THE DETRITAL FOOD WEB AND SURFACE MINE RECLAMATION[1]

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Abstract.—Soil microorganisms and microfauna are major constituents of the detrital food web. As they decompose plant and animal residues they recycle essential plant nutrients. In so doing they regulate the productivity of the system. Because of their major role in system regulation this presentation will investigate the processes involved in the development of a detrital food web in disturbed mine spoils.

Detrital food webs are important in the regulation of climax ecosystems and the reclamation of disturbed ecosystems. Seventy to ninety percent of all the energy, fixed as carbon, that enters climax communities ends up in the soil detritus. The productivity of these systems depend on the detrital food web for nutrient regeneration. The detrital food web is a complex mixture of microflora and fauna which interact with one another to decompose dead organic matter. In so doing they recycle the energy and nutrients immobilized in detritus. In contrast, severely disturbed systems, such as strip mine overburden material, are generaly detrital poor. Disturbed systems depend on fertilization for nutrients and short linear food chains for nutrient cycling. If left unaided the succession from pioneer to climax communities, and thus the development of detrital food webs, can take hundreds or even thousands of years. In order to accelerate the successional process, a detrital food web must be established as quickly as possible. To reach this goal the detrital food web must first be inoculated into the spoil and then maintained. The long term stability of the web will depend on establishing internal and external regulation.

Topsoiling can shorten the successional process by acting as an inoculant of detrital food web organisms as well as a nutrient pool. However, in arid and semiarid regions of the Southwest there is sometimes insufficient top soil for adequate reclamation, and what soil that is present is of poor quality and contains very low quantities of detritus. Thus, alternative reclamation practices must be considered (Scholl & Pace, 1984; Elkins et al., 1984).

Mulching acts as an energy and nutrient pool to maintain the detrital food web organisms until sufficient carbon inputs can occur (Visser et al.,1979). Even though carbon and energy are being fixed by primary producers a lag time exists before this material enters the spoil and is incorporated into detritus to maintain the detrital food web (Wilson 1965). This lag results from the flow of carbon and energy through various plant compartments (i.e. aboveground living, standing dead, litter, and living and dead roots). The success of a reclamation process in establishing a detrital food web thus depends on the timing between the loss of mulch and the input of litter into the detrital food web.

Studies where both litter formation and mulch decomposition have been measured in reclaimed mine spoils is severely lacking. In one reclaimed mine in northern Colorado[3] a litter layer begins to develop during the second year after reclamation. In the arid environment of reclaimed mine spoils in northern New Mexico straw (most commonly used mulch) decomposes within 4 to 10 years (Elkins et al., 1984). Even though these are different studies they suggest that there may be adequate overlap in the timings between these two processes to support a detrital food web. However, Parker et al., (1985) measured a decline in the decomposition activity during the first four years after reclamation which was accompanied by a reduction in the soil biota. Their results indicate that topsoiling and mulching inoculated but failed to establish an equilibrium in the detrital food web within four years after reclamation.

Detrital food webs in climax communities have evolved over centuries of continual inputs and outputs of detritus resulting in a pulse-flow equilibrium. The processing of this detritus involves the succession of both microflora and fauna (Santos and Whitford 1981; Santos et al., 1981; Parker et al., 1984). Without inputs of

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fresh detritus, the organisms specializing in the early stages of decomposition will either be reduced to very low numbers or vanish until conditions are more favorable for their development. Some of the soil fauna have the ability to migrate to more favorable areas (Whitford et al., 1981). However, in the early stages of ecosystem development litter and detritus have not evolved the number of niches and habitats as that of in climax communities. Thus, the areas where the fauna may migrate to are few. Parker et al., (1985) found that key families of litter inhabiting Cryptostigmata mites were absent in a reclaimed mine spoil. These microarthropods are important in the decomposition of litter in a number of terrestrial ecosystems. Their absence suggests there may not be available habitats (i.e. surface litter) for them to occupy during the first four years after reclamation.

The results of Elkins et al., (1984) and Parker et al., (1985) indicate the detrital food webs in the reclaimed mine spoils used in their studies may not be as stable or complex as those in climax communities. Their studies do show that a detrital food web can be inoculated into a mine spoil and the main problem is the maintainence of the web.

Since we know that detrital food webs can exist on reclaimed mine spoils, an understanding of the processes which regulate the web may aid in improving the stability of the web, and therefore, the stability of the reclaimed site. The detrital food web is regulated both internally and externally. The internal regulation is through organism-organism interactions such as competition and predation. The major external controls are substrate availability and climate.

The microfauna are the major internal regulators of flows through the detrital food web. In active detrital food webs the microfauna perform a number of different functions. They fragment plant materials and transport them into the soil through communition. They inoculate plant debris with microorganisms. They also prey or graze on the decomposer microflora. Their grazing can vary in intensity from no effect upon the microflora, through intermediate levels, to levels of overgrazing. Intermediate grazing can maintain the microflora in a more physiologically active state increasing the turnover of the microbial biomass and the release of nutrients stored within it (Cole et al., 1978; Anderson et al., 1981, 1982: Parker et al., 1984). Overgrazing can decrease microbial activity (Hanlon and Anderson 1980; Parker et al., 1984).

The soil fauna help reduce plant-microflora competition for essential nutrients in the early stages of reclamation by increasing the turnover of the microbial biomass. Microbial populations increase very rapidly in the first year after reclamation due to the mixing of topsoil and the addition of mulch. When given high carbonaceous substrates, such as decomposing plant roots or straw mulch, the decomposer microflora (especially fungi) have the potential to immobilize substantial quantities of essential nutrients and store them as biomass (Parker et al., 1984). This immobilization can be significant enough to result in a decrease in primary production (Parker et al., 1984; Whitford and Parker 1985). If left to undergo natural attrition (in the absence of soil fauna) the turnover of this biomass and the nutrients contained within would be very slow (Cole et al., 1978; Parker et al., 1984). In the presence of the soil fauna nutrients are mineralized at much higher rates than when the fauna have been removed (Cole et al., 1978; Parker et al.,1984).

The soil microfauna which are found in recently reclaimed mine spoils can be grouped into two broad categories: those which must escape adverse conditions by entering a dormant stage and those which tend to be more opportunistic in their feeding habits by occuping a number of different niches (Elkins et al., 1984; Parker et al 1985). The former group are comprised primarly of protozoans, nematodes and some microarthropods, and the latter group of microarthropods. The former group also tends to be dependent on water for activity, while the latter group is relatively independent of water.

Climate, especially the interaction between temperature and rainfall, is very important in regulating the activity of the detrital microflora and the fauna dependent on water for activity. In most temperate ecosystems the activity of the detrital food web (as measured by decomposition) is closely associated to abiotic parameters such as actual evapotranspiration (Meentemeyer 1978). In arid and disturbed systems this relationship breaks down and has been attributed to microarthropod activity (Whitford et al., 1981; Elkins et al., 1982).

While investigating alternative reclamation practices, Elkins et al., (1984) observed that the type and quanity of mulch may be important in the establishment of a detrital food web. They compared the standard reclamation practice (including topsoiling and mulching) against mulching alone with either straw or bark. They observed that bark mulch was superior to straw mulch and topsoiling in developing a detrital food web on reclaimed mine spoils. Bark contains a high level of lignin which makes it more recalcitrant when compared to straw. Thus, a greater potential for maintaining the detrital food web for a longer period of time. The bark mulch in their study was added at a higher rate than the straw, which would increase the number of potential habitats for the fauna to survive.

CONCLUSIONS

Detrital food webs can be inoculated into mine spoils to help increase the succession of these systems. Maintaining the stability of the detrital food web is of major concern. Parkinson (1979) and Elkins et al., (1984) emphasize the importance of investigating reclamation processes on the ecosystem level. Only at the ecosystem level can we truly understand the assets and faults of different reclamation practices and

their ability to stabilize the detrital food web. This review has made an attempt to update our current knowledge on detrital food webs rather than individual processes. As can be seen we have only just begun to understand the mechanisms involved in the establishment of detrital food webs on reclaimed mine spoils.

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