7. Energy Flow and Ecosystem Function

SUMMARY

Every living organism needs water, energy, carbon and nutrients to stay alive, grow and reproduce. There are two types of organisms that comprise the living part of all ecosystems. These are called autotrophs or producers and heterotrophs or consumers. An autotroph is an organism that can manufacture its own food energy, through the process of photosynthesis. A heterotroph is an organism that can not manufacture its own food energy and therefore must obtain its energy by eating autotrophs or other heterotrophs.

From the perspective of energy flow in ecological systems, there are four general types of heterotrophs. Herbivores are called primary consumers because they eat only plants. Carnivores are called secondary consumers because the eat herbivores. There is also a group of secondary consumers called omnivores because they eat both herbivores and other carnivores. The other type of consumer that is critical to energy flow in ecosystems is comprised of organisms that feed on dead plant and animal matter. These are called detritivores.

The organic matter produced by autotrophs and heterotrophs in excess of what they need to sustain life, is referred to as biomass. Production refers to how much biomass is produced by an organism over a period of time. Primary production refers to organic matter produced by autotrophs. Secondary production refers to organic matter produced by heterotrophs.

The energy and matter produced by plants are distributed among other organisms in a habitat through pathways known as food chains and food webs. A food chain is made up of a simple linkage of producer to consumers. An example is a fish eats an aquatic plant and a larger fish eats the fish that just ate the plant. Food webs are more complex since they are made up of a network of food chains each of which connects an autotroph, at the lowest feeding level, to the herbivores that comprise the primary consumers and then to the various carnivores that comprise the secondary consumers. Detritus is organic matter which is produced after higher plants have been broken down through the process of decay carried out by the micro-organisms and other organisms that are called detritivores. This process is very important in the food web of rivers.

Organic material in rivers has two origins:

1) Allochthonous material. This material that is introduced into rivers from the outside. An example is leaves or branches from trees, insects or other animals that fall into a river.

2) Autochthonous material. This material is produced within the river ecosystem itself by aquatic plants for example.

Periphyton or Biofilm. These two terms refer to the main source of primary production in shallow stony rivers. Biofilm is defined as a complex mixture of algae and other microbes, – especially diatoms and cyanobacteria. Although biofilm is an important source of primary production in parts of rivers, heavy growth of riparian vegetation can create large areas of almost permanent shade that can limit photosynthesis, and nutrients and thus reduce the availability of biofilm.

The surface of wider rivers receives ample light because of the reduced shading effect of riparian vegetation. However, in deep or in turbid sections of the river, water clarity is reduced and this reduces the level of light penetration. If this reduction is great enough, it may be insufficient to sustain periphyton growth. Macrophyte production is significant in lowland reaches only, and rooted macrophytes may be limited by light penetration in turbid water. Phytoplankton is also limited by turbidity in large rivers and sometimes by nutrients, but it can be important in some areas of the river, – especially on floodplains. Wet-season rains tend to reduce the amounts of autotrophs present by washing them away, and this is likely to result in a decline in primary production during and subsequent to the monsoons. Significant amount of organic matter enters rivers and is then transferred within them as organic particles of various sizes and as matter that is dissolved in the water.

Feeding groups are important in the functioning of river ecosystems. Organisms can be divided into feeding groups based on their specific roles.

• The grazer-scraper category comprises herbivores that feed on periphyton and biofilms.

• Shredders are detritivores feeding on coarse organic particles, especially leaf litter derived from the riparian zone.

• Collectors eat fine and very fine organic particles and can be subdivided according to whether the food particles they collect are suspended in the water, as in the case of filtering-collectors or filter-feeders, or have been deposited on the substratum in the case of collector-gatherers.

• Predators are species that eat other animals.

• Deposit-feeders ingest fine bottom sediments and the organic material that they contain.

Life in running waters is organised at many levels to use energy originally derived from the sun, and chemicals present in the water and soil, for maintenance, growth and reproduction. The interactions between organisms typically involve flows of energy and essential chemicals (nutrients). These flows of energy create an interdependence known as the food web. This interdependency means that damage to one component of the ecosystem can lead to impacts on, or even damage to, other ecosystem components.

Management of aquatic ecosystems therefore requires an understanding of the functional role and relationships of all the organisms that comprise an ecosystem. River management presents particular challenges because, with the unidirectional downstream flow of water, rivers are open systems in terms of energy. They are sustained by both in-stream events fuelled by sunlight and

by the input of material from the surrounding land. It is therefore evident that the health of the aquatic system depends on appropriate management of land and water.

The energy used by organisms maintains body functions, enables growth and reproduction, thereby producing more plant and animal tissue. Feeding relationships between organisms leads to the transfer of energy along pathways that link to form a food web. In rivers, as in all other aquatic and terrestrial systems, the energy at the base of the food webs is derived from sunlight fixed by plants growing in the water or on land. Energy derived from land plants enters the water in the form of dead plant parts, mainly leaves, but sometimes in the form of dissolved organic matter. This material is used as a source of energy by micro-organisms such as fungi and bacteria as well as by invertebrates. Through a complex set of interactions, this energy is gradually incorporated into animal tissue or processed into fine organic particles.

Plants in the river are also important in food webs, with microscopic algae being eaten when they are alive, whereas larger aquatic plants mainly enter food chains after they have died. A process called cascade interactions in food webs occurs when one group of organisms indirectly affects another group by feeding on the animals that eat them. An example is where predators eat herbivores that feed on the plants and by so doing allow the plants they would have consumed to multiply.

Understanding river systems both physically and ecologically, involves four conceptual models. A conceptual model is what scientists use to illustrate how they think a river system should function.

River Continuum Concept. The way in which river communities are structured to make use of different types of energy such as that derived from aquatic plants versus that coming from plants on land, changes along the length of a river. This process of change is to some extent, rather predictable and has been summarised in a model referred to as the River Continuum Concept.

The River Flood-Pulse Concept. This concept stresses the importance of the lateral flow of materials in response to the river flood cycle, and in particular it identifies the importance of floodplains in the Mekong and other large tropical rivers. Both of these models are useful aids to thinking about river ecology. Human activities interfere with the natural downstream transition in community organization along rivers.

Nutrient Spiralling Concept. This concept is also referred to as resource spiralling describes how organic matter in a river system moves and is processed. It explains the ways in which different components of the community interact to capture and transfer nutrients among themselves, thereby slowing their downstream transport.

Serial Discontinuity Concept. This concept provides a model based upon consideration of how disrupting the natural structure of the river, by separating its naturally occurring parts, influences river functions. This concept provides a very helpful tool for predicting the effects of impacts, such as dam building, on river ecology and provides a means for illustrating the relationship between where a dam is built and its potential impact on the river system.

http://www.cbd.int/programmes/areas/water/toolkit/html/1.8.0a_energy_ecosystem.html