Systems Perspective

Organization...

1. What is a Systems Perspective?
2. Why Think in Systems?
3. Key Concepts/Principles
4. What is Systems Thinking
5. A Systems Language

and if there is time....

6. System Diagramming

System Perspective...

Systems Perspective...

No system can understand itself...

...much less systems of greater complexity

The lion does not understand that he/she's main function in the world is genetic control.

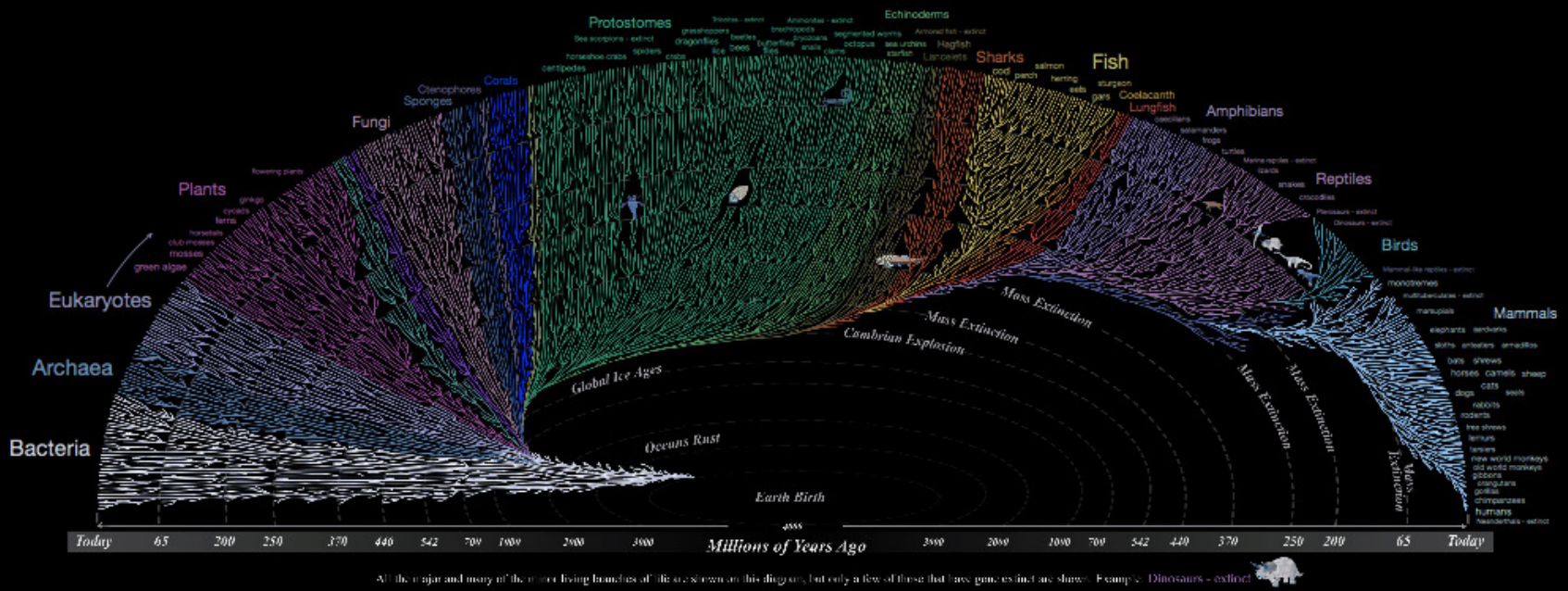
The squirrel does not understand its main function is to plant oak trees.

Systems Perspective...

To gain insight into the complex systems of humanity and nature...

We must aggregate complexity developing insight and understanding using analogous systems for comparison

…and learn from natural systems that have had millions of years of evolution to test and retest systems configurations



Systems Perspective...

Definitions…

System - a set of components comprising a whole where each component interacts with or is related to at least one other component and they all serve a common objective.

Systems are defined by three things:

- Elements
- Interactions
- Purpose of Function

Systems Perspective...

Definitions…

ELEMENTS

Component - an artifact that is one of the individual parts of which a composite entity is made up; a constituent element of a system

Driver - a parameter that controls the behavior of a system. Drivers can be either external or internal to a system.

INTERCONNECTIONS

Flows – information, materials and energy flows between elements

Processes - a naturally occurring or designed sequence of actions taken to achieve a particular end.

PURPOSE or FUNCTION

Purpose - the reason for which a systems exists or the activity (role) of a system

Systems Perspective...

The systems approach integrates the analytic and the synthetic methods, encompassing both holism and reductionism.

It was first proposed under the name of "General System Theory" by the biologist *Ludwig von Bertalanffy*.

Analytic - to analyze…to take apart, break into component pieces
Synthetic - the put together…to consider as a whole

Why Think Systems...?

Systems Thinking...

In a world growing ever more complicated, crowded, and interdependent, Thinking in Systems helps to avoid confusion and helplessness, the first step toward finding proactive and effective solutions.

Donella Meadows
"Thinking in Systems," 2008

Systems Thinking...

As our world continues to change rapidly and become more complex, systems thinking will help us manage, adapt, and see the wide range of choices we have before us.

It is a way of thinking that gives us the freedom to identify the causes of problems and see new opportunities.

Donella Meadows
"Thinking in Systems," 2008

Systems Thinking...

Systems Theory: the transdisciplinary study of the organization of phenomena, independent of their substance, type, or spatial or temporal scale of existence. It investigates both the principles common to all complex entities, and the models which can be used to describe them.

Systems Thinking...

Rather than reducing an entity to the properties of its parts or elements, systems theory focuses on the arrangement of and relations between the parts which connect them into a whole (holism).

The same concepts and principles of organization underlie the different disciplines (physics, biology, technology, sociology, etc.), providing a basis for their unification.

Systems Thinking...

How to know if you are looking at a system and not just a collection of objects:

1. Can you identify different parts?...and
2. Do the parts affect each other?...and
3. Do the parts produce a behavior that is different from the behavior of each part by itself?

Donella Meadows
"Thinking in Systems," 2008

Key Concepts...

Key Concepts...

System: An organized entity made up of interrelated and interdependent parts.

Boundaries: Define a system and distinguish it from other systems in the environment.

Feedback Loop: The process by which a system self-corrects based on reactions to changes that affect its sources

Key Concepts...

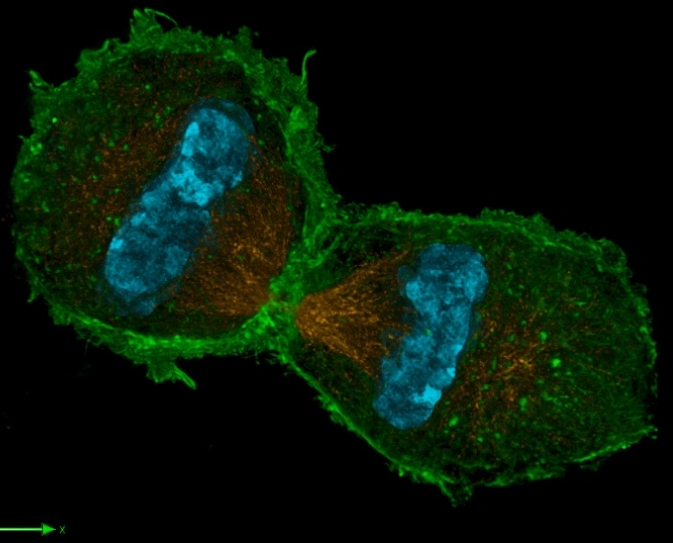
Homeostasis: The tendency of a system to resist change and maintain status quo.

Adaptation: The tendency of a system to make the changes needed in structure and function that allow the system to adjust to change.

Key Concepts...

Autopoiesis: auto- meaning “self” and poiesis, meaning “creation or production”. A system that is organized to continuously reproduce its own parts and structure (Living systems)

Autocatalysis: a form of positive feedback wherein the effect on every consecutive link in the feedback loop is positive.



Key Concepts...

Emergent Process: *emergence* occurs when an entity is observed to have properties its parts do not have on their own. These properties or behaviors emerge only when the parts interact in a wider whole.

For example, smooth forward motion emerges when a bicycle and its rider interoperate, but neither part can produce the behavior on their own.

Key Concepts...

Hierarchy: the overall emergent structure of systems where smaller subsystems form part of larger systems which in turn form part of even larger systems

Key Concepts...

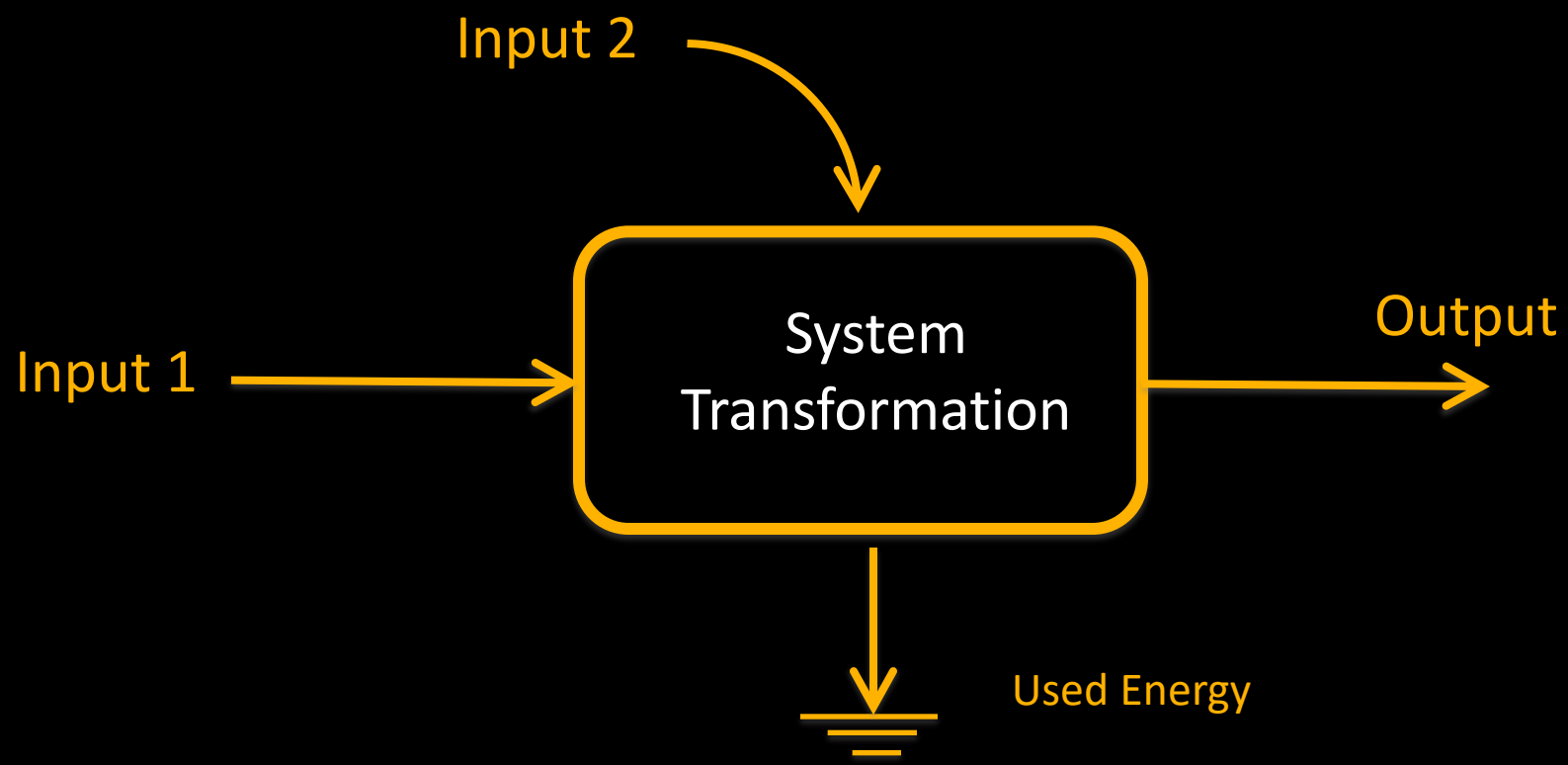
Maximum Power Principle: Systems that survive use energy they obtain in their own maintenance and in the capture of more energy.

Systems Principles...

System Principles...

1. Energy & Systems

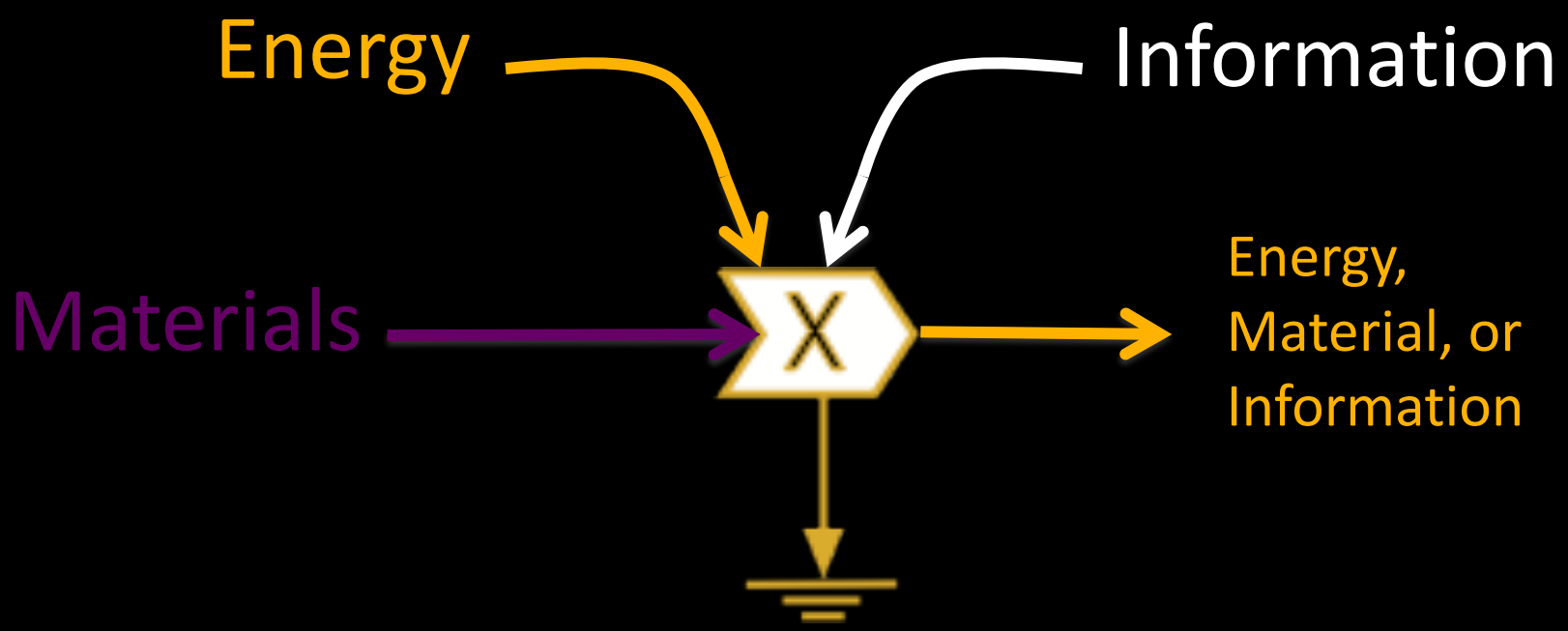
Systems transform inputs of energy and resources



System Principles...

2. Energy Transformations

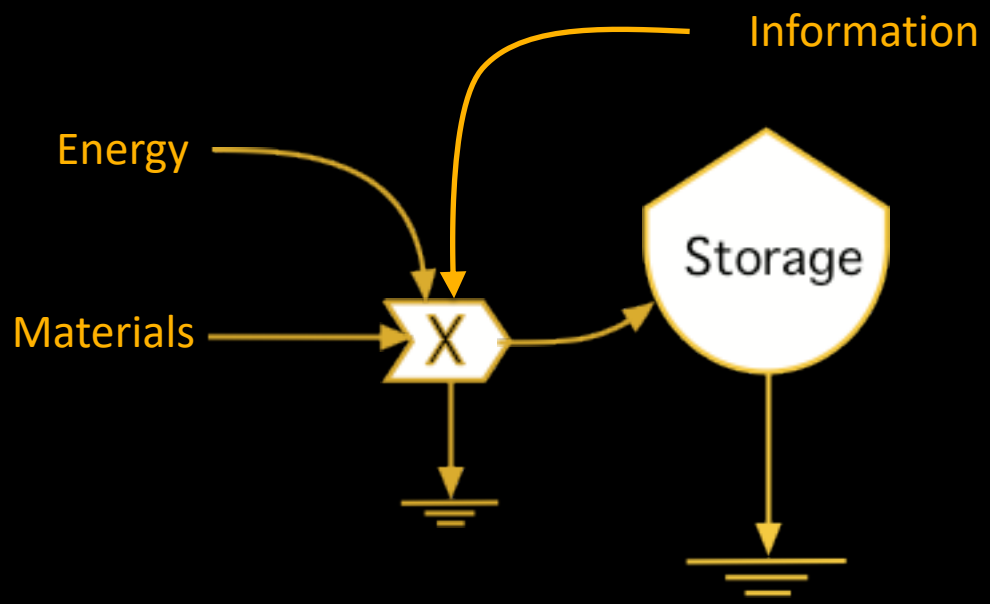
All Transformations require three forms of input,
Energy, Materials and Information



System Principles...

3. Storage & Structure

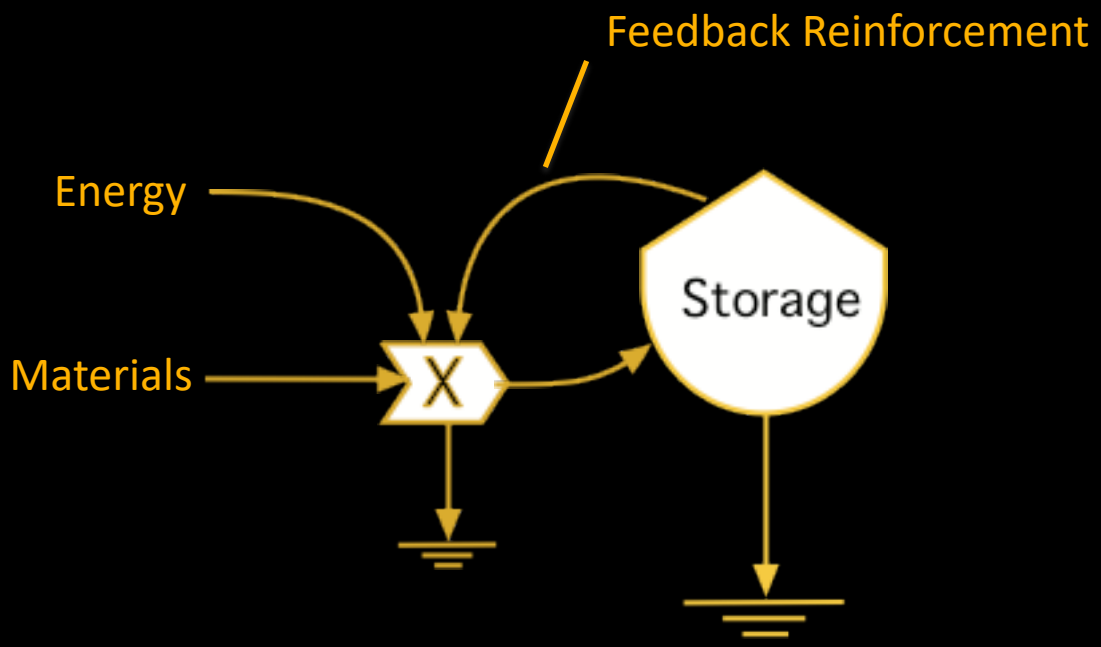
All systems develop high quality storages of materials, energy and information.



System Principles...

4. Feedback Reinforcement

A main property of systems is the use of high quality storages in positive feed back actions



Systems Thinking...

Systems Thinking...

Systems thinking is a set of synthetic/analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviors, and devising modifications to them in order to produce desired effects.

Arnold, R.D. and J.P. Wade. 2015. Definition of Systems Thinking: a systems approach. Procedia Computer Science 44:669-678

Systems Thinking...

Elements of Systems Thinking...

1. Recognizing interconnections
2. Identifying and understanding feedback
3. Understanding system structure
4. Differentiating types of stocks, flows, variables
5. Identifying and understanding non-linear relationships
6. Understanding dynamic behavior
7. Reducing complexity by aggregation and modeling systems

Arnold, R.D. and J.P. Wade. 2015. Definition of Systems Thinking: a systems approach. Procedia Computer Science 44:669-678

Systems Thinking...

Finally....

Systems Mapping.

Systems mapping is a key tool of the systems thinker.

There are many ways of mapping, but they all share common practices....they show the interconnections between components, the flows between them and the processes that bind them together.

Energy Systems Diagrams...


Systems Language...

System Language...

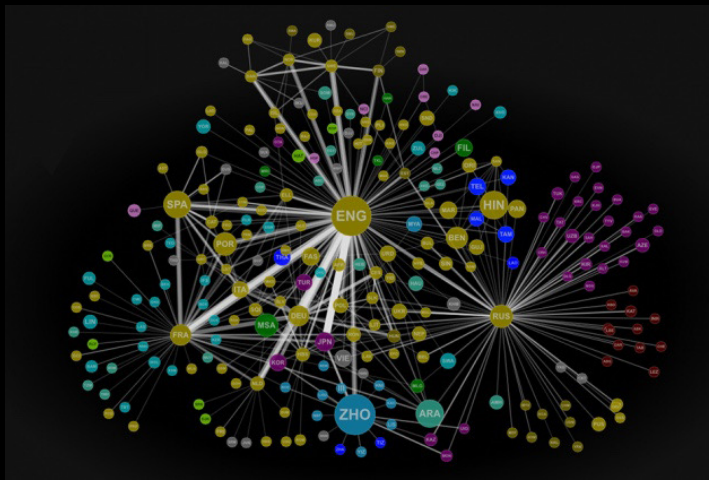
Why a systems language?

To convert non-quantitative verbal (or cerebral) models to… more quantitative, more accurate, more predictive, more consistent, and less confusing network diagrams

System Language...

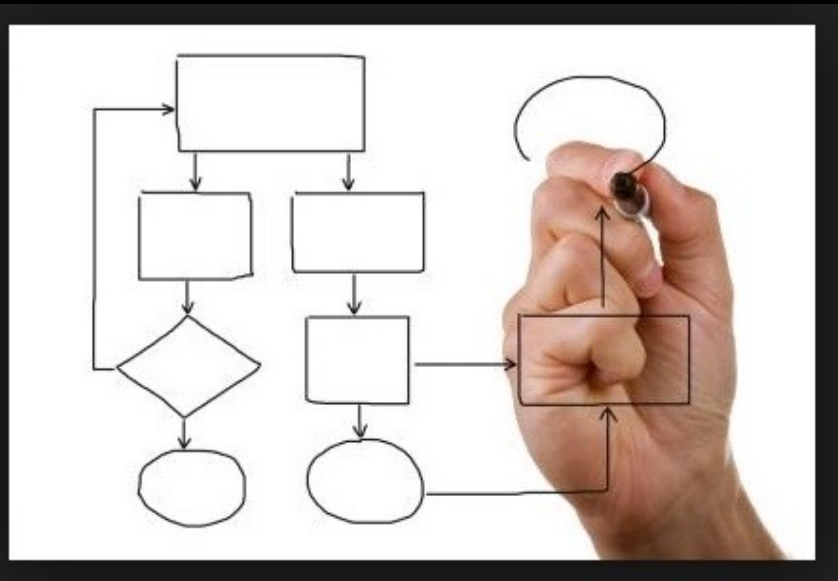
Language - a system of visual, auditory, or tactile symbols of communication and the rules used to manipulate them.

System Diagramming Language - a set of symbols and formal grammar, syntactic, and semantic rules, to communicate structure and relationships of systems.



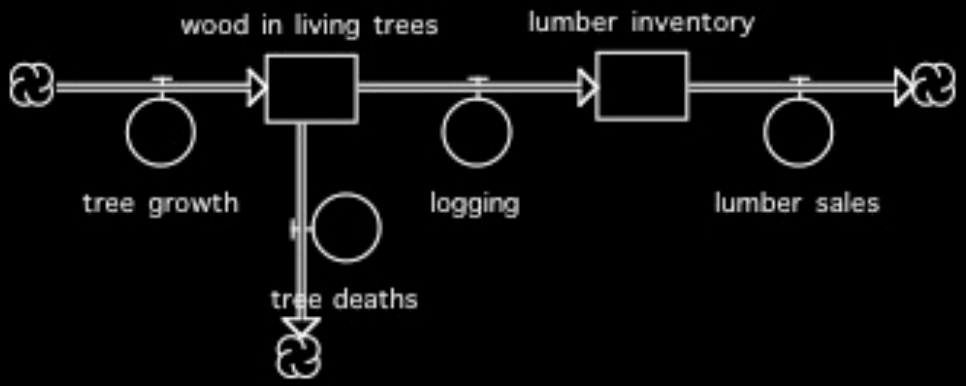
System Language...

Graphical modeling languages - a diagram technique with named symbols that represent concepts and lines that connect the symbols and that represent relationships and various other graphical annotations to represent constraints.



System Language...

System Diagram - the highest level view of a system, showing the system as a whole, its components, their interactions, and its inputs and outputs from/to external factors.

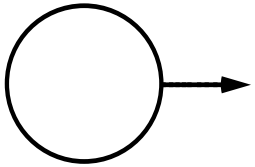


ENERGY SYSTEMS SYMBOLS

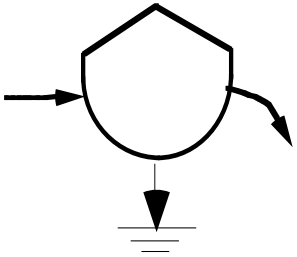
System Frame: A rectangular box drawn to represent the boundaries of the system selected.

System Language...

Pathway Line: a flow of energy, often with a flow of materials.

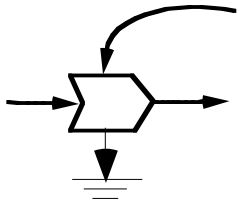


SOURCE: outside source of energy; a forcing function

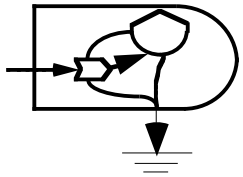


STORAGE: a compartment of energy storage within the system storing quantity as the balance of inflows and outflows

System Language...



INTERACTION: process which combines different types of energy flows or material flows to produce an outflow in proportion to a function of the inflows.



PRODUCER: unit that collects and trnasforms low-quality energy under control interactions of higher quality flows.

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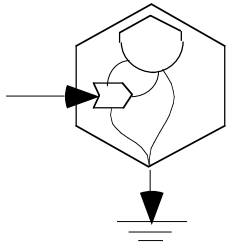
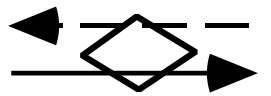
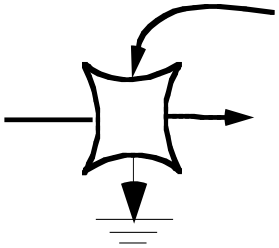


CONSUMER: unit that transforms energy quality, stores it, and feeds it back autocatalytically to improve inflow

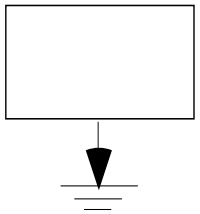
System Language...



TRANSACTION: a unit that indicates the sale of goods or services (solid line) in exchange for payment of money (dashed line).



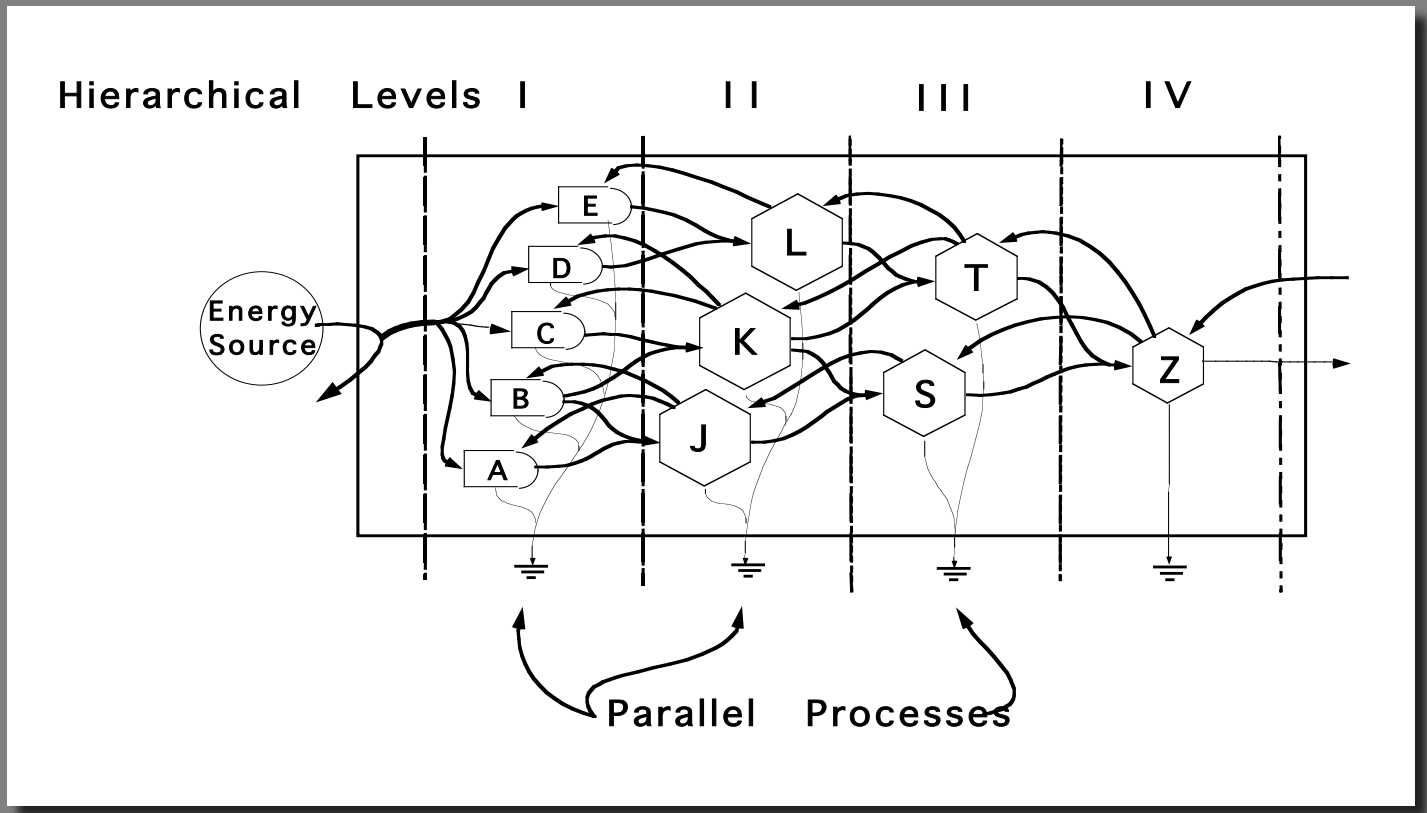
SWITCHING ACTION: symbol that indicates one or more switching functions where flows are interrupted or initiated.



BOX: miscellaneous symbol for whatever unit or function is labled.

System Language...

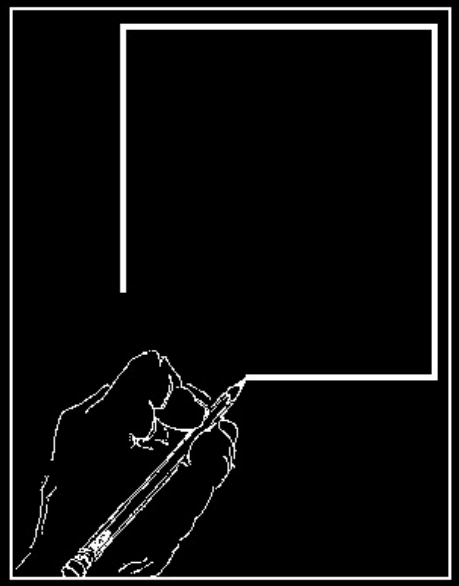
Systems are organized hierarchically &
Energy flows from left to right



System Diagramming...

System Diagramming...

Procedures for Drawing a Systems Model



1. Draw the frame of attention that selects the boundary
2. Make a list of the important input pathways that cross the boundary
3. Make a list of the components believed to be important
4. Make a list of the processes believed to be important within the defined system.

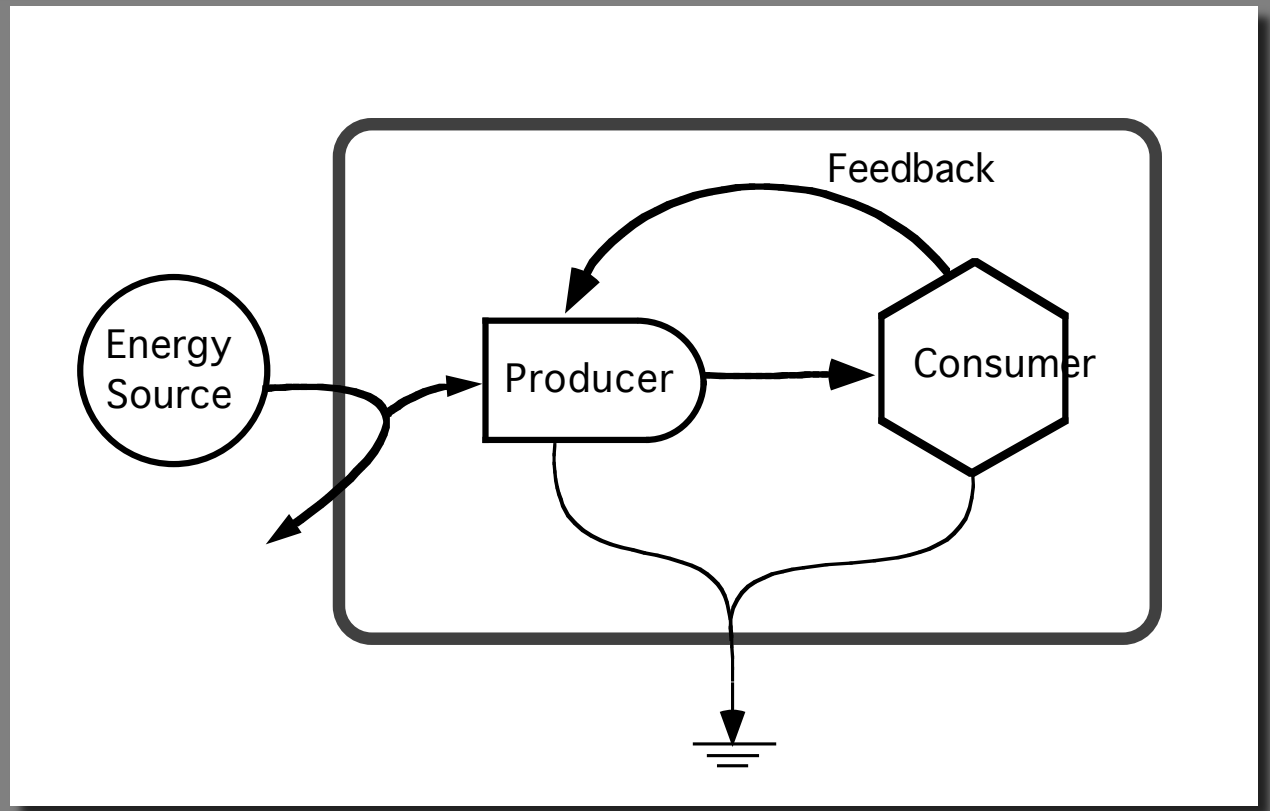
Procedures for Drawing a Systems Model

5. Remember that matter is conserved.
6. Check to see that money flows form a closed loop within the frame and that money inflows across the boundary lead to money outflows.

System Diagramming...

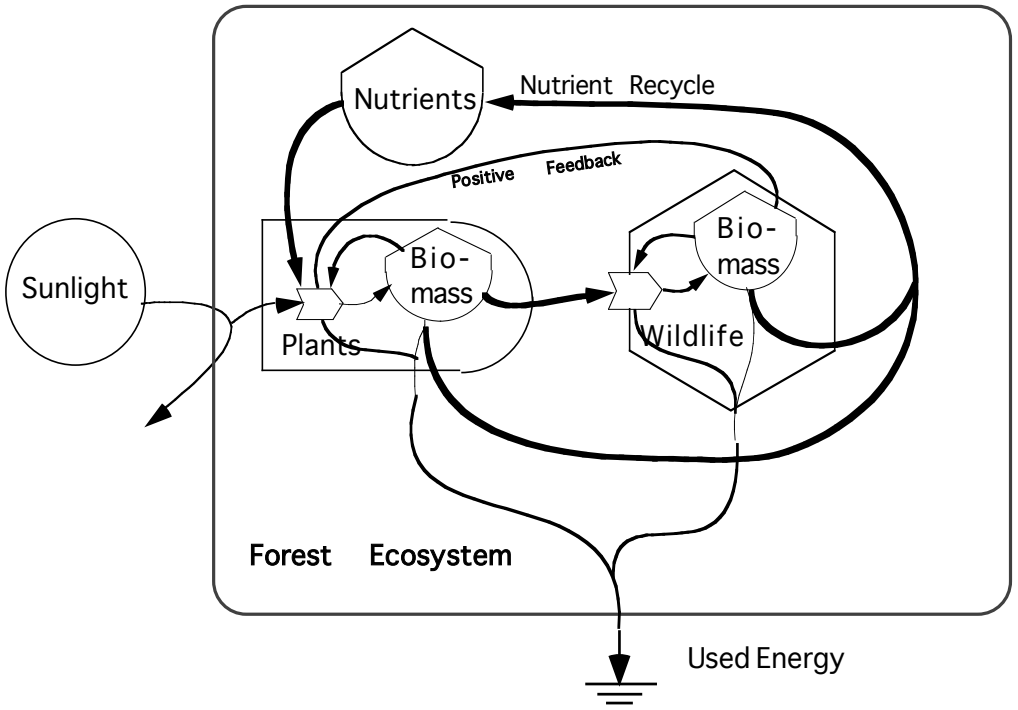
Diagramming Conventions….

Simple diagram of a forest...



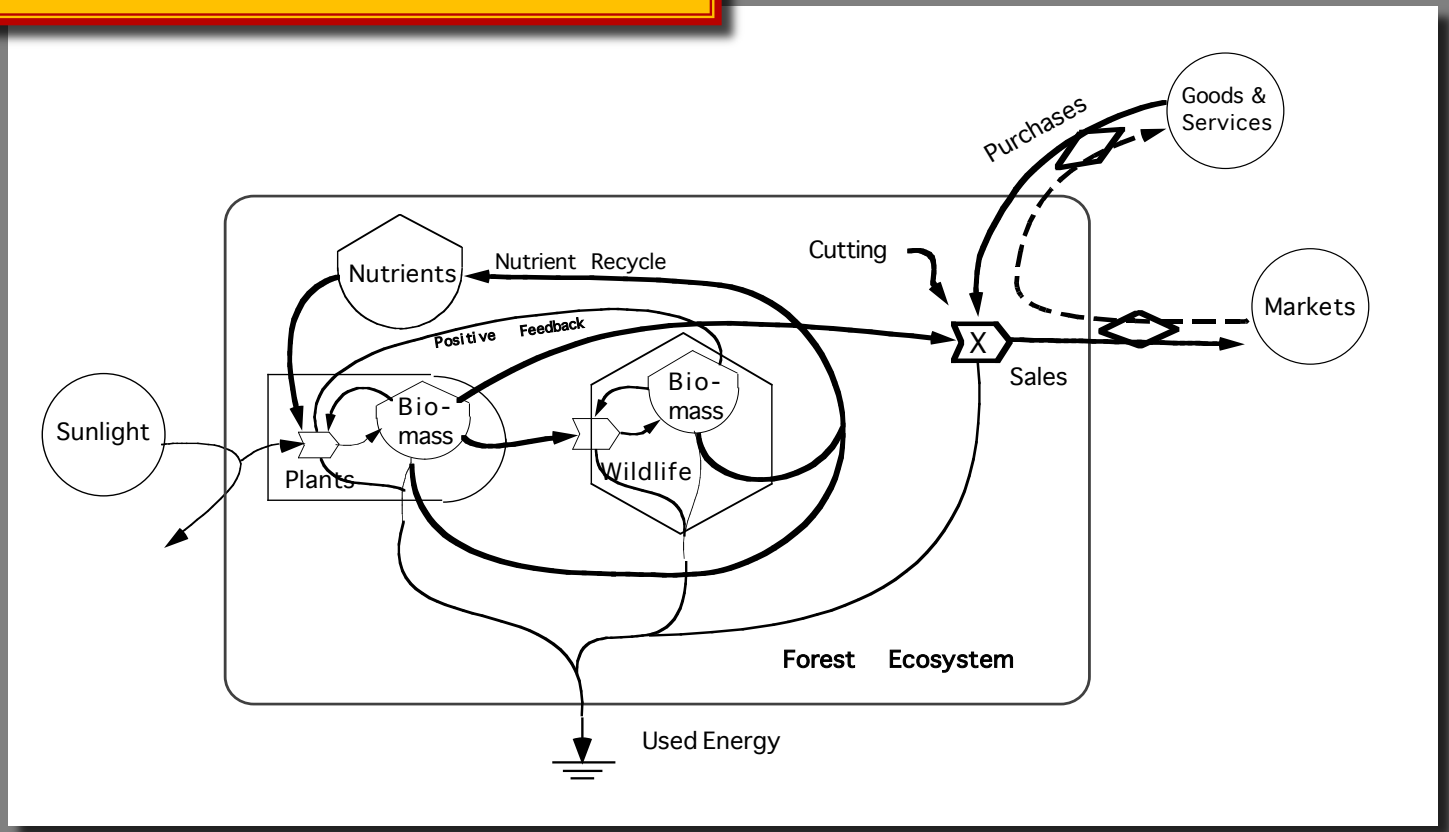
System Diagramming...

A more complex diagram of a forest...



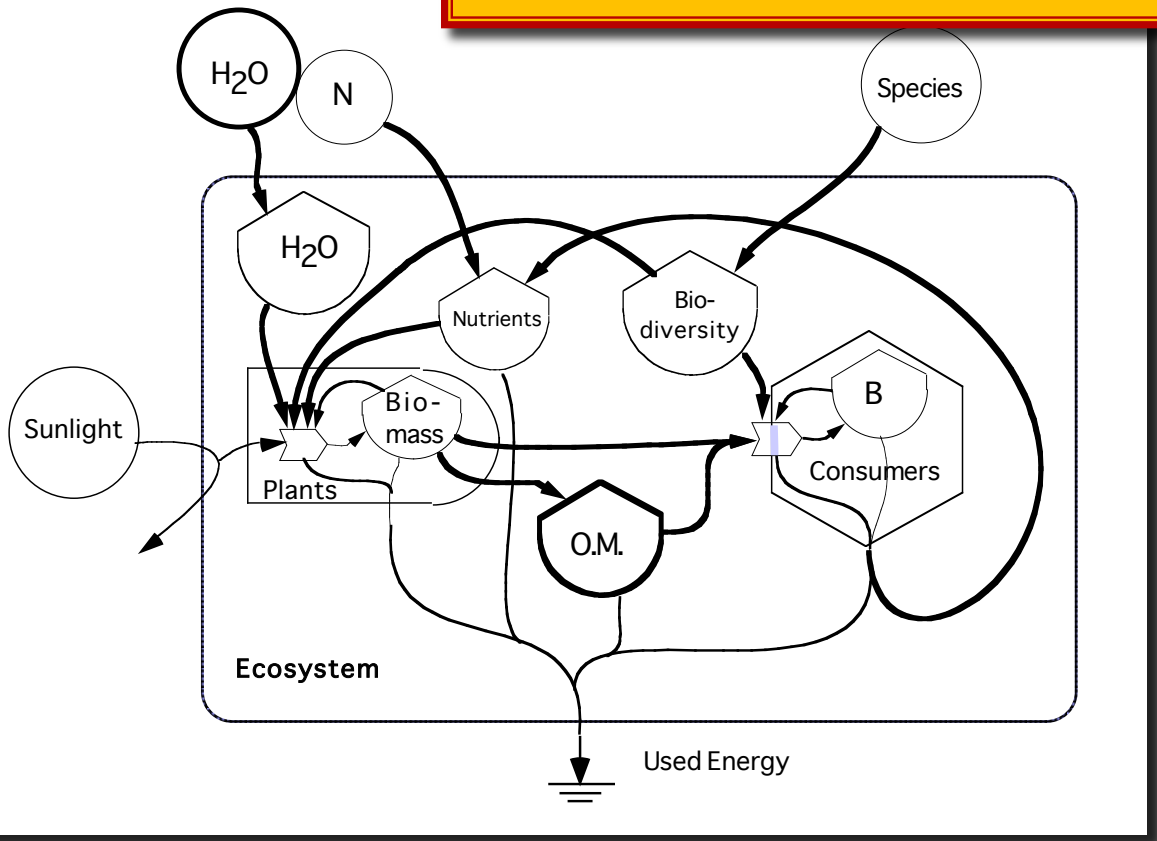
System Diagramming...

Adding more complexity...

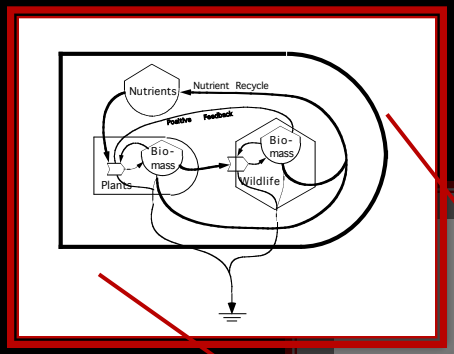


System Diagramming...

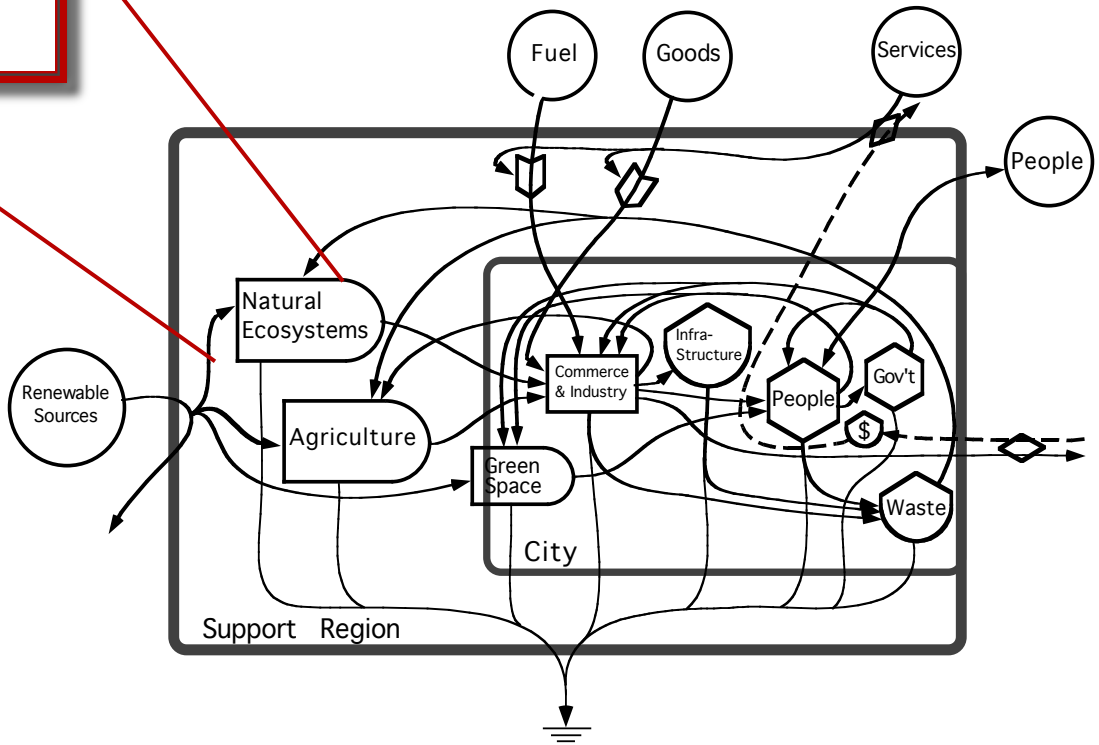
A generic ecosystem...



System Diagramming...

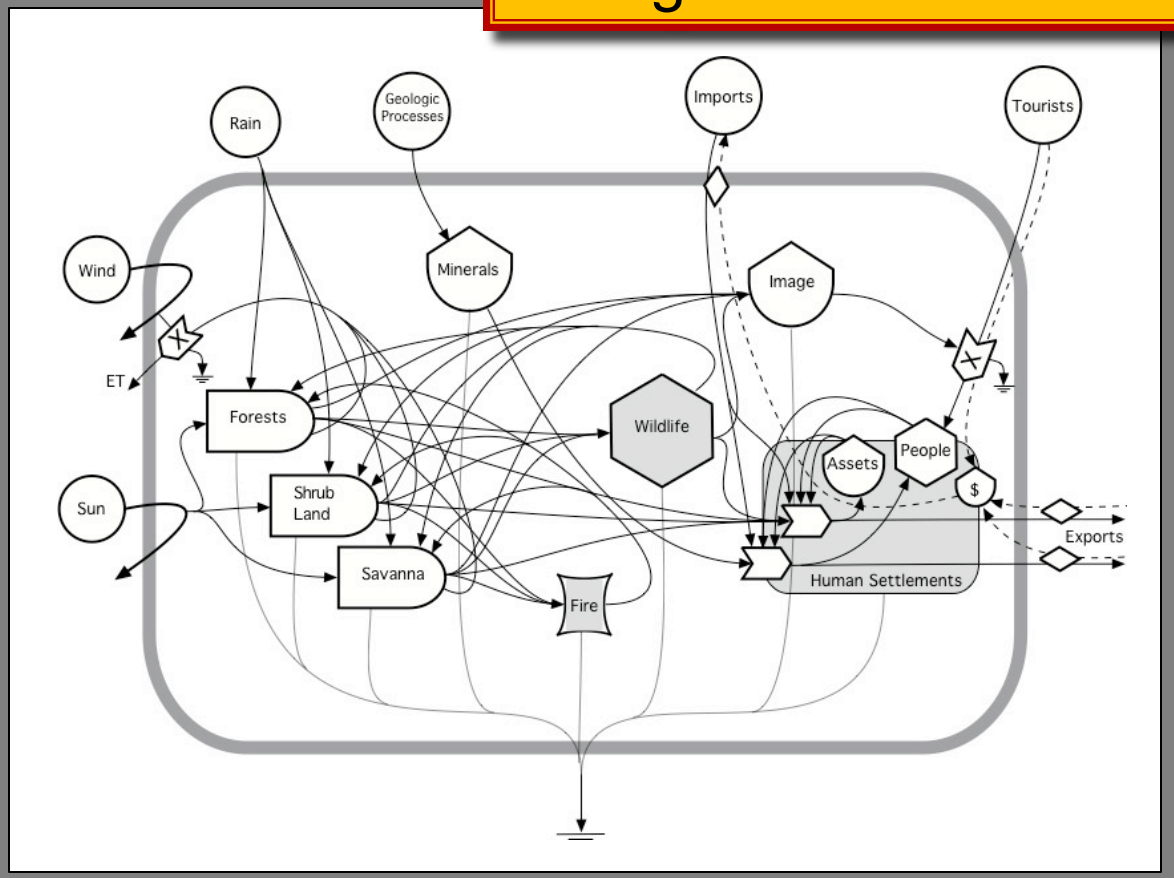


A city & support region...



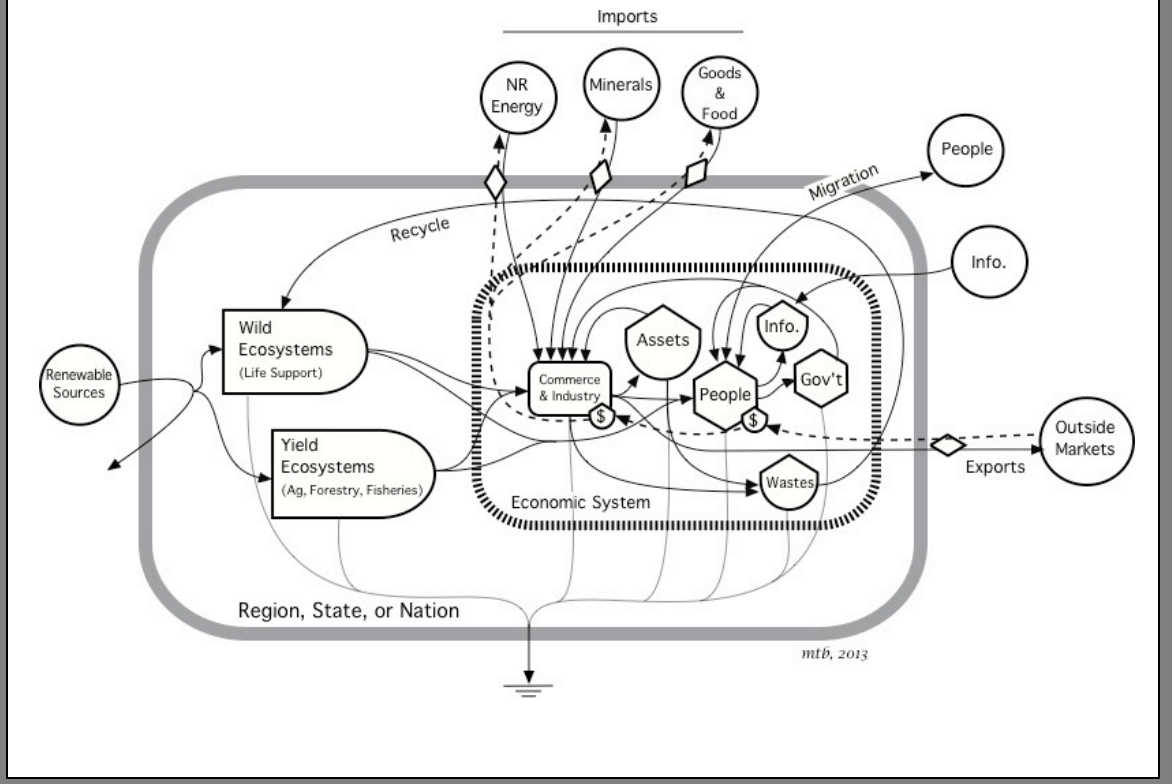
System Diagramming...

A diagram of S. Africa...



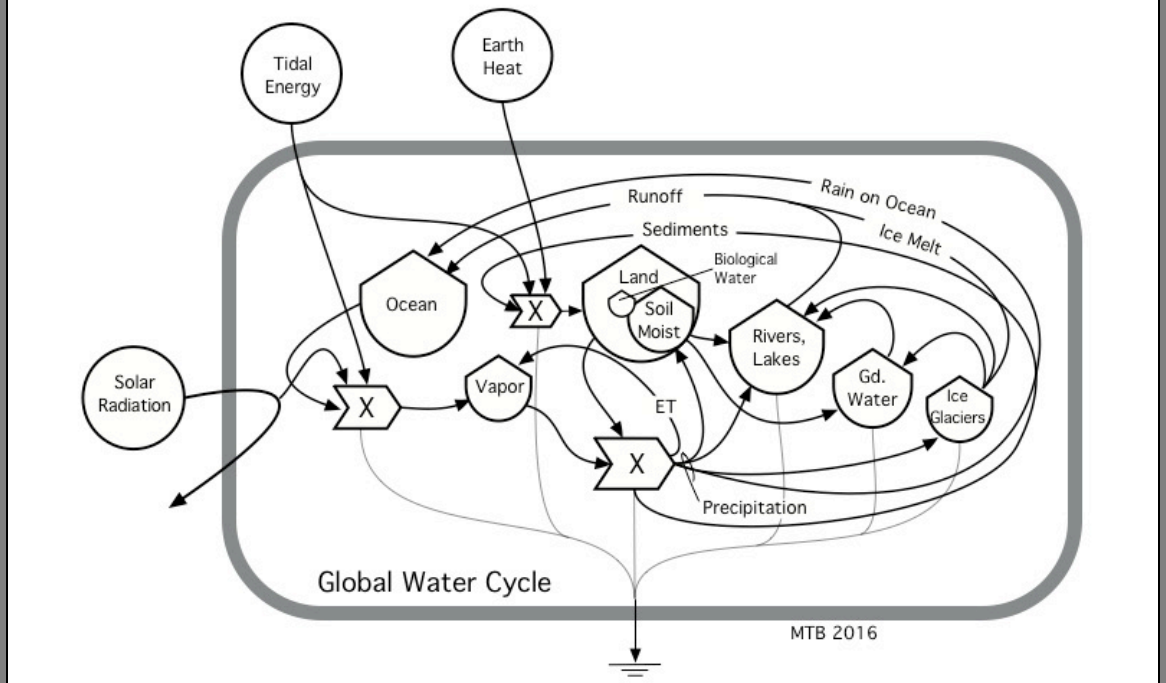
System Diagramming...

Diagram of Region...



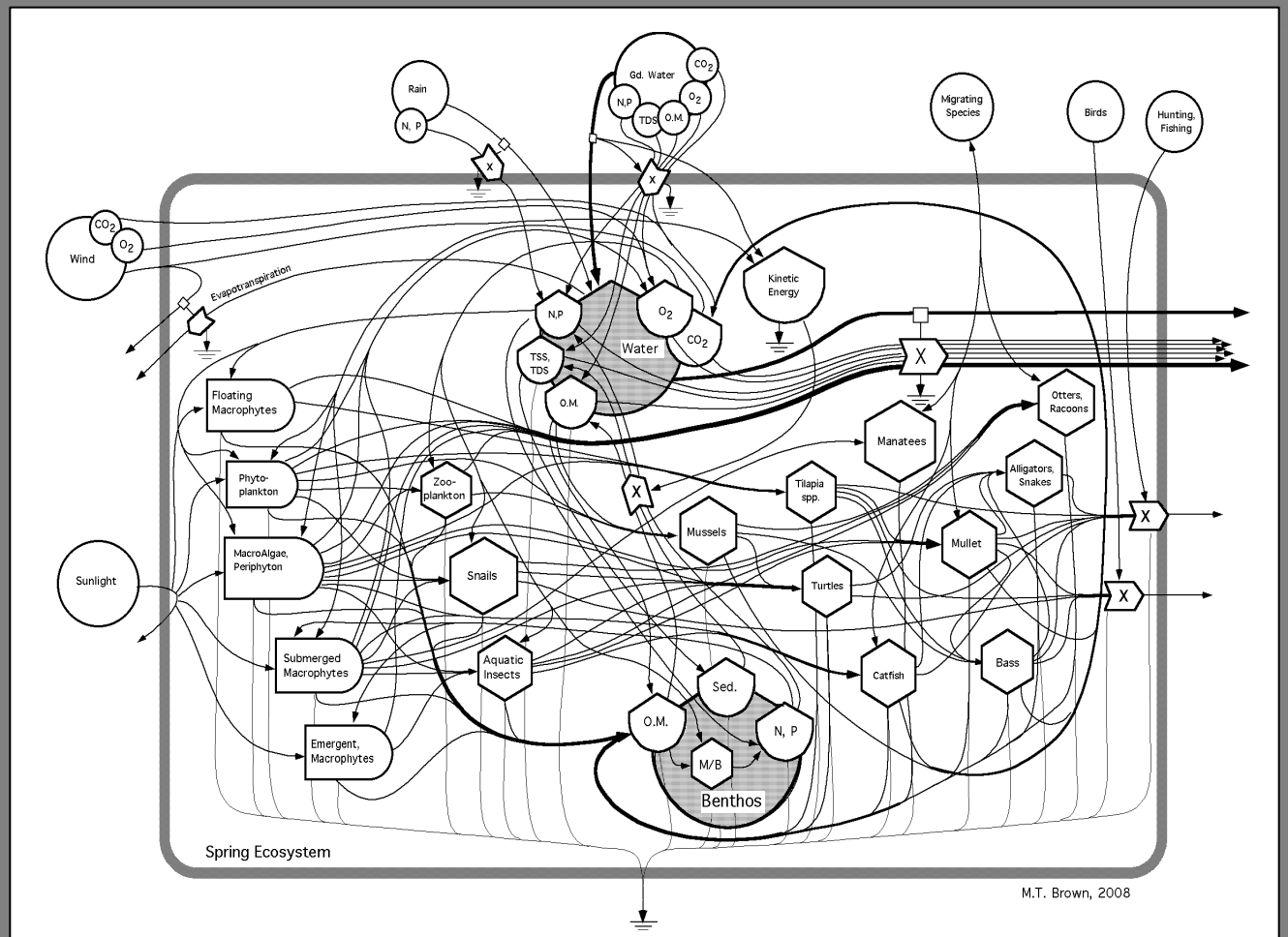
System Diagramming...

Global Water Cycle...



System Diagramming...

Silver Springs, Florida...



Questions?