Energy flow and ecosystem dynamics and wood energy in forest ecosystems

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All living beings in the world need energy for the growth and survival. For this purpose the ultimate energy source is the Sun which supplies the energy continuously for the Earth. All times some part of the Earth receives solar energy in different quantities according to the shape of the Earth.

The amount of the solar energy reaches the Earth is very small compared to the total energy emission from the Sun. The reason is the absorption and the reflection of the energy by the air molecules and clouds in the atmosphere. Only 35 % of the solar radiation reaches the Earth as direct radiation and other 20% is reaches as scatter or diffused radiation.

On an average 0.1% of the incoming solar energy is fixed by green plants known as the producers by photosynthesis. These plants absorb the energy and carbon dioxide from the atmosphere and water and nutrients from soil through the root system. Within the chlorophyll pigments, the energy is fixed as carbon as shown in the following equation.

$$CO_2 + H_2O \xrightarrow{Chlorophyll,\ Energy} C_6H_{12}O_6 + H_2O + O_2$$

The photosynthetically active portion of sunlight (PAR) is captured by plants in the process of photosynthesis. The annual dry matter production is 150-200 billion tons of organic matter.

The portion of PAR captured depends on the surface area of leaves and on the efficiency of converting PAR into high-energy organic molecules. Above two factors are determined by the availability of site resources such as nutrients and water. Interaction between foliage and solar radiation results in net photosynthesis. Some of the photosynthate produced is used by the plant as an energy source and the energy and carbon substrates produced are lost via respiration.

The energy fixed by a single plant is not significant in dry matter production. However, in an ecosystem level, it is definitely an important process. An ecosystem is defined as the place where the interaction can be observed between living and non-living parts, and the flow of materials and energy between these parts. Components of an ecosystem can be divided into biotic and biotic communities. Biotic community is composed of plant, animal and microbial communities. Atmosphere and soil or geological substrate complete the abiotic community.

Ecosystems can be divided into many forms. The following table shows one of the commonest ways to categorize the ecosystems and their productivity.

Vegetation type	Production, gm^{-2}, yr^{-1}
Sea grasses	14,600
Coral reefs	3,600-9,100
Tropical forests	1,500-3,000
Temperate forests	1,100-1,500
Dry deserts	200

According to the above table, sea grass has the highest productivity per unit area. Tropical forest and temperate forests become to second and third place respectively. The forests are the most important ecosystems in wood energy aspect.

Other than the energy all other materials recycle in the ecosystems. Energy is not cycled and it passes through the systems once and lost to the environment. Therefore it has to be continuously supplied. The unconsumed producers and all the herbivores and the carnivores die after some time. The energy flow from the producers to different consumer levels can be constructed as a pyramid. At the bottom of the pyramid known as the first tropic level, the producers can be identified. The producers construct the food through photosynthesis and then the herbivores known as primary consumers consume the plants for their energy requirements. These primary consumers are eaten by the secondary consumers also known as carnivores. These carnivores such as big fish can be consumed by the tertiary consumers such as man at the forth level of the energy pyramid. From one level to the other only 10% of the energy is passed and the rest is not consumed and therefore the energy wastage is very high from one tropic level to the other. Therefore if a pyramid is constructed using the producers and the consumers, at the bottom the largest number which is the producers can be found. Top of that the second tropic level, the primary consumers can be found and the least number is observed at the top of the pyramid which is the tertiary consumer.

The soil system replenishes its nutritional status by materials that are recycled from living and non-living. Dead leaves return the materials to soil. Plants grow, flower, produce seeds and multiply. Animals are born, grow, breed and die. For some time materials are held within the living bodies of plants and animals. After death, microorganisms (bacteria, fungi) breakdown the dead materials and return these to the environment for reuse.

The dead bodies are decomposed by microorganisms and by this procedure, complex matters formed in plant and animal bodies are broken down into chemical molecules. These molecules are then released to the soil to be available for another producer. A system as mentioned above is called a “self sustaining ecosystem” (Dynamic living ecosystem) and no need of external nutrients such as fertiliser to be added.

Interaction between foliage and solar radiation results in net photosynthesis. Some of the photosynthate produced is used by the plant as an energy source and the energy and carbon are lost via respiration.

Concerning the wood energy, among all the ecosystems in the world, forests are the most important parts. As mentioned in early chapters, a minor fraction of the total solar Radiation is fixed by the plants through photosynthesis. This fixed energy can be harvested as fuel wood from forests. The net primary production can be obtained by subtracting the production used for the respiration from the total production as shown in the following equation.

Net primary production (NPP) = Net photosynthesis - Net respiration

NPP can be lost due to the competition among individuals, herbivore actions and insect and disease outbreak.

A loss of energy can also happen trough the biomass loss due to litter fall, leaf death, plant death and the distortion due to herbivores. The rest of called the biomass accumulation, which can be harvested as the final yield. However, when harvesting there might be some losses due to different harvesting systems used by the workers. However, the yield of the forest ecosystems can be affected by many factors. The efficiency of the photosynthesis is influenced by the leaf area and the number of leaves in the canopy and the ability of absorbing water and nutrients from the soil. A part of the carbon produced by the photosynthesis is re-used by the tree for its respiration and therefore energy lost occurs.

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