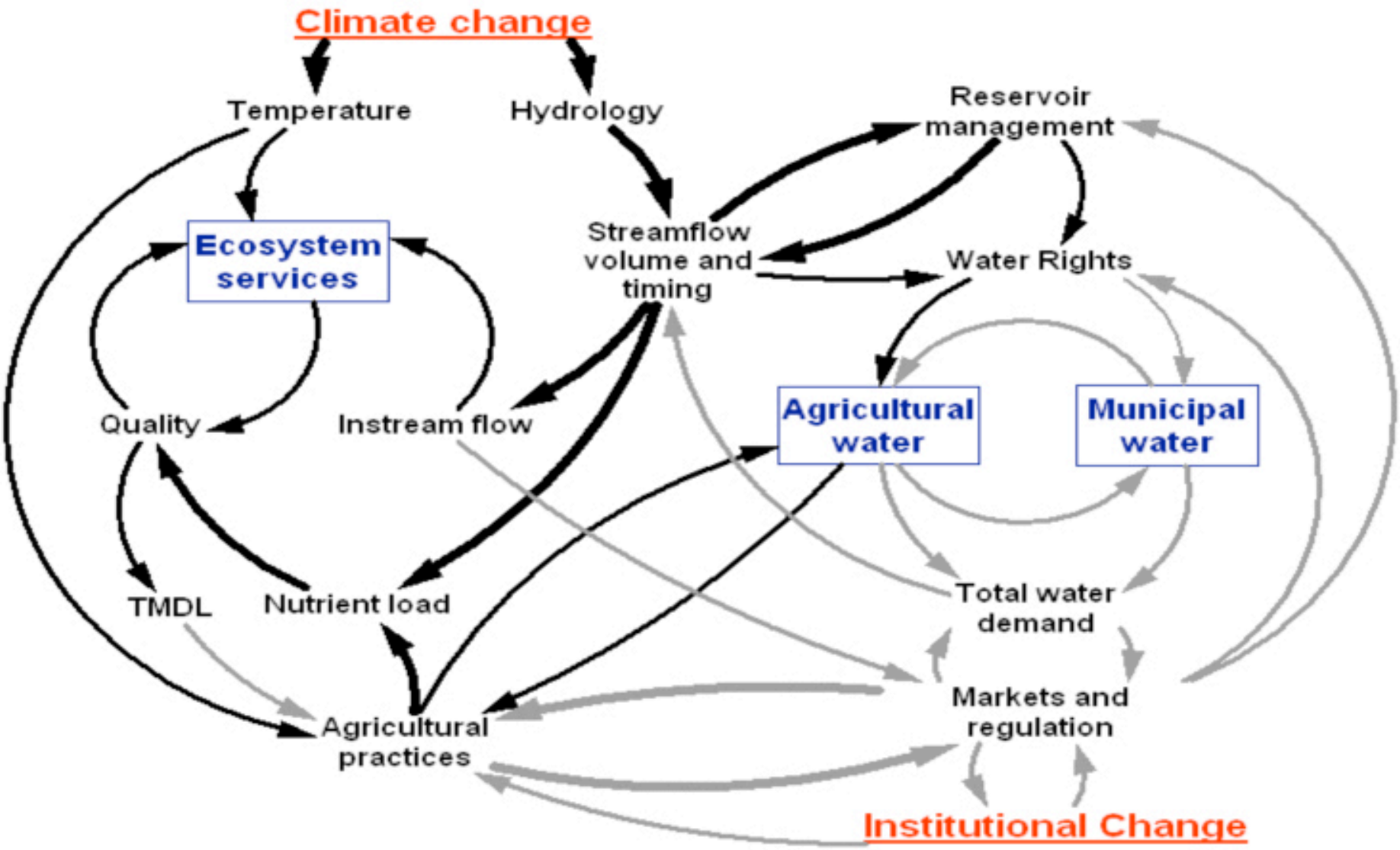
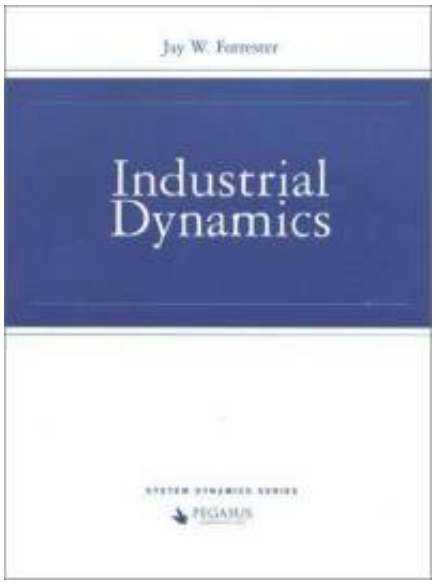
With a big thank you to Andy Ford!

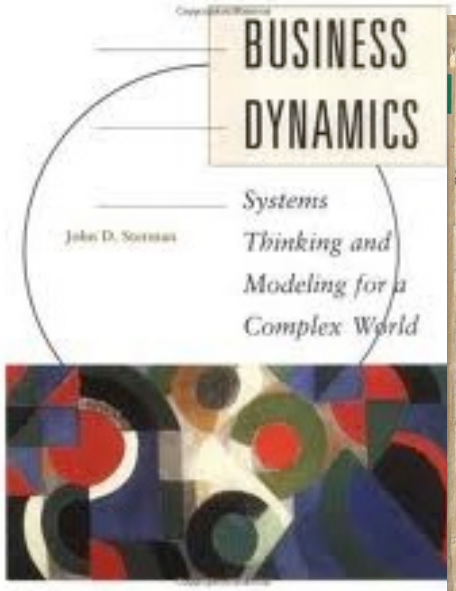
System Dynamics in WISDM

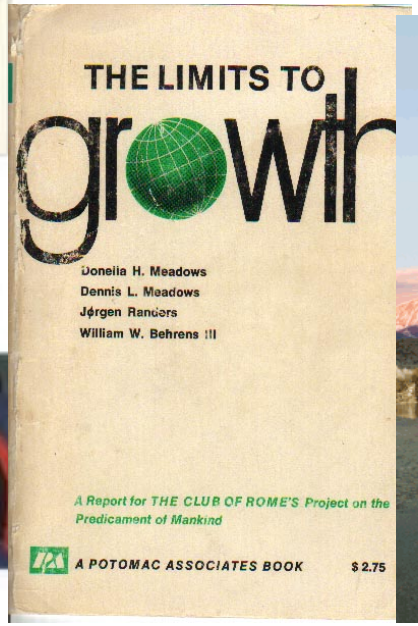


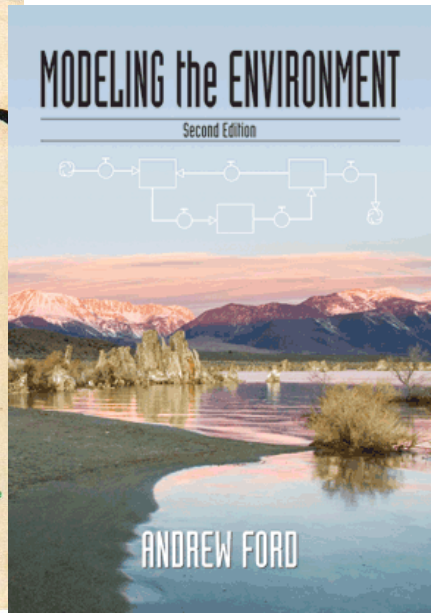
What is System Dynamics?

- Approach to studying and managing complex systems that change over time
- Addresses internal feedback loops and time delays that affect the behavior of the entire system

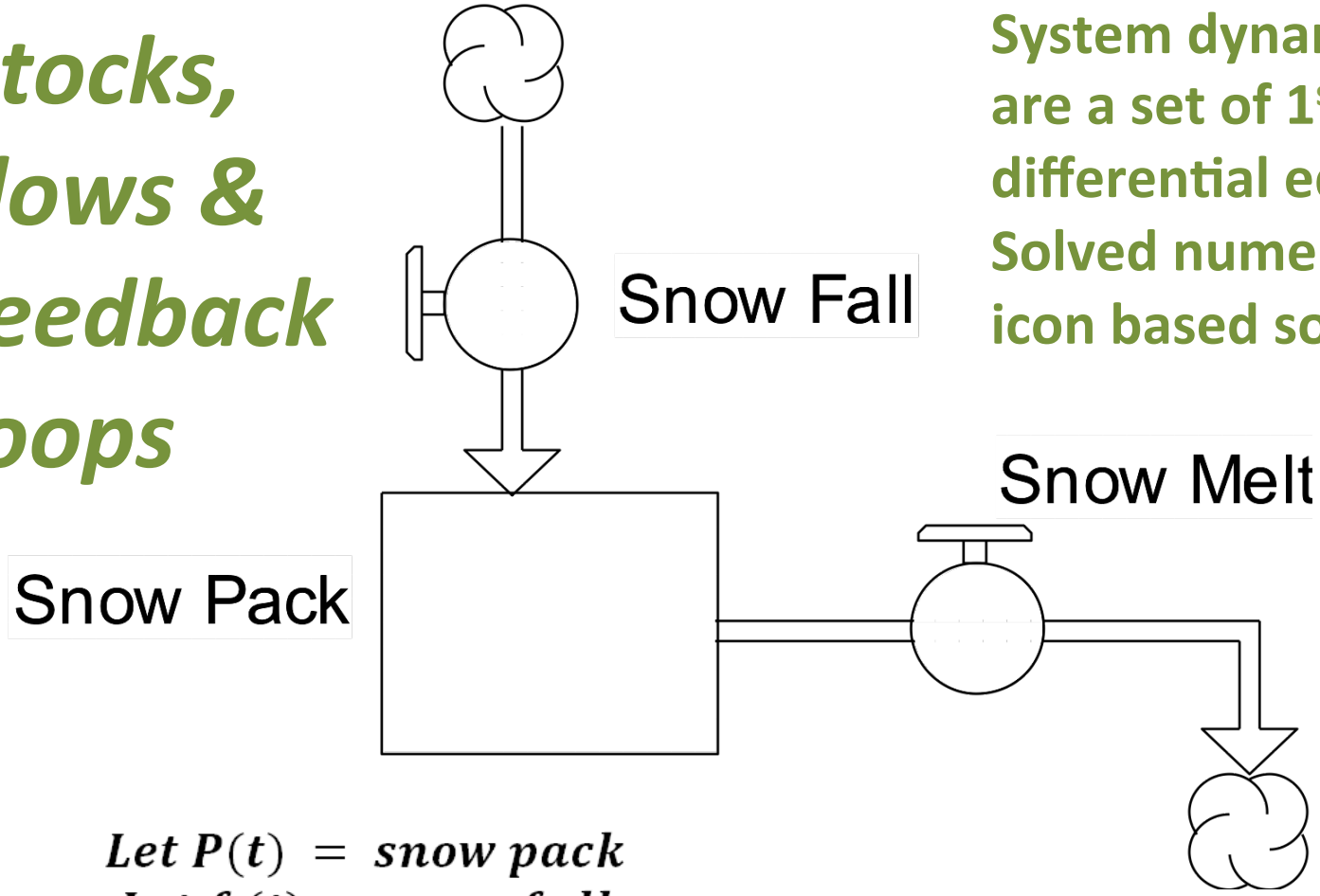








Stocks, flows & feedback loops



System dynamics models are a set of 1st order differential equations. Solved numerically with icon based software.

$$Let\ P(t) = snow\ pack$$
$$Let\ f\ (t) = snow\ fall$$
$$Let\ m(t) = snow\ melt$$

$$\frac{Dp}{Dt} = f(t) - m(t),$$

$$solved\ numerically\ via:$$

$$P(t) = P(t - dt) + (f(t) - m(t)) * dt$$

Easier for non-specialists to interpret and use than a purely process-based modeling approach

The Steps of System Dynamics Modeling

1) Acquainted – Get acquainted with the system
2) Be Specific – Be specific about the dynamic problem
3) Construct – Construct the stock and flow diagram
4) Draw – Draw casual loop diagrams
5) Estimate – Estimate the parameter values
6) Run – Run the model to get the reference mode
7) Sensitivity – Conduct the sensitivity analysis
8) Test – Test the impact of policies

Intro to Computer Aided Negotiations

- Used in mediating water disputes since the early 1980s
- The field is a process of defining terms and integrating different methodological approaches to strengthen it's presence in field of water resources

Then: Army Corps of Engineers developed CADRe: Computer Aided Dispute Resolution

Now: Collaborative Modeling/Computer Aided Negotiation

Collaborative Modeling Purpose

- Can address resource management challenges
- Stakeholders integrate differing perspectives and interests
- Participants build a shared language and to identify areas of agreement and disagreement
- Can clarify assumptions and facts, while building trust in the process.

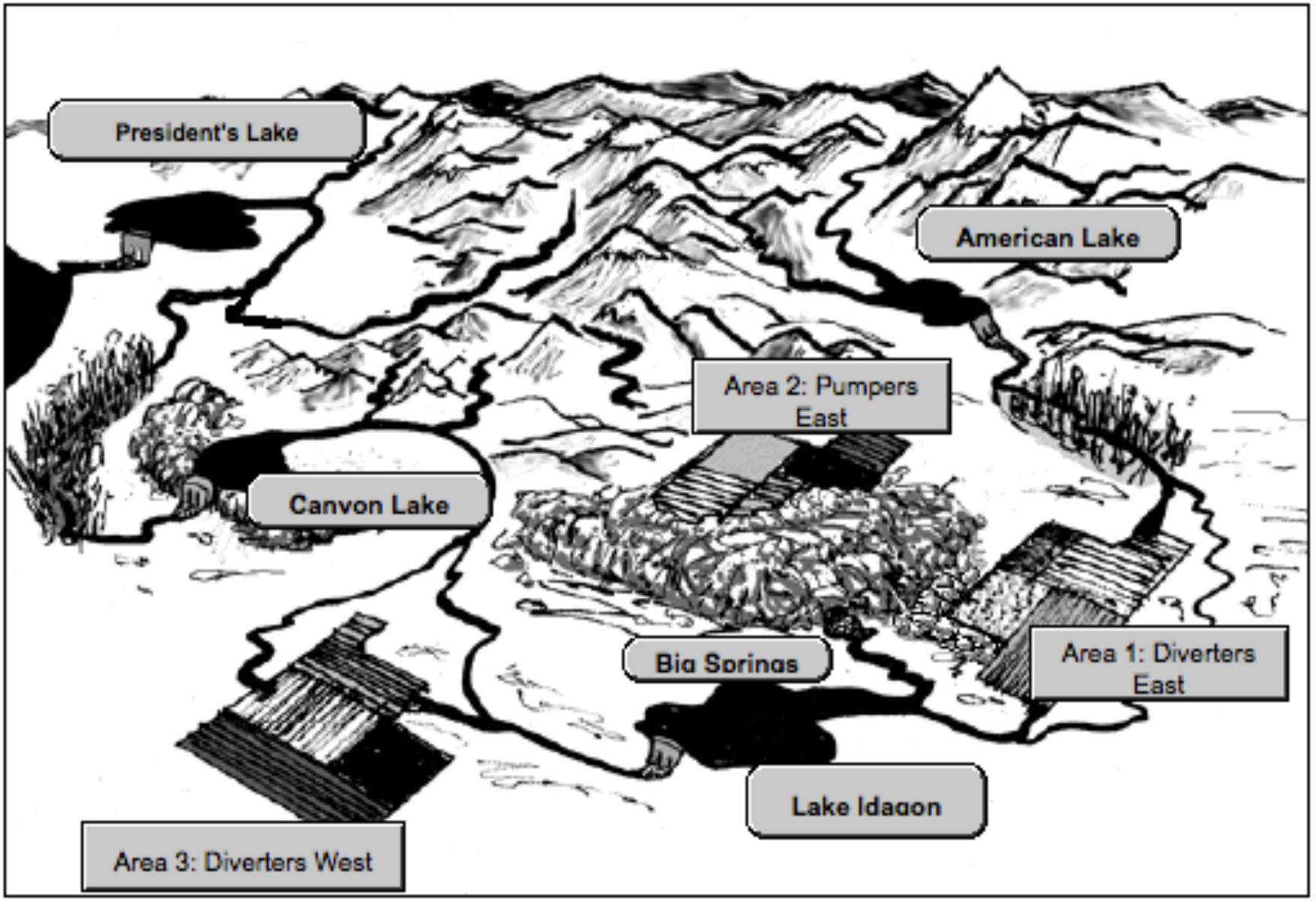
Collaborative Modeling Examples in Water Planning and Management

- Potomac River Basin
- Lake Ontario – St. Lawrence River Study
- Roanoke River Basin Hydropower Re-License
- Portugal - Nuno Videira
- Solomon's Harbor Watershed
- St. Albans Bay Watershed
- Upper Mississippi River
- ACT-ACF Basin
- Cedar and Green Rivers
- Gila River
- James River
- Kanawha River
- Rappahannock River
- Snake Plan Aquifer
- Pacific Northwest Climate Change
- Lake Powell/Lake Mead
- Los Angeles
- Marais des Cygnes – Osage
- Middle Rio Grande
- Mississippi Headwaters
- Susquehanna River
- Upper Rio Grande River
- Willamette River

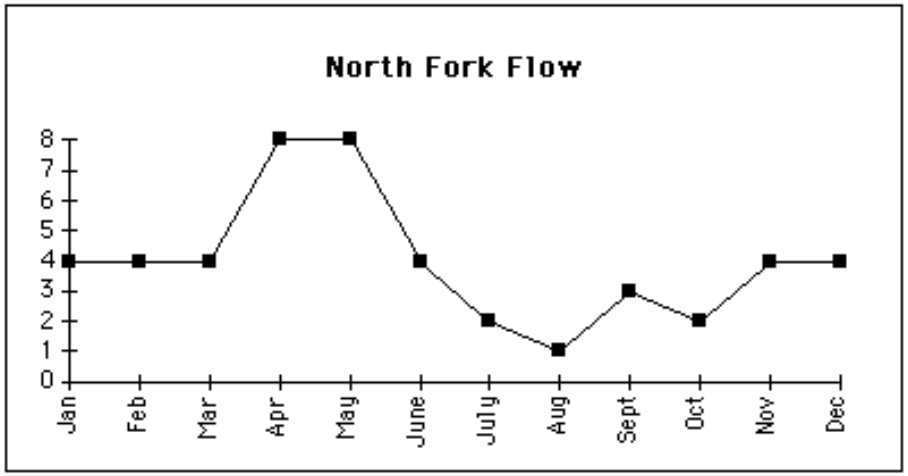
History of the Idagon

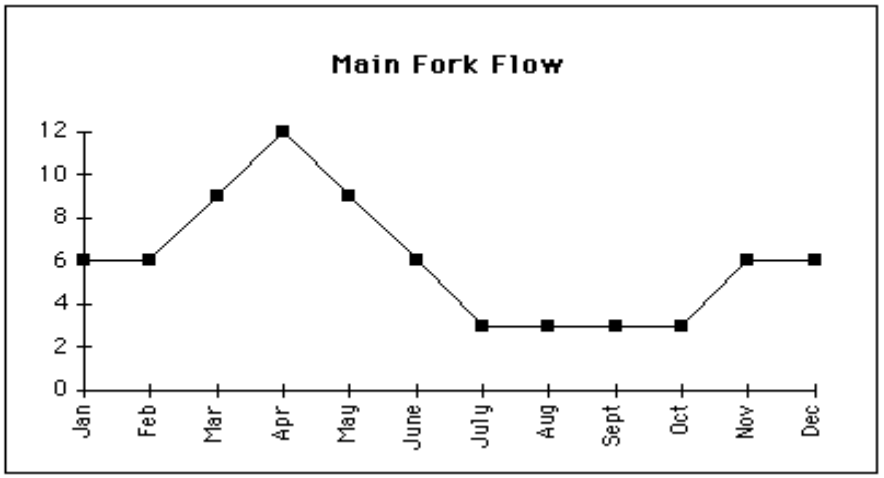
- Grew out of an initiative at Idaho National Lab
- Partnership with Andy Ford and WSU students and the Rocky Mountain Water Institute
- Chose to build understanding of the Snake River
- Represent groundwater, crops and instream flows together
- Not a commercially valuable model, but a learning tool
- By defining values at the outset, there can be a formal evaluation of outcomes

The Idagon

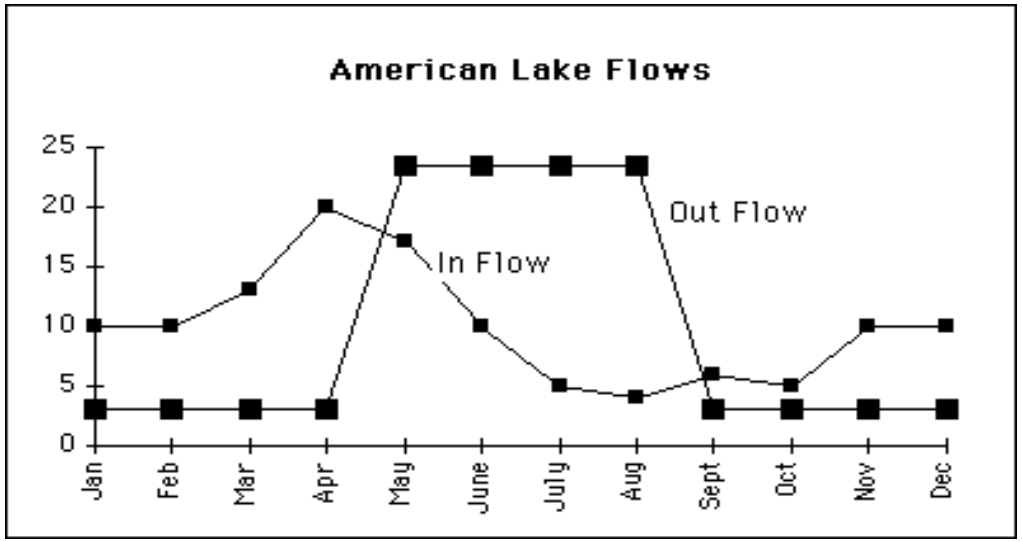

President's Lake
American Lake
Area 2: Pumpers East
Canvon Lake
Area 1: Diverters East
Big Springs
Lake Idagon
Area 3: Diverters West

American Lake

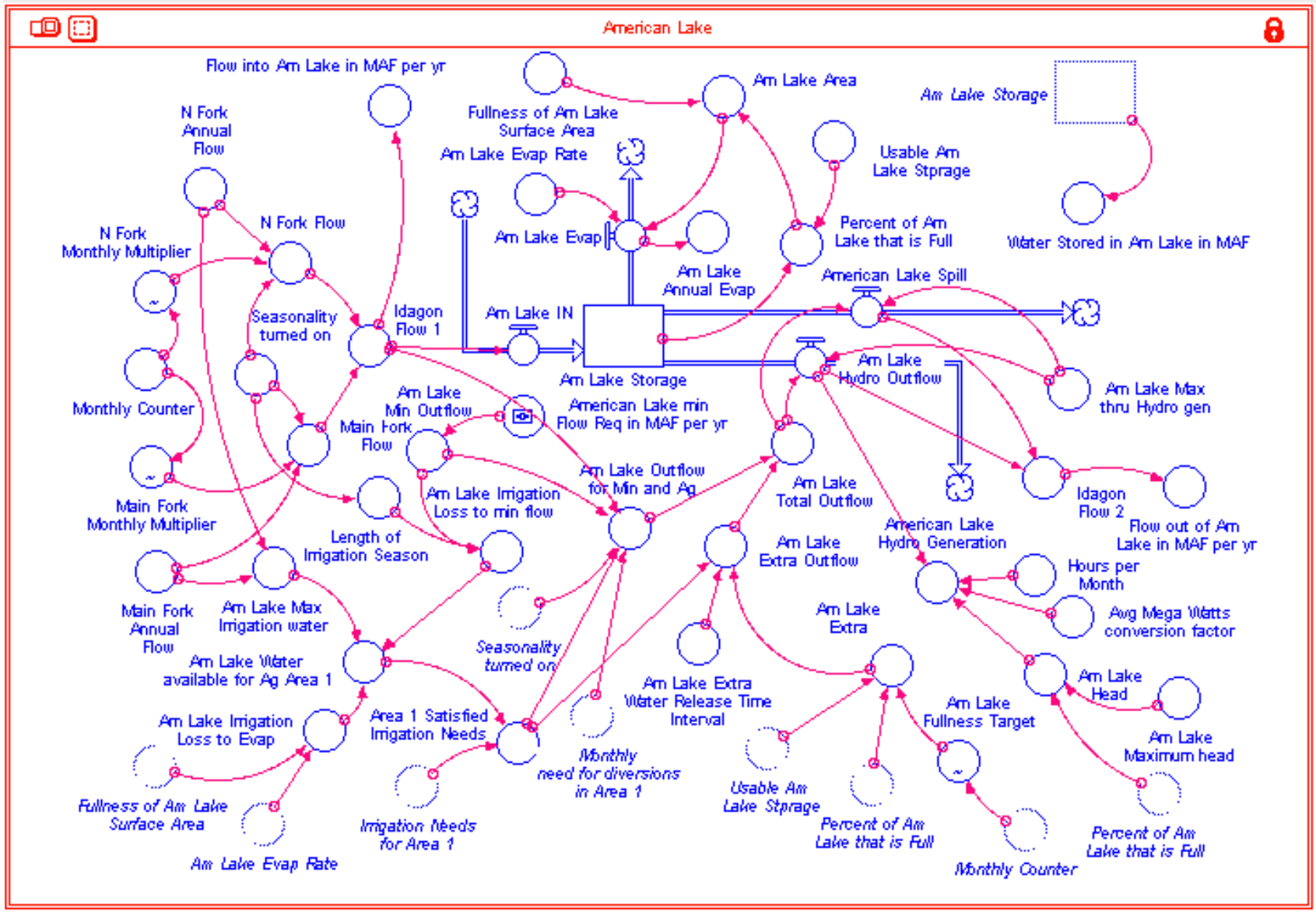




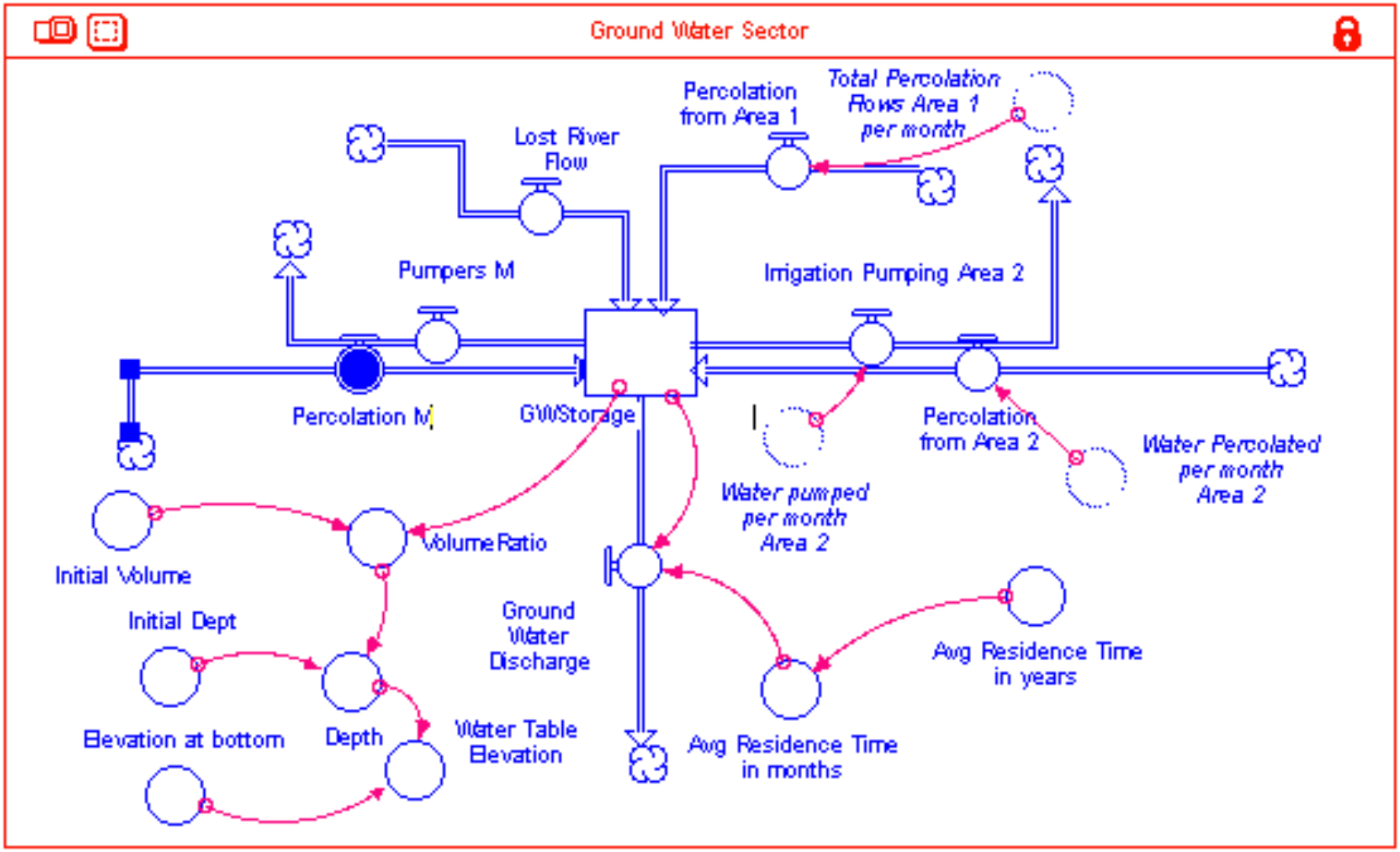
North Fork & Main Fork flow into American Lake



American Lake Component



Groundwater Component



Feedback Loop