ECOLOGICAL ROLES OF NATURAL DECOMPOSITION OF PLANTS IN ECOSYSTEM

by

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Abstract

Decomposition is a biological process that includes the physical break down and biochemical transformation of complex organic molecules of dead material into simple organic and inorganic molecules. Decomposers include fungi, bacterial, microfauna, mesofauna and macrofauna. Decomposition process of plant matter occurs in many stages. It begins with leaching by water; the most easily lost and soluble carbon compounds are liberated in this process. Another early process is physical breakup of the plant material into smaller bits which have greater surface area for microbial colonization and attacks. Aeration, soil PH, litter properties, microbial activities and climatic conductions are the factors that influence the rate of decomposition in nature. To date, decomposition in nature is very essential in the productive of ecosystem biodiversity in both soil and forest management. Understanding the interaction between plant components and their subsequent decomposition in nature provides insights on how plant decomposition influences ecosystem. Thus, an ecological recycling is the movement and exchange of organic matter back into the production of living matter. The process is regulated by food web.

Key words: Organic matter, Decomposition, Recycling, Ecosystem

Introduction

When a plant, animal dies, that plant and animal is broken into tiny pieces and those pieces become part of the soil. This is called decomposition. Thus, decomposition is the process of breaking down organic material, such as dead plant or animal tissue, into smaller molecules that are available for use by the organisms of an ecosystem. Furthermore, decomposition is the process whereby litter on the soil surface or below ground roots is broken down to smaller particles (Swift, 1979). Decomposition is effected by bacteria, fungi, protists, worms and certain other organisms. It releases soluble forms of nutrients that are available for plant uptake and provides soil organic matter (Waring and Schlesinger, 1985). Understanding decomposition processes and the influence of soil management practices on them is crucial to maintaining the long-term productivity of soils. Organic matter decomposition also contributes carbon dioxide to the atmosphere, thus influencing globe warming.

Fungi and bacteria are the dominant decomposers (Richards, 1987). Small animals, Such as mites, fragment fine litter and enhance microbial decomposition. Earthworm, although important in the decomposition process in deciduous forests, are not thought to play a major role in coniferous forests, but they are present (Richard, 1987). Insects and wood borers, play a very important role by fragmenting wood and introducing fungal decomposers (Harmon, 1986).

Simple sugars decompose completely to carbon dioxide and water, but decomposition of the complicated organic substrates in forest ecosystem is not complete. Hand-to-decompose or recalcitrant substances accumulate in the soil as humus, which comprises the soil organic matter so important in maintaining forest productivity. Soil organic matter maintains soil structure, improves soil water balance, and is a long-term source of site nutrients. It is particularly vulnerable to loss through improper forest practices and its important in preventing compaction and erosion.

There are many sources of organic matter in soils, and are of these is coarse woody debris (CWD) such as log and lags. Determining the important of CWD in forests has been the focus of much research in recent years (Harmon, 1988), and maintaining CWD in forest is one of the major components of a new forestry (Eubanks, 1989; Franklin, 1989). Coarse woody debris provide (1) Plant habitat through nurse logs (2) Moisture and nutrients for flat roots and mycorrihiza (3) habitat for animals and birds (4) Pools in streams for fish habitats (5) Sites for nitrogen (N) fixation and (6) a long-term source of soil organic matter. It also protects against erosion by improving scope and stream stability, maintains species diversity, and helps in maintaining long-term site productivity. Many of these roles change as CWD decomposes. The process of decomposition is essential for recycling the finite matter that occupies physical space in the biome.

Ecologically speaking, the decomposition process of plant litter influences the release of essential plant nutrients such nitrogen and thereby exerts a large influence on the growth rates of plant species (Cotrufo *et al*., 2000). However, most studies on litter decomposition in forests have included only two or three tree litter species and compared monocultures with just one mixing treatment. This narrow stage of methodical approaches strongly limits the thorough assessment of diversity effects and is one reason why generalizations of litter – mass loss as a function of litter diversity are not yet possible (Hattenschwiller *et al*., 2005). Thus, a substantial fraction of the studies indicates that mass loss from various litter mixture is more rapid than would have been predicted from the decay rates of individuals included in the mixture (Hattenschwiler and Gasser, 2005). Thus, it exhibits non-addictive characteristics, which is in contrast to additive responses that can be predicted from the decay of the individual litter species (Garter and Cardon, 2004). According to Hattenschwiller *et al*., (2005), these non-addictive (i.e, synergistic) effects can be brought about by four complexes of mechanisms: (1) Nutrient transfer; preferential decomposition of high-quality litter increases nutrient availability and induces nutrient transfer to the low-quality litter that, in turn, will be decomposed more rapidly (Salamca *et al*., 1998); (2) Stimulating effects of specific litter compounds (Schimel *et al*., 1998), who demonstrated, however that retarding effects are possible as well; (3) improved microclimatic conditions, or (4) interactions across tropic levels of decomposers, e.g. regulation of the population density at lower tropic levels, which can depend on the diversity of litter species. To date, however, no general pattern of litter – diversity effects on the mass loss from litter during decomposition has emerged (Wardle *et al*., 1997, 2009).

More so, the decomposition of leaf litter is largely influenced by the concentrations and ratios of nutrients (Berg and McClaugherty, 2008). In general, decomposition rates increase with a decrease in the ratio of carbon to nitrogen (C.N. ratio), which is therefore an important indicator of litter quality (Heal *et al*., 1997). Another constituent limiting the rate of litter degradation is lignin (Melillo *et al*., 1982; Osono and Takeda, 2005), a complex aromatic heteropolymer in cell walls, which is one of the litter components that are most recalcitrant to decomposition (Osono, 2007; Berg and McClaughterty, 2008).
The objective of this paper is specifically to assess the roles of natural decomposition of plants in ecosystem

Plant Decomposition

Decomposition of plant matter occurs in many stages. It begins with leaching by water; the most easily lost and soluble carbon compounds are liberated in this process. Another early process is physical break up or fragmentation of the plant material into smaller bits which have greater surface area for microbial colonization and attack. In smaller dead plants this process is largely carried out by the soil invertebrate fauna, whereas, in the larger plants, primarily parasitic life – forms such as insects and fungi play a major break down role and are not assisted by numerous detritivore species. Following this, the plant dentritus (consisting of cellulose, hemicellellose microbial products, and lignin) undergoes chemical alteration by microbes. Different types of compounds decompose at different rates. This is dependent on their chemical structure. For instance, lignin is a component of wood, which is relatively resistant to decomposition and can infact only be decomposed by certain fungi, such as the black – rot fungi, said fungi are thought to be seeking the nitrogen content of lignin rather than its carbon content. Lignin is one such remaining product of decomposing plants with a very complex chemical structure causing the rate of microbial break down to slow. Warmth deterines the speed of plant decay, with the rate of decay increasing as heat increases, i.e. a plant in a warm environment will decay over a shorter period of time. In most grassland ecosystems, natural damage from fire, insects that feed on decaying matter, termites, grazing mammals, and the physical movement of animals through the grass are the primary agents of break down and nutrient cycling, while bacteria and fungi play the main roles in further decomposition.

The chemical aspects of plant decomposition always involve the release of carbon dioxide in the ecosystem.

Ecological Energy Flow

Carbon and energy incorporated into plant tissues (net primary production) is either consumed by animals which the plant is alive or it remains uneaten when the plant tissue dies and becomes detritus. In terrestrial ecosystems, roughly 90% of the NPP ends up being broken down by decomposers. The remainder is either consumed by animals while still alive and enters the plant-based trophic systems, or it is consumed after it has died, and enters the detritus – based trophic systems. In aquatic systems, the proportion of plant biomass that gets consumed by herbivores is much higher. In trophic systems photosynthetic organisms are the primary producers. The organisms that consume their tissues are called primary consumes or secondary producers – herbivores. Organisms which feed on microbes (bacteria and fungi) are termed microbivores. Animals that feed on primary consumers – carnivores – are secondary consumers. Each of these constitutes a trophic level. The sequence of consumption – from plant to herbivore to carnivore – forms a food chain

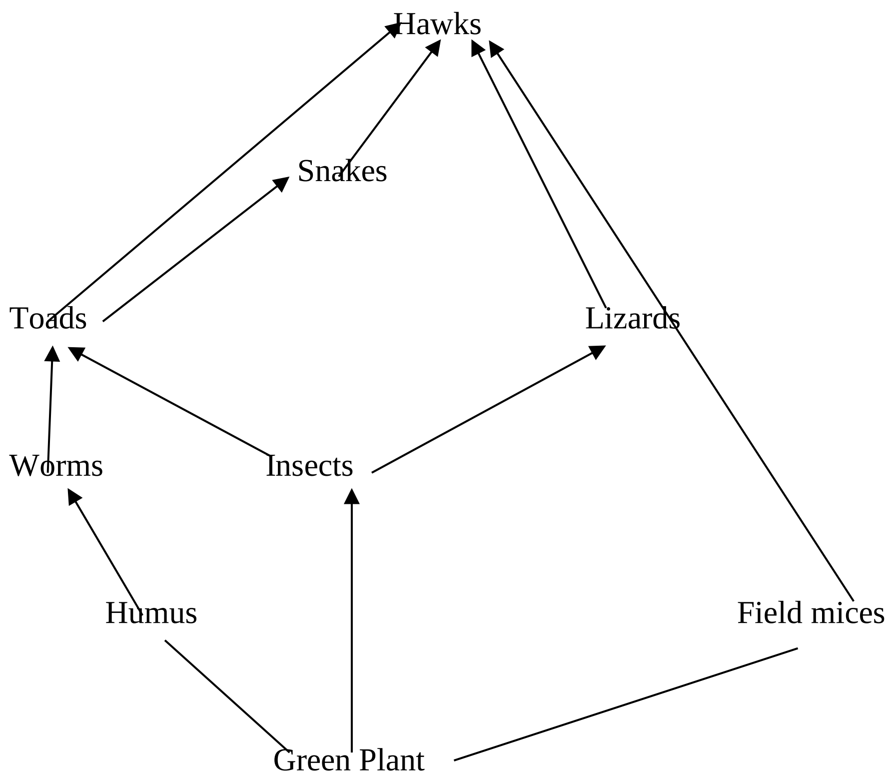

Figure 1: Energy flow in ecosystem. Source: Stone, Cozens and Ndu, (2001)

Relevance of Decomposition in Nature

Energy and carbon cycle enter ecosystems through photosynthesis, are incorporated into living tissue, transferred to other organisms that feed on the living and dead plant matter, and eventually released through respiration. Most mineral nutrients, on the other hand, are recycled within ecosystems. However, ecological recycling is the movement and exchange of organic and inorganic matter back into the production of living matter. Thus, the decomposition process of plant litter influences the release of essential plant nutrients such nitrogen and thereby exerts a large influence on the growth rates of plant species (Cotrufo *et al*., 2000). The process is regulated by Food web pathway that decomposes matter into mineral nutrients. Nutrients cycle occurs within ecosystems. Ecosystems are interconnected systems where matter and energy flow and is exchanges as organisms feed, digest, and migrate about. Minerals and nutrients accumulate in varied densities and uneven configurations across the planet. Ecosystems recycle locally, converting mineral nutrients into the production of biomass and on a larger scale they participate in a global system of inputs and outputs where matter is exchanged and transported through a larger system of biogeochemical cycles. Particulate matter is recycled by biodiversity inhabiting the detritus in soils, water columns and along particle surfaces. Ecologist may refer to ecological recycling, biogeochemical recycling, organic cycling, biocycling, natural cycling, or just recycling in reference to the work of nature. Whereas the global biogeochemical cycle describe the natural movement and exchange of very kind of particulate matter through the living and non-living components of the Earth, nutrient cycling refers to the biodiversity within community food web system that loop organic nutrients of water supplies back into production. The difference is a matter of scale and compartmentalization with nutrient cycles feeding into global biogeochemical cycles. Solar energy flows through ecosystems along unidirectional and non-cyclic pathways, whereas the movement of mineral nutrients is cyclic. Mineral cycles include water, phosphorus cycle, oxygen cycle, among others that continually recycle along with other mineral nutrients into productive ecological nutrition. Global biochemical recycling regulated by the action of food webs moving particulate matter from one living generation onto next. Earths ecosystems have recycled mineral nutrients sustainably for billions of years.

Conclusion

Literatures so far cited in this work have shown that forest management has reduced the amount of coarse woody debris below that encountered in natural ecosystems and this is of some concern with respect to the maintenance of long-term productivity in managed ecosystems. However, woody litter provides a long-term source of soil organic matter and nitrogen, which could be important in maintaining site productivity. However, decomposition in nature is very essential in the productivity of ecosystem biodiversity in both soil and forest managements. Thus, natural decomposition of plants plays a vital role in recycling energy flow in ecosystem as it ensures productivity of both soil and forest ecosystems.

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