1.2 Systems and Models

1.2.1 Ecosystem Scales

a) Small scale – Local

b) Large scale – Biome (a collection of ecosystems with similar climatic conditions, precipitation and temperature and insolation)

c) Global – Gaia

1.2.2 Open system, closed system and isolated system

- An open system exchanges matter and energy with its surroundings (for example, an ecosystem). Most systems are open systems. All ecosystems are open systems exchanging matter and energy with their environment.

- A closed system exchanges energy but not matter. No natural closed systems exist on Earth but the planet itself can be thought of as an “almost” closed system. The “Biosphere II” experiment (a prototype city) was an attempt to model this in Arizona in the 1980’s. The experiment failed and the result shows how difficult it is to make a sustainable closed system. So, strictly, closed systems do not occur naturally on Earth, but all the global cycles of matter, for example, the water and nitrogen cycles, approximate to closed systems.

- An isolated system exchanges neither matter nor energy. No such systems exist (with the possible exception of the entire universe).

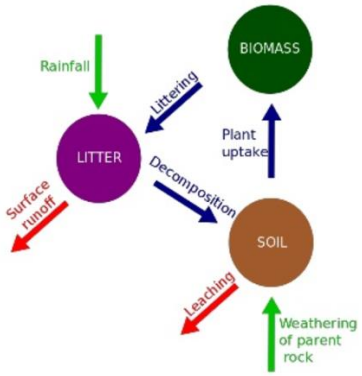
System	Energy exchanged	Matter exchanged
Open	Yes	Yes
Closed	Yes	No
Isolated	No	No

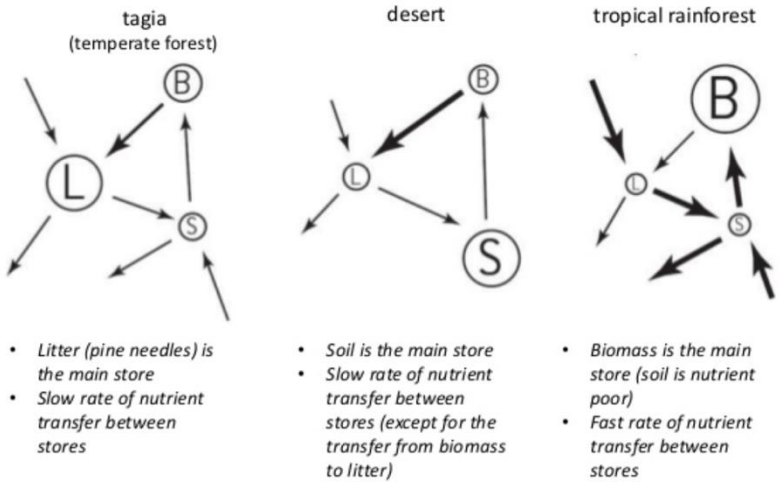
1.2.3 Transfer and transformation processes (Gersmehl diagrams 1976)

Transfers are processes that involve a change in location within a certain system but no change in state, for example water flowing from ground water into a river.

Transformations lead to the formation of new products (photosynthesis) or involves a change in state (water evaporation)

Diagrams showing differences in nutrient flow and storage between ecosystems:





1.2.4 Models

A model is a simplified version of reality used to understand how our system works and to predict how it will respond to a change. It inevitably involves some approximation and therefore lots of accuracy.

Advantages:

- Easier to work with than complex reality
- Can be used to predict effect of a change of input
- Can be applied to other similar situations
- Can help to see patterns
- Can be used to visualize really big or really small things

Disadvantages:

- Accuracy is lost because the model is simplified
- If assumptions are wrong, model will be wrong
- Predictions can be inaccurate

1.2.2 First and Second Laws of Thermodynamics

The **first law of thermodynamics** concerns the conservation of energy. According to this law, energy is neither created nor destroyed. What this really means is that the total energy in an isolated system, such as the entire universe, is constant. All that can happen is that the form the energy takes changes.

For example, in a food chain, the energy enters the system as light energy.
→ Through photosynthesis it is converted to stored chemical energy (eg. glucose).
→ The stored energy is passed along to consumers as food. Therefore, no new energy is created, it is just passed along the food chain.

Keep in mind that not all light energy is used for photosynthesis:

- 30 % is reflected back into space
- 50 % is converted to heat
- Most of the rest is used to power the hydrological cycle: rain, wind, evaporation etc.
- Less than 1 % is used for photosynthesis

The **second law of thermodynamics** states that the **entropy** of an isolated system not in equilibrium will tend to increase over time. What this really means, is that energy conversions are never 100 % efficient.

When energy is transformed into work, some energy is always lost to the environment as waste heat. Entropy refers to the spreading out or dispersal of energy, so there will always be a reduction in the amount of energy passed to the next trophic level.

→ Energy = work + heat (and other wasted energy)