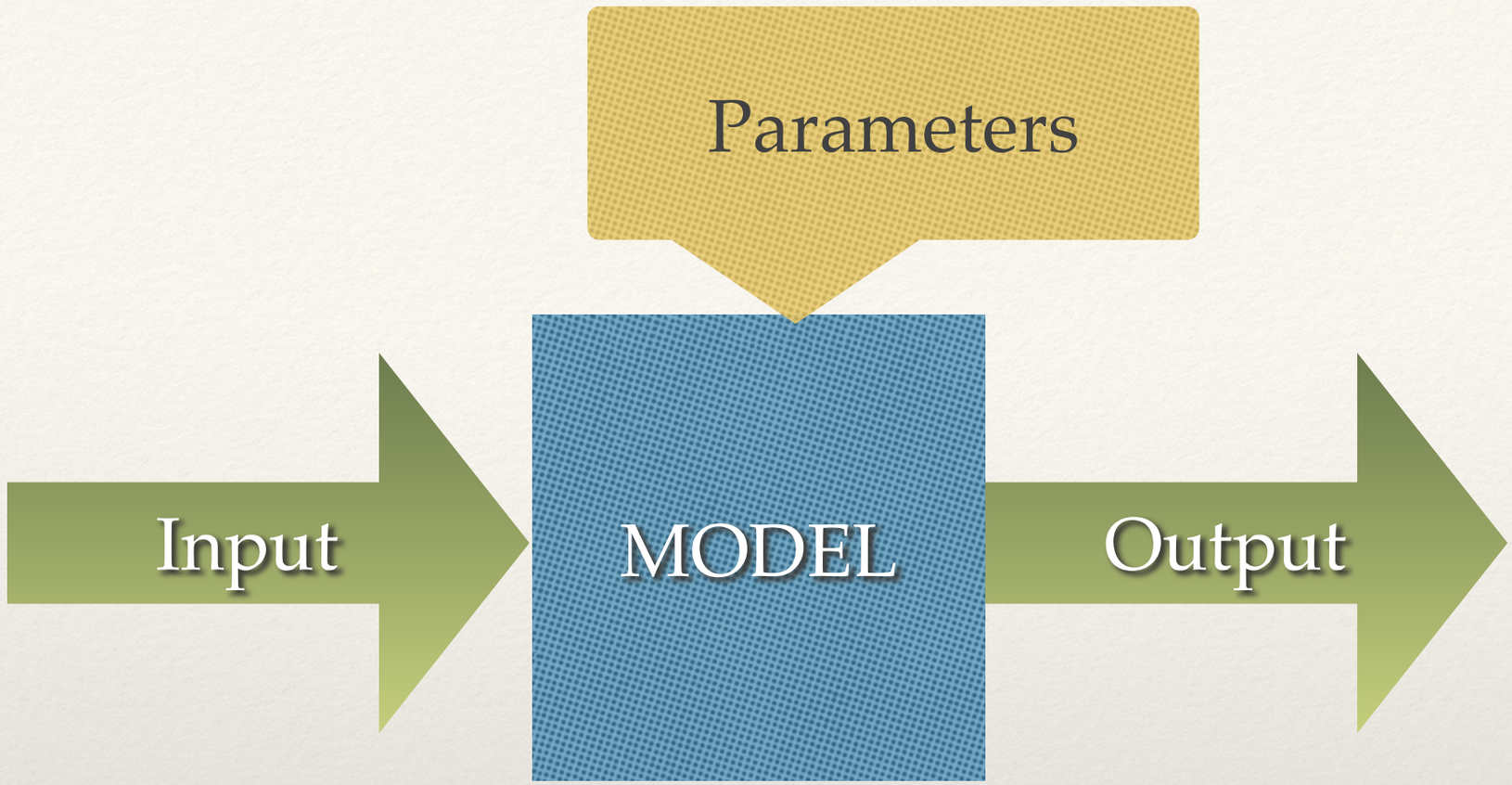
STEPS: Modeling for Problem Solving in ES

1. **Clearly define your goal (question you want to answer, hypothesis you want to test, prediction you want to make) - as precisely as possible**
2. Design or Select your model
3. Implement the model
4. Evaluate the model and quantify uncertainty
5. Apply the model to the goal
6. Communicate model results

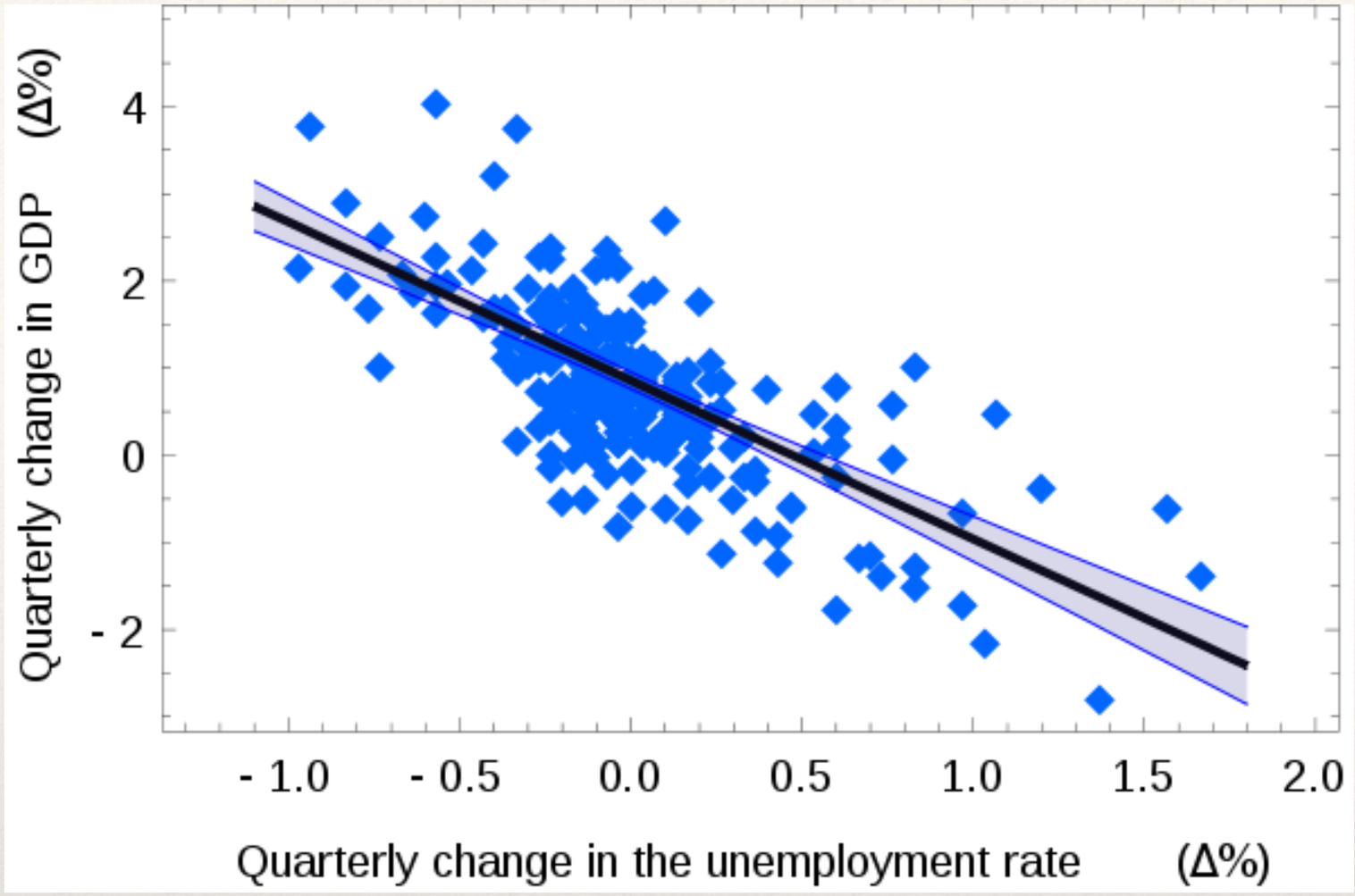
Design/Selecting Models

- What are your inputs-outputs
- What's in the box (the model itself) that gives you a relationship between outputs and inputs
  - Transfer function
- Parameters, values that influences how the model relationships work



Basic components of models

Inputs: Varying; think x of a x vs y regression
Parameters: single values that influence relationships in the model
Outputs: what you want to estimate



The US "changes in unemployment – GDP growth" regression with the 95% confidence bands.

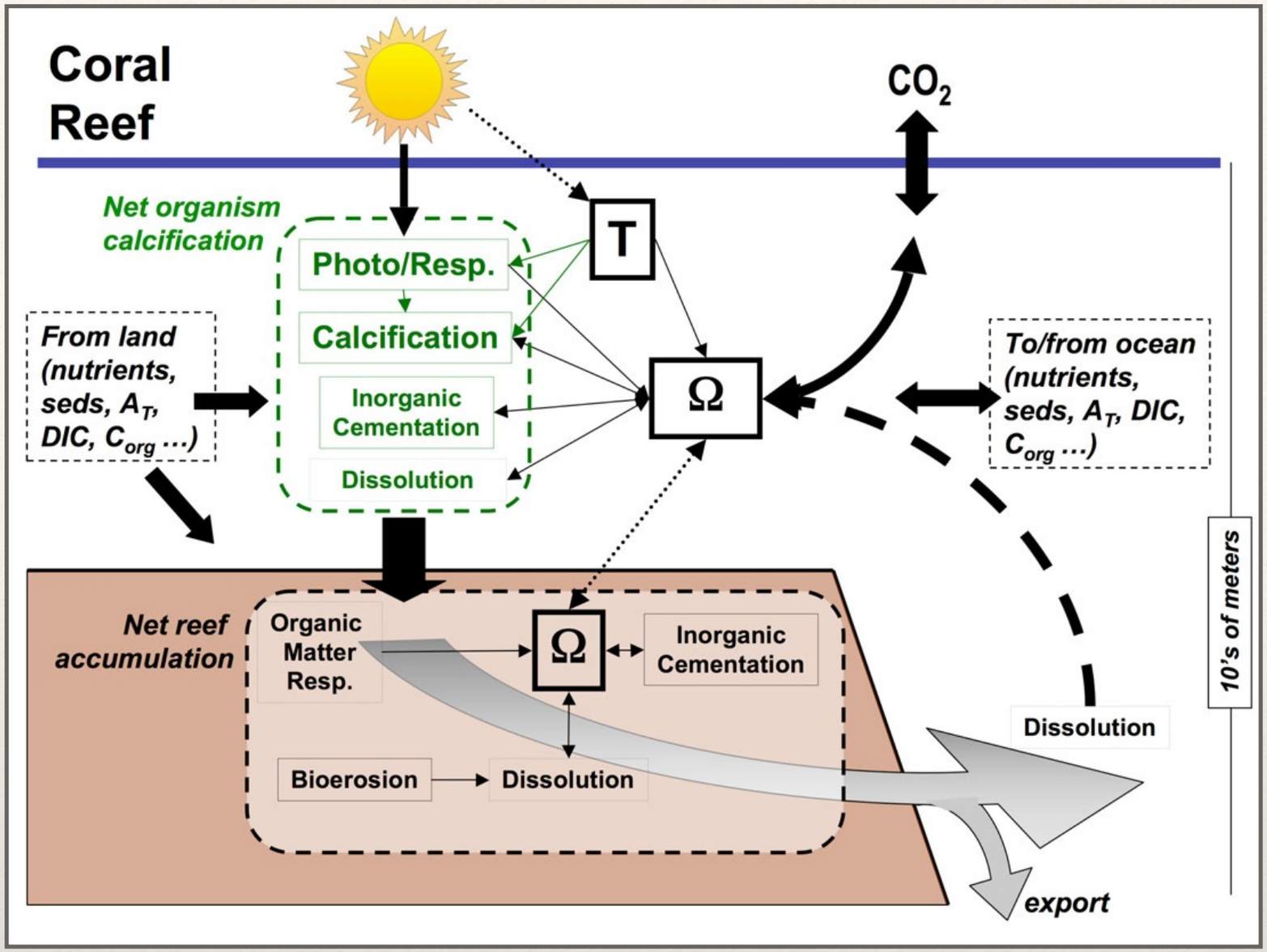
Lorem Ipsum Dolor

Simple model

Input: Change in unemployment rate
Output: Change in GDP
Parameters: Slope and intercept of the line

What's in the box

- Often more complicated than a simple regression…
- So we need to think through what the relationships are; the processes are that we want to take in to account
- Here's where we decide: what's included and what is not
- Conceptual models are a good place to start



http://www.nar.ucar.edu/2008/RAL/images/1.2_ocean_08_lg.jpg

Modeling changes both the changes in seawater chemistry in coral reef waters, as well as the responses of reef organisms.

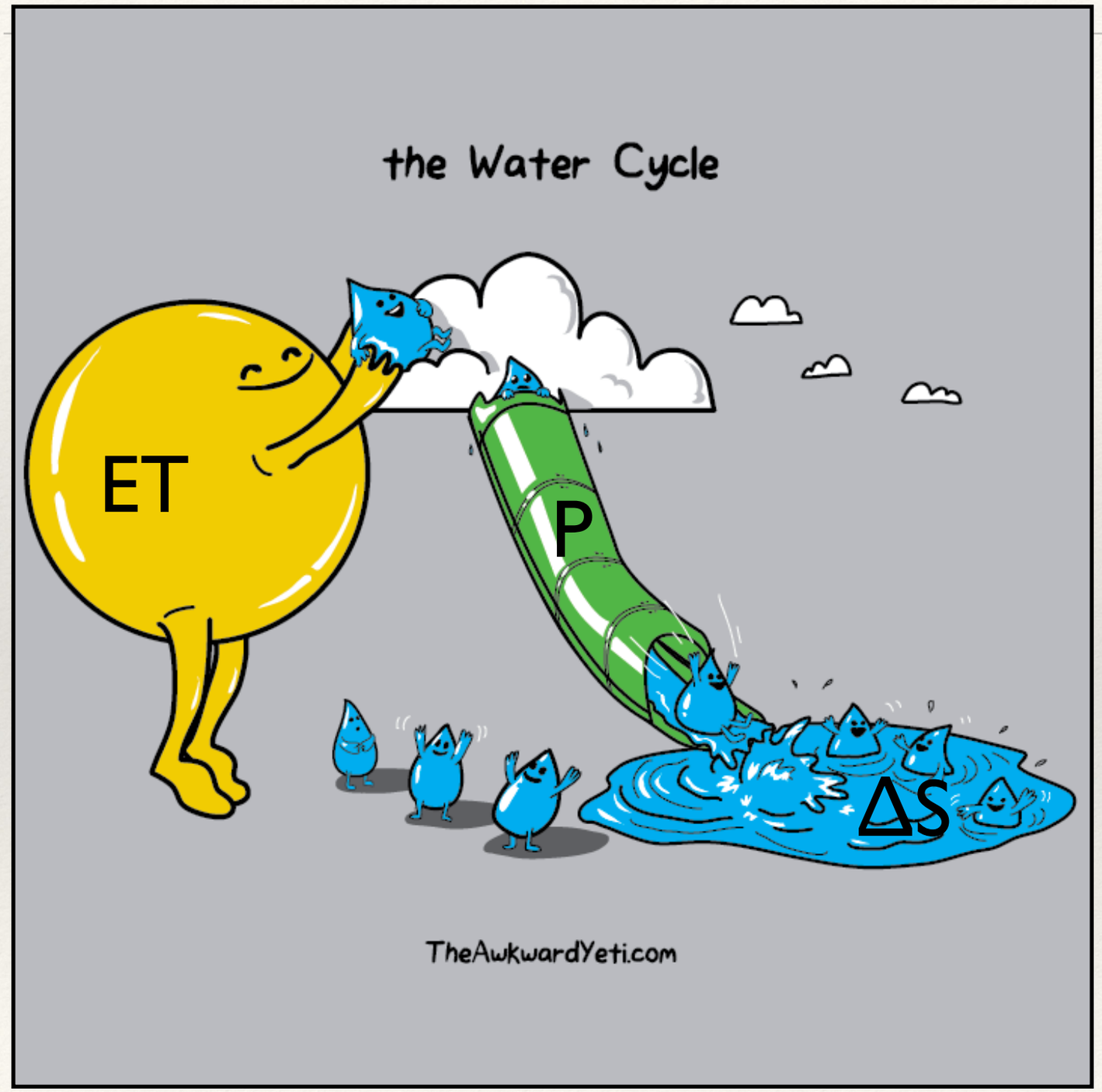
Complex model

Input: Solar energy and atmospheric CO2, land DIC,
Output: Reef Dissolution7, DOC/DIC export
Parameters: Many parameters that control rates of photo synthesis, calcification etc

Conceptual models

- Tells you what is included in translating inputs to output
- Because models are ALWAYs simplifications of reality this step is really important
  - For model development
    - What will you need to know to design or select
  - For communicating to users
    - How can they interpret results - what is accounted for what is not

Conceptual models of the hydrologic cycle



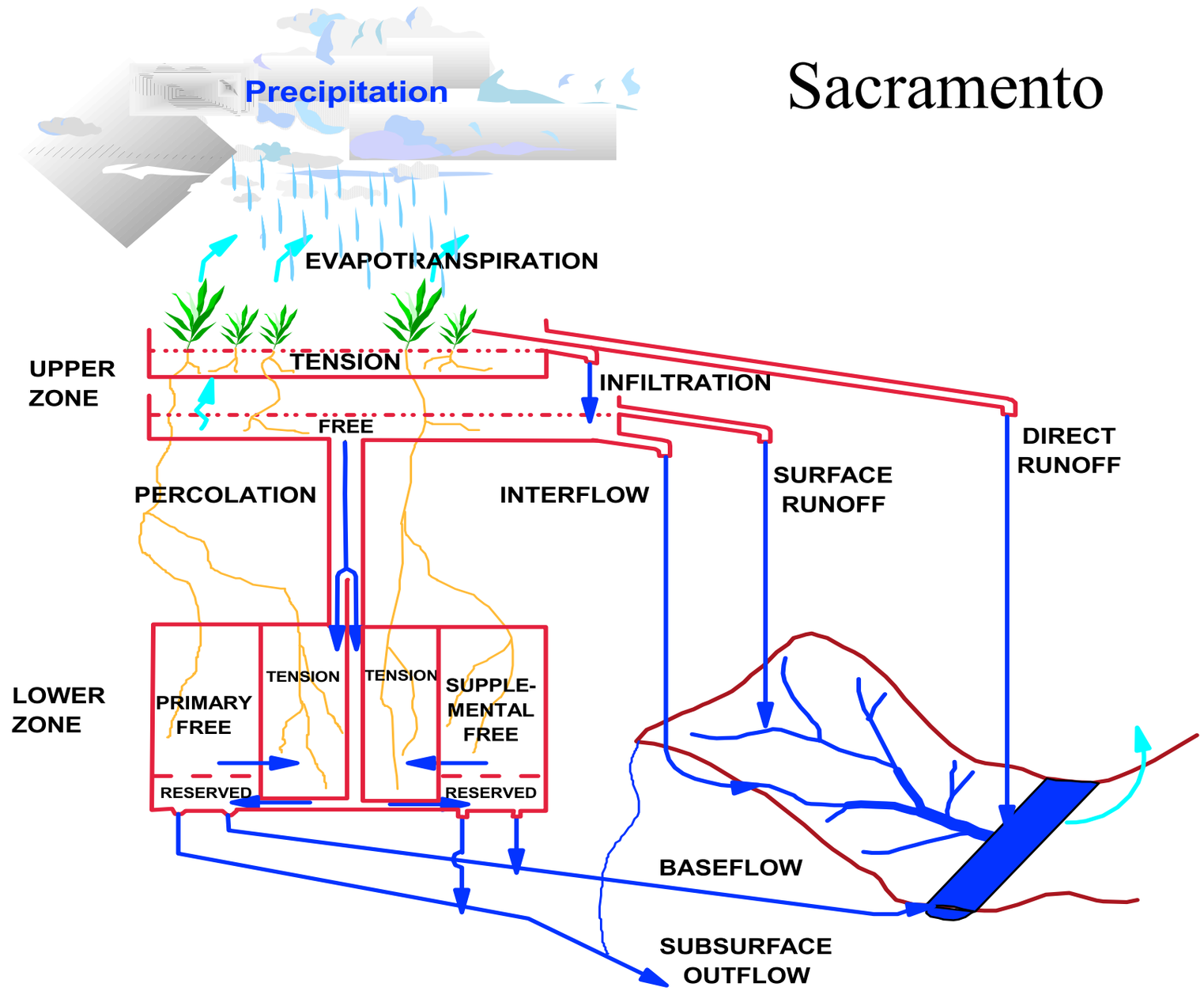
Precipitation = Evapotranspiration + Change in Storage

$P = ET + \Delta S$

(at global scales ΔS includes streamflow since that water is still "stored" in the earth

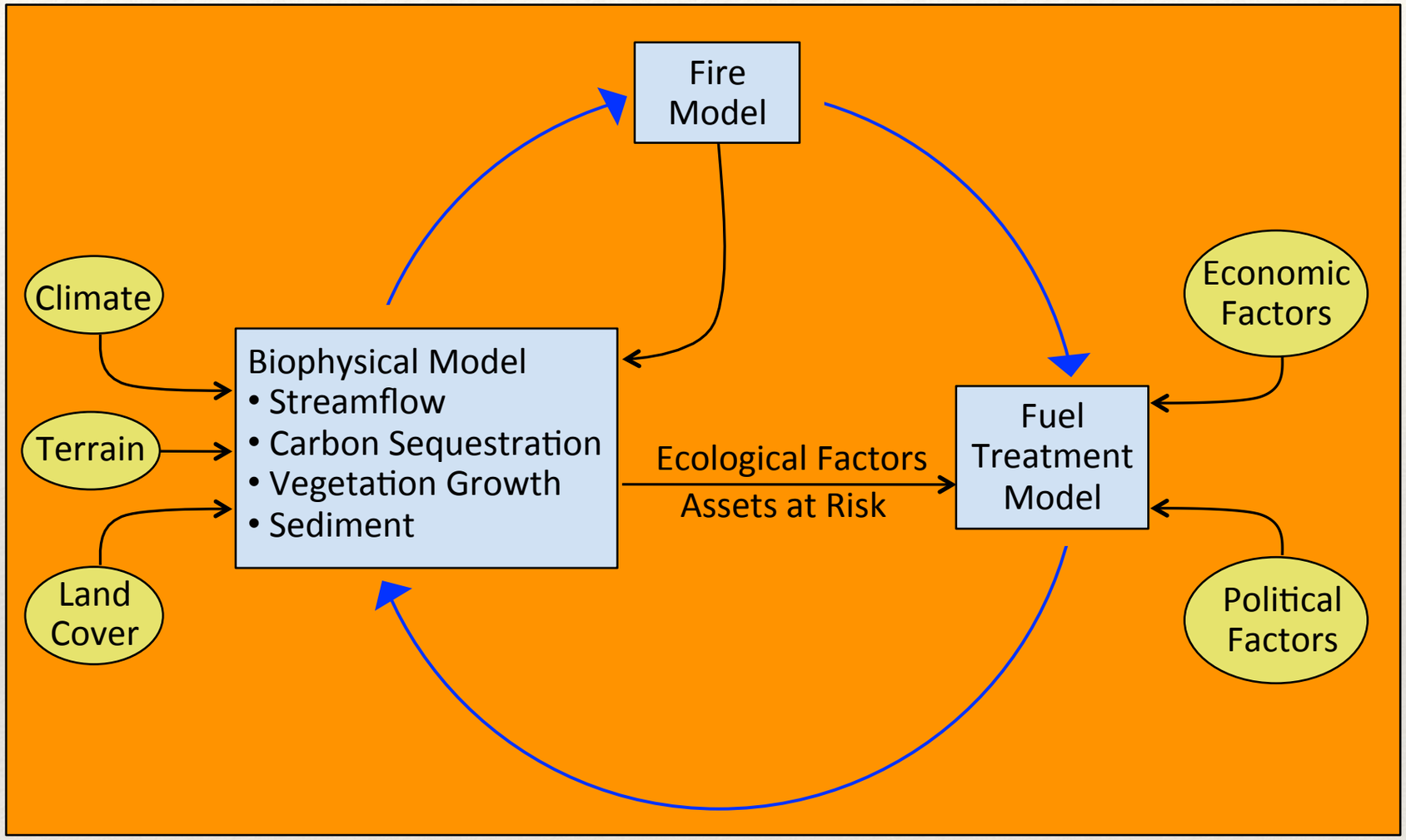
Conceptual Models

How much you resolve a given component (of the water balance in this case) depends on what you are interested in what is the Q?



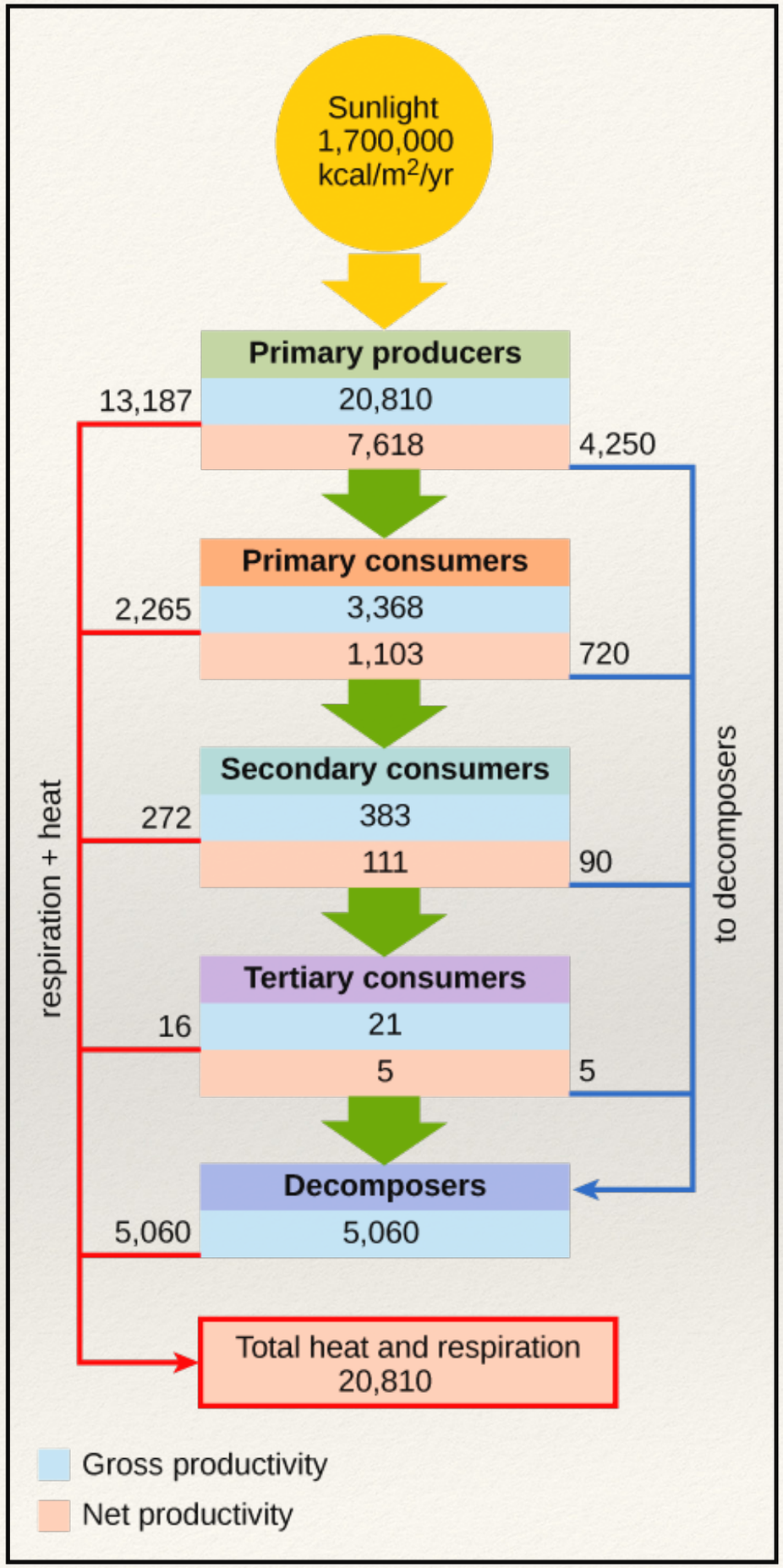
Sacramento

SERI-Fire


Fire Model
Climate
Terrain
Land Cover
Biophysical Model
• Streamflow
• Carbon Sequestration
• Vegetation Growth
• Sediment
Ecological Factors
Assets at Risk
Fuel Treatment Model
Economic Factors
Political Factors

https://www.boundless.com/biology/textbooks/boundless-biology-textbook/ecosystems-46/energy-flow-through-ecosystems-257/productivity-within-trophic-levels-952-12212/

Conceptual model as a flow chart (with example values)



Conceptual models can be of a processes (decision, assessment)

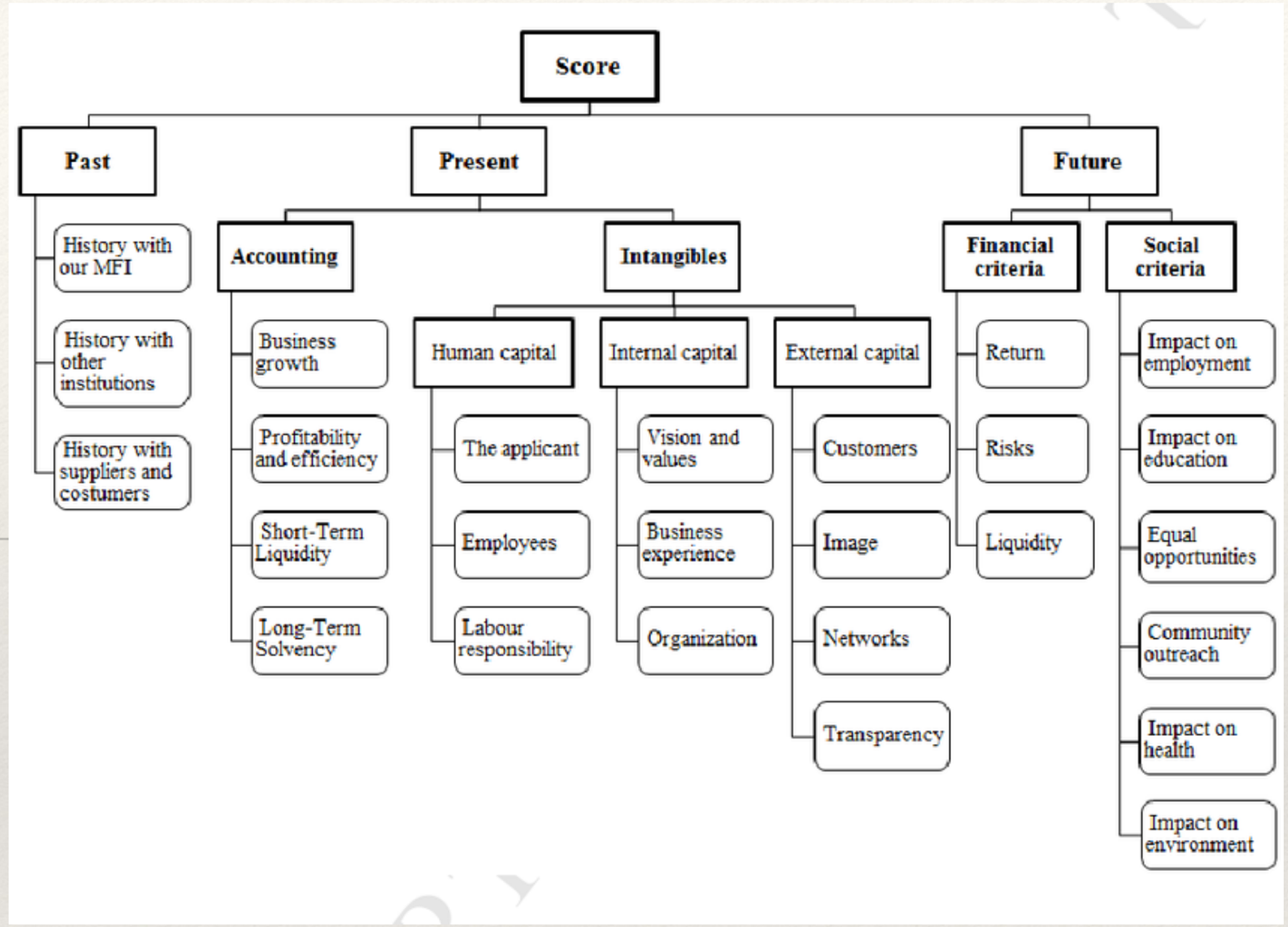


Figure 1. Flowchart of the social and environmental microcredit scoring decisional process. The model includes financial assessment and social impact assessment.

Serrano-Cinca C, Gutiérrez-Nieto B, Reyes NM, A Social and Environmental Approach to Microfinance Credit Scoring, Journal of Cleaner Production (2015), doi: 10.101

Academic paper (PDF): A Social and Environmental Approach to Microfinance Credit Scoring. Available from: https://www.researchgate.net/publication/282855291_A_Social_and_Environmental_Approach_to_Microfinance_Credit_Scoring [accessed Apr 5, 2017].

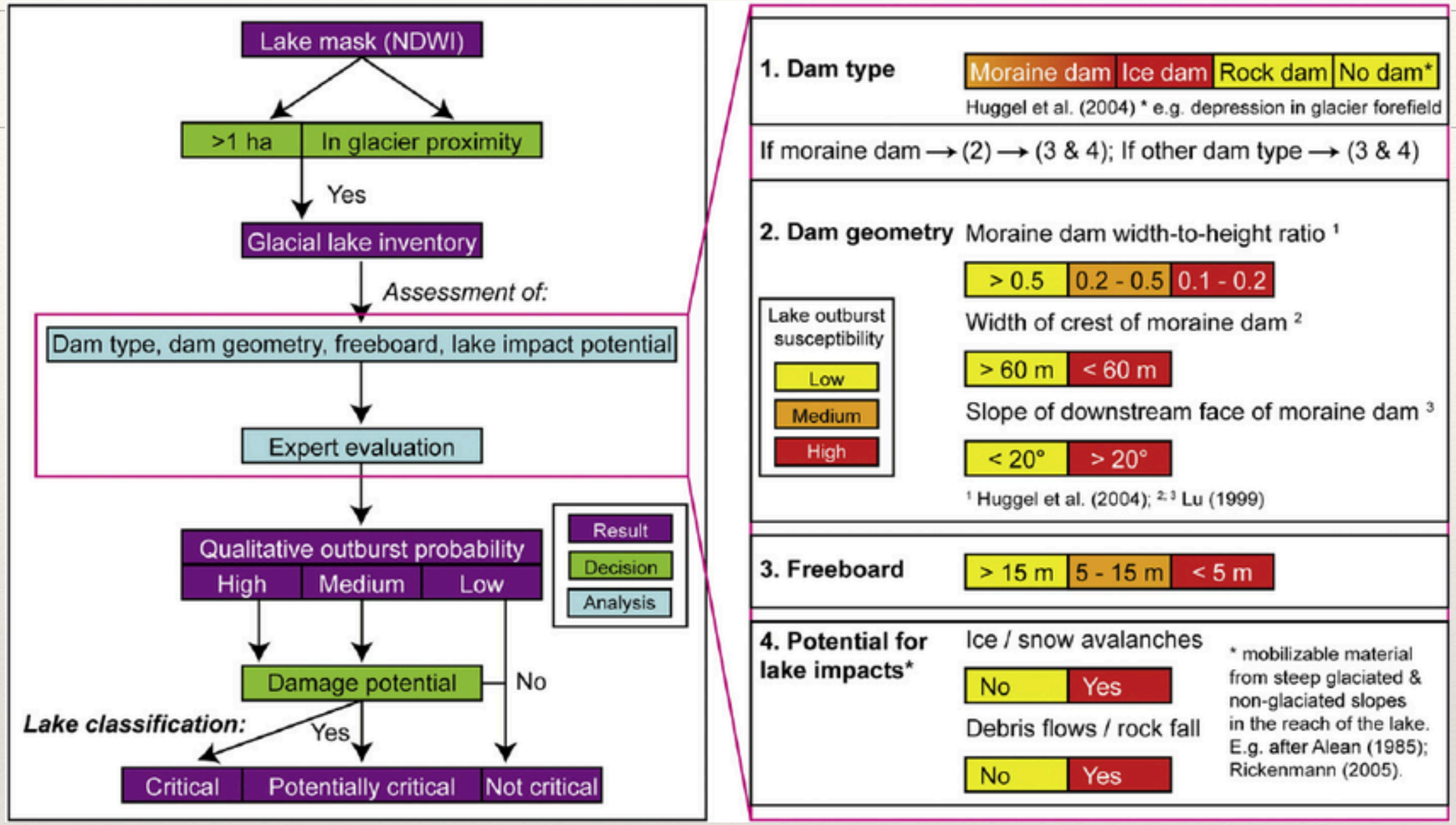
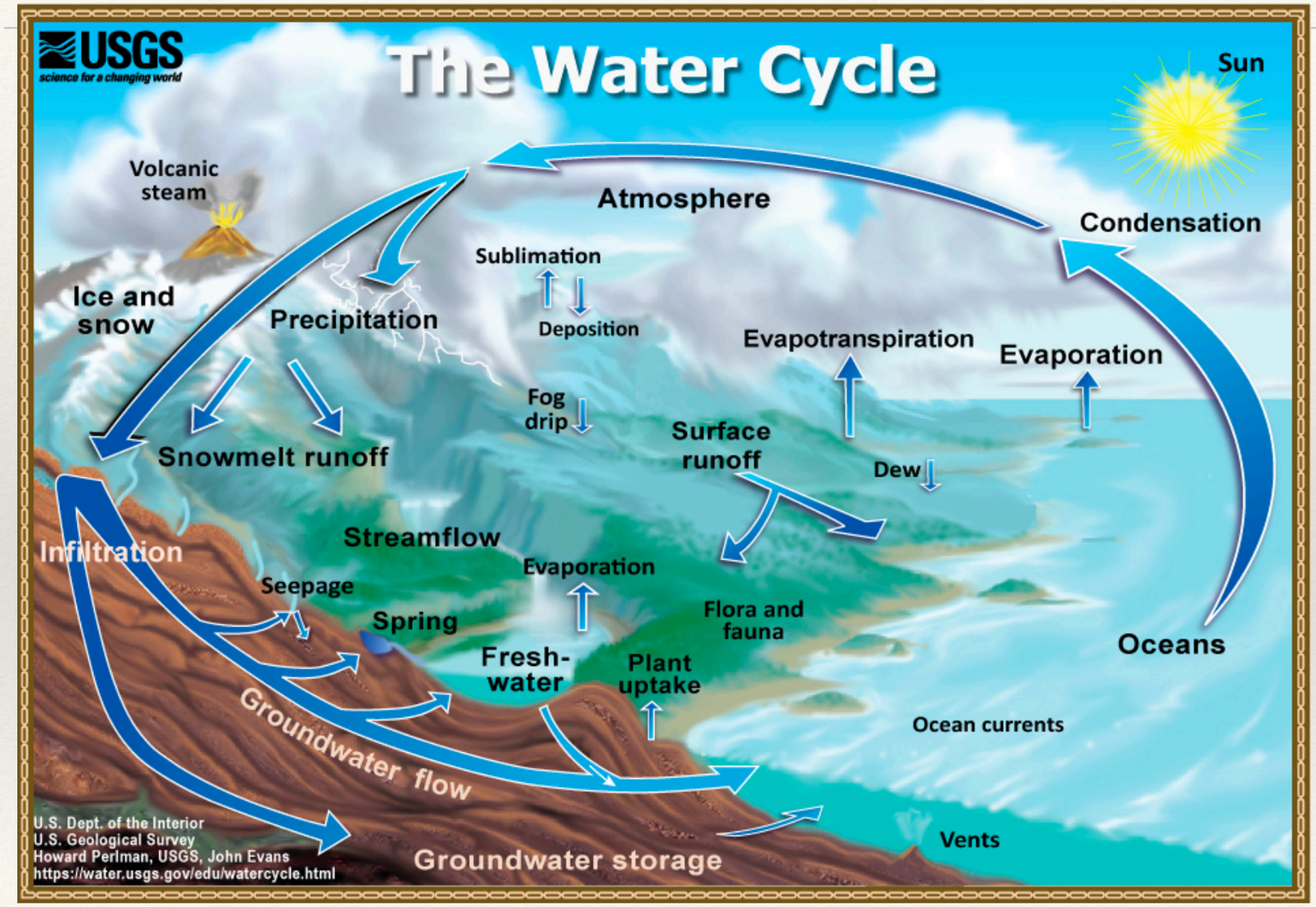


Fig. 2. Flow-chart illustrating the working steps of glacial lake detection based on the normalized difference water index (NDWI), lake-outburst probability assessment and lake classi fi cation in the Indian Himalayas.
Rouce et al., Hydrol. Earth Syst. Sci., 20, 3455–3475, 2016 www.hydrol-earth-syst-sci.net/20/3455/2016/ doi:10.5194/hess-20-3455-2016

Model assessment

- A diagram of the conceptual model is key -it tells you what the model designer thinks is important!
- When reading papers…selecting models…designing models

Conceptual models of the hydrologic cycle



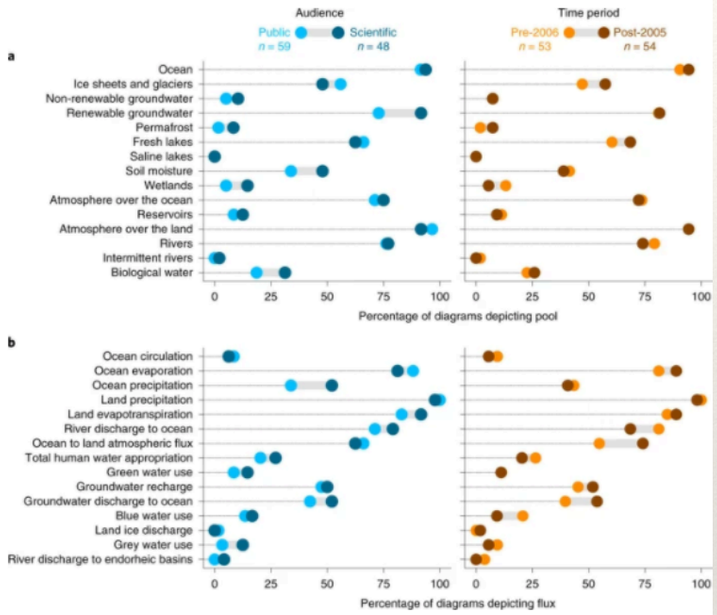
https://water.usgs.gov/edu/watercycle.html

USGS

Critique?

Conceptual models - you can learn a lot by comparing

Fig. 2: Pools and fluxes represented in water cycle diagrams.



a,**b**, Percentage of water cycle diagrams that represent major pools (**a**) and fluxes (**b**) in the global water cycle. Pools and fluxes are ordered by size based on Fig. 1, starting with the largest pool (ocean) and flux (ocean circulation). We categorized diagrams by intended audience and time period. Public diagrams include those made for advertising, advocacy, government outreach and primary or secondary education, whereas scientific diagrams were made for higher education textbooks and peer-reviewed publications. We compared the diagrams made before and after 1 January 2006, which corresponds with the publishing of several high-profile papers that advocated increased integration of social and hydrological systems. The grey bar between points is visible for differences greater than 10 percentage points.

"Here we compiled a synthesis of the global water cycle, which we compared with 464 water cycle diagrams from around the world. Although human freshwater appropriation now equals half of global river discharge, only 15% of the water cycle diagrams depicted human interaction with water

Only 2% of the diagrams showed climate change or water pollution—two of the central causes of the global water crisis—which effectively conveys a false sense of water security""

From AGU abstract Abbott et al., (2019)

Abbott, B.W., Bishop, K., Zarnetske, J.P. et al. Human domination of the global water cycle absent from depictions and perceptions. Nat. Geosci. 12, 533–540 (2019). https://doi.org/10.1038/s41561-019-0374-y

STEPS: Modeling for Problem Solving in ES

1. **Clearly define your goal (question you want to answer, hypothesis you want to test, prediction you want to make) - as precisely as possible**
2. **Develop a conceptual model - draw it!**
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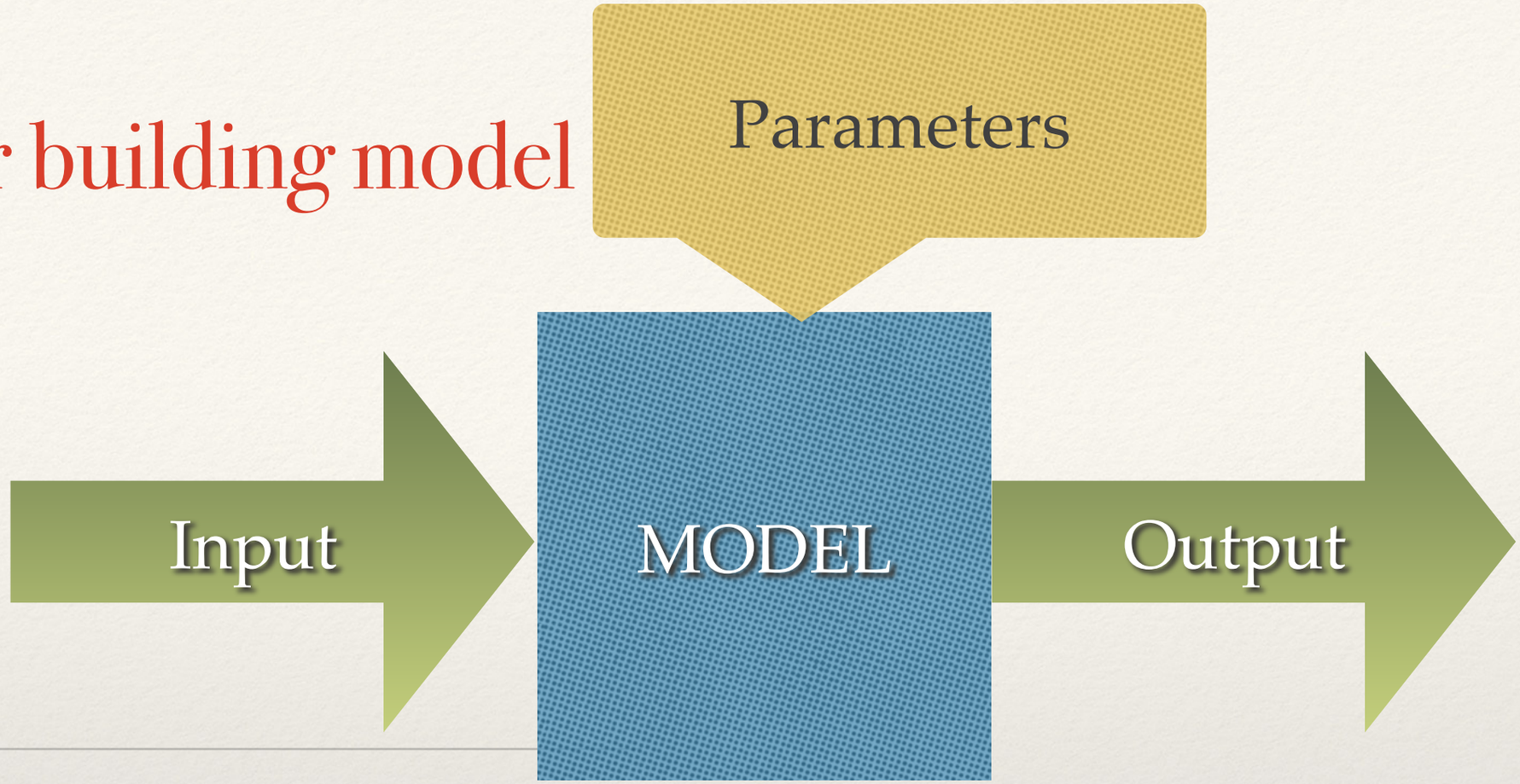
Steps for building model



1. Design conceptual model
2. Translate conceptual model into a mathematical representation
3. Choose programming language
4. Define inputs (data type, units)
5. Define output (data type, units)
6. Define model structure
7. Write model
8. Document the model (meta data)
9. Test model

Conceptual models: What is the box

- *Inputs and Outputs*
  - what
  - temporal resolution, extent
  - spatial resolution, extent
- *System boundaries*
  - determine what is I/O and what is internal

Conceptual models: Whats in the box

- *variables*
  - lego bricks
  - state, fluxes in a process model
  - pieces that make up inside our world/box
- *intermediate products*
  - I/O to different steps in a process

Conceptual models: Whats in the box

- *Relationships variables*
  - causal (warm temp increases mosquito growth)
  - feedback (soil water influences plant growth influences soil water)
- *Process*
  - sequential steps (prioritization of habitat quality)

Conceptual models: Composing

- Differentiate between inputs/outputs, variables (states vs products), intermediate products, relationships
- Relationships are often lines with arrows
- Use shape and color to differentiate I/O, variables …
- Vary level of abstraction (sometimes you start with variables that are submodes in themselves)

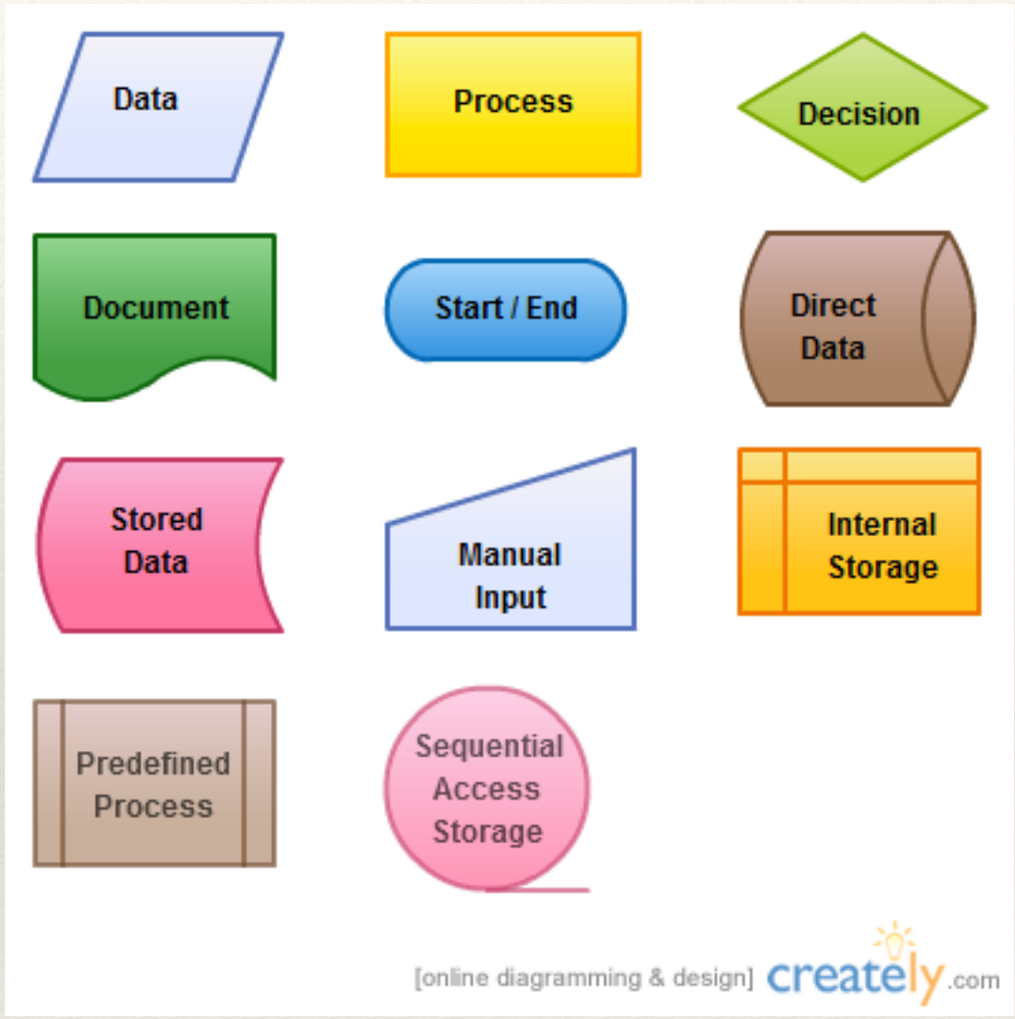
Conceptual models: Composing

- Pictorial representation of how you think about your system, whats included - will tell you really quickly if your model is appropriate for answering specific Qs

Building Models

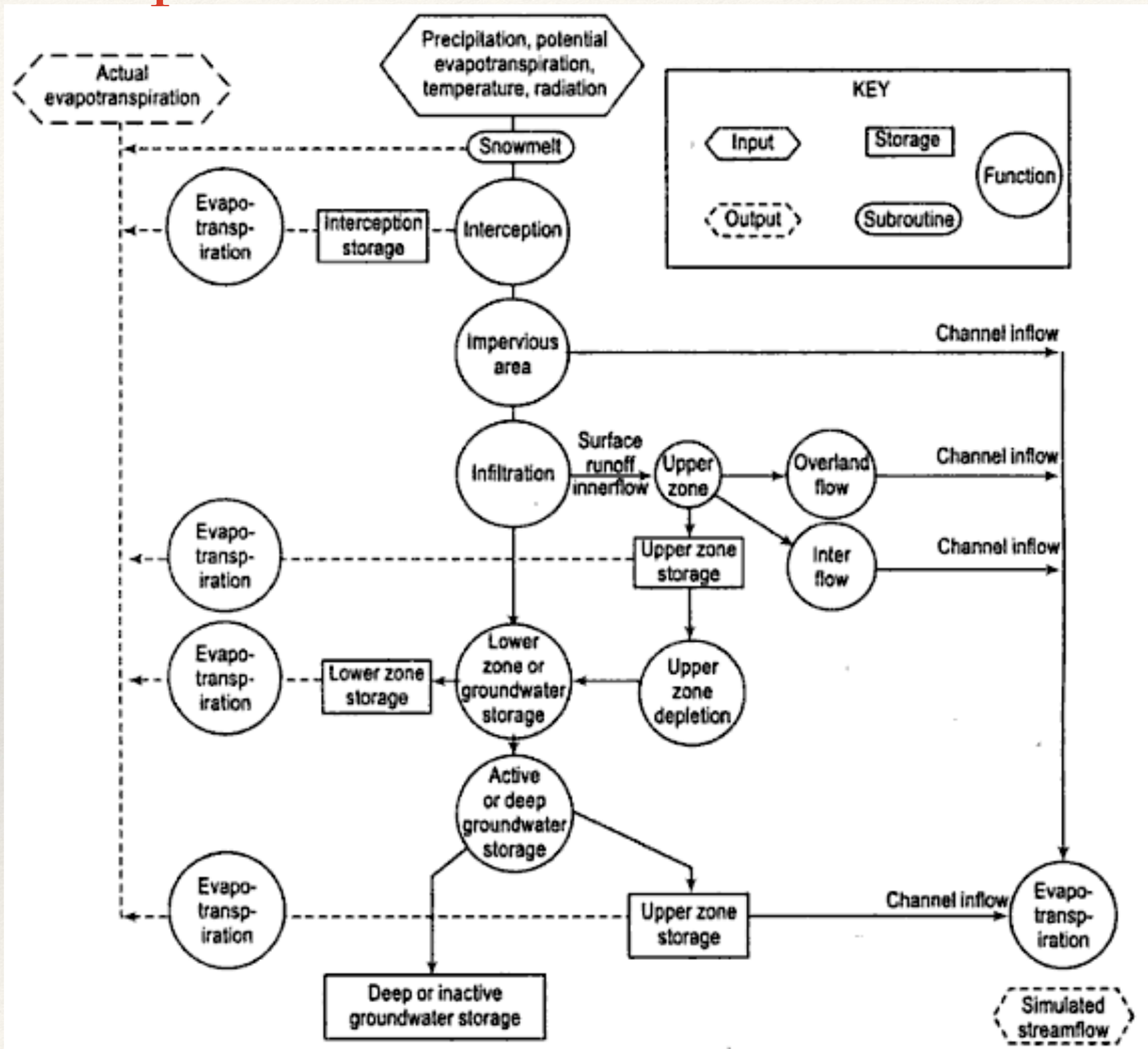
Return to conceptual model; expand to show how you will implement;

Some model designers uses standard symbols for the different

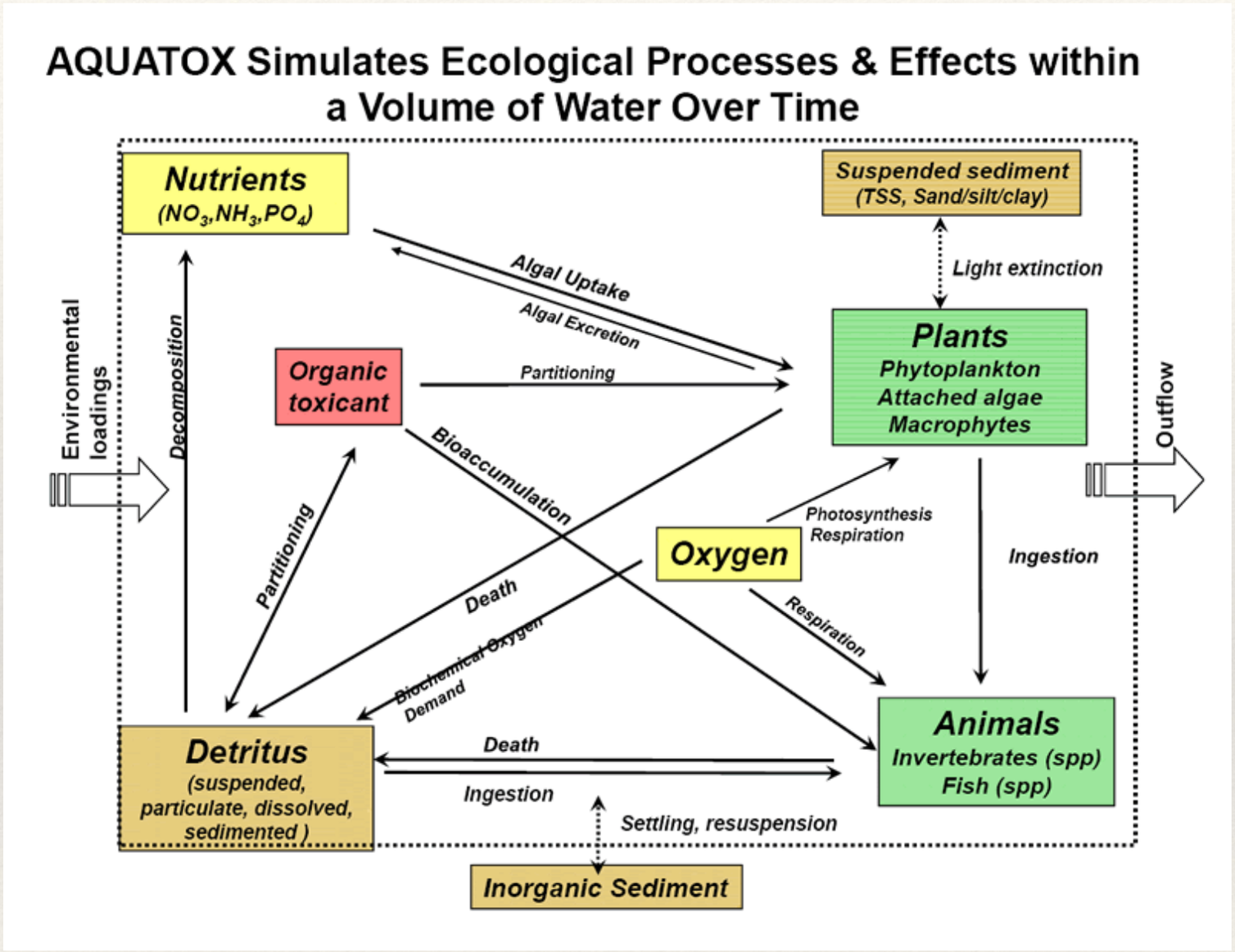


Conceptual Models

- PhD of Norman Crawford under supervision of Ray K Linsley at Stanford University in 1962



Conceptual models: for design of your system



Assignment 1

Assignment 1:

For assignment one we will be creating two conceptual models: one of a model that we will build upon over the next 4 assignments, and the other to present in class. You will work in groups of 3-4.

Conceptual model to be presented in class:

Identify an environmental problem that would benefit from information that could be provided by model. Summarize the goal of the model in a single paragraph. Draw a conceptual model model, which again includes all that apply: inputs, outputs, reservoirs/stores, other intermediate variables or steps, relationships between variables. Put your conceptual model on a single slide and be prepared to present the key inputs and outputs of the model, and the purpose of the model in class

Conceptual model that will be built upon:

This will be a conceptual model of almond yield anomaly. Review the Lobell et al. 2006 paper; specifically look at the equation for almonds in table 2. Draw a conceptual model to represent this equation. Be sure to include all that apply: inputs, outputs. Identify the output (as precisely as you can) on the conceptual model. Be sure to understand what anomaly means! We will go over this together in class. Submit this model as a figure.

Submit the following to gauchospace

1. the one paragraph description of your model
2. the slide with your conceptual model for your selected model
3. slide/figure of the almond conceptual model

Submit as a group

❖