

SHORT-ROTATION EUCALYPT PLANTATIONS IN BRAZIL: Environmental Issues

2.3 SOIL

2.3.1 Litter Effects

The effects of eucalypts on the soil have been studied in several countries over many years. Most of the concerns related to soil effects deal with depletion of nutrients and allelopathy caused by the litter, which is said to exert an antibiotic effect on soil microorganisms. This concern was verified by research that showed a very low concentration of nitrifying bacteria in eucalypt plantations litter (Florenzano 1956). However, many of the litter problems can be alleviated by alternating rotation or mixing species and clones to promote decomposition. An extensive literature review demonstrated that afforestation with eucalypts improved soil fertility in the long term in several areas of the world (Phillipis 1956, Ricardo and Madeira 1985, Karshon 1961). However, long-term sustainability and site fertility still needs to be a key concern in any plantation scheme.

In the state of Minas Gerais a comprehensive study was undertaken to analyze the effects of the short-rotation eucalypt plantations on soil properties in 8- to 10-year-old *Eucalyptus grandis* stands established on lateritic and sandy soils. Samples of soils were collected at varying depths of up to 0.60 m on eucalypt plantations as well as on a nearby savanna-like stand. Chemical, physical, and biological analyses of the soil samples showed no statistically significant differences between eucalypt and savanna soils. Further, in an experiment in which eucalypts soils were used in a greenhouse to grow beans no allelopathic effects were detected (CETEC 1984).

Identical work was carried out in Minas Gerais on 25-year-old *Eucalyptus citriodora* and *E. paniculata* plantations. The chemical, physical, and biological soil analyses of these plantations were compared with those of nearby native forests and pastures. The eucalypt soils contained 27 tons of litter per hectare compared to only 12 tons produced by the native forest and had more microorganisms and nutrients (Fouseca 1984).

2.3.2 Reclamation

Afforestation has been recognized as one of the most effective means to reclaim marginal, eroded, or mined land (Van Goor 1985). A plantation of a single species can have a positive effect on soil if it is established on land having no cover or having been impoverished by misuse. However, the high growth rates and short rotations of most of the commercial eucalypt plantations result in a very high nutrient uptake from the soil. In fact, nutrient use for an intensively managed eucalypt plantation can be comparable to that of an agricultural crop (Miller 1989). However, agricultural crops normally require more total nutrients than do the short-rotation intensive culture eucalypt plantations (Lima 1993).

2.3.3 Protection

Eucalypt plantations are also sometimes accused of not providing adequate soil protection. This lack of protection can lead to less water infiltration and greater runoff, resulting in soil erosion and watershed sedimentation. This was probably true in the 1970s when site preparation for establishment of the eucalypt plantations was similar to that for agricultural crops. Vegetation was burned, and the soil was plowed and harrowed. This resulted in exposure of the soil to rainfall for at least the first 6 months, before seedling crowns had grown sufficiently to cover the soil. Today silvicultural practices have essentially eliminated the use of fire, as well as plowing and harrowing of the entire area, for site preparation. These practices have been replaced by soil preparation in strips or by 3-m-spaced furrows in which seedlings are planted every 2

to 3 m (Lima 1990). Properly managed eucalypt plantations can provide soil protection. As always, sensitive sites need to be treated carefully to avoid adverse effects on soils.

2.4 BIODIVERSITY

In a native forest ecosystem a balance exists among the main components of the system and among the energy flows of the food webs. One of the most important factors in the stability of the system is its biodiversity (Evans 1992). Plantations are specialized but generally simplified ecosystems. Establishment of monoculture short-rotation eucalypt plantations has been criticized as detrimental to the environment because of its negative effect on biodiversity (i.e., reduction in the number of plant and animal species). However, these effects can be minimized by adequate management of both the plantations and the remaining native forests and vegetation (Berndt 1992).

2.4.1 Fauna

One of the criticisms of eucalypts in Brazil is, being an exotic species, it does not provide shelter and food for the native fauna. This is probably true not only for eucalypt plantations but any monoculture, be it an exotic or native. Compared with multispecies plantations, single-species forest plantations may reduce the availability of diverse food and shelter for the local wildlife (Evans 1992). Besides these direct effects, forest plantations may create indirect effects that promote modifications in food webs in other areas of the region that can lead to the disappearance of some faunal species (Avery 1989). However, it has been noted that faunal species will adapt to the new conditions generated by a forest plantation whether eucalypts or native species (Rochelle and Brunnel 1979). Thus, the existence of eucalypt plantations per se are not necessarily detrimental to wildlife (Lima 1993). The controversy dealing with the impact of plantations on fauna is fed by conflicting research results. For example, in Viçosa, Minas Gerais, a study was conducted to determine the number of small mammals in four different types of forest. While some mammal species were found in a 10-year-old *Eucalyptus saligna* plantation, a much larger number was found in a 31-year old *Araucaria angustifolia* stand and in 15- and 52-year-old mixed natural forests (Dietz et al. 1975). On the other hand, in Aracruz, Espírito Santo, a survey comparing bird populations in a 9-year-old *E. citriodora* (having a relatively well-developed understory) and an adjacent natural forest found 50 birds (28 species) in the eucalypts, 17 birds (10 species) in the native forest, and 22 birds (11 species) in the border between the two (Almeida and Laranjeiro 1982).

Avoiding or diminishing silvicultural treatments after stand establishment allows birds to occupy the area in search of food. This bird population consists mainly of species that feed on insects (Almeida 1981). As a consequence, there is a direct benefit to these birds as well as to the plantations in that birds help control insect populations. In a study conducted in Telêmaco Borba, Paraná, bird population was appraised in *Araucaria angustifolia* and *Eucalyptus sp.* plantations and in mixed native forests. The results showed a greater bird population density in the plantations compared with the natural forest; however, species diversity was greater in the native vegetation. The greater biodiversity in the adjacent native forests and a higher population density in the plantations can combine to show an overall positive benefit (Berndt 1993).

One of the major problems related to short-rotation eucalypt plantations and animal populations has to do with species that require habitat that consists of old trees or mature forests. Three actions have been suggested to help alleviate this problem: (1) leave some trees in the plantation at the time of harvesting, (2) extend the rotation period, and (3) leave natural vegetation intermixed with the short-rotation plantations (Loyin 1985). The last has been the preferred action of Brazilian forest companies (Almeida et al. 1982). However, consideration is also being given to extending the rotation period (Spinelli 1993).

Since the beginning of the reforestation programs in the 1960s, forest companies had two options in attempting to preserve natural forests: plant 1% of the total number of trees using only native species or leave 10% of total area in the original vegetation (Reis and Reis 1992). The latter option has been preferred because in most of the afforested areas at least 10% of the area in riparian vegetation or forest cover was located along the rivers and streams or on very steep slopes, which could not be harvested

according to the National Forest Code. Further, it was difficult to get seeds of native species with which to accomplish the first (planting) option. Since reforestation programs that require the preservation of native forests began, regions where plantations are established are typically mosaics of plantations, pastures, grasslands, croplands and native vegetation. This diversity of habitat is very important to faunal preservation (Evans 1992). Plantations certainly have helped to alleviate the harvesting pressure on native forests and have provided for habitat that otherwise would have been lost.

Other management practices that are very important to the success of a conservation program for fauna involve leaving native areas undisturbed (Moss 1979), planting fruit trees, and constructing small ponds throughout in the plantation area. Such practices have been carried out recently by most of the forest companies in Brazil.

It is possible to identify three stages in the development of a short-rotation eucalypt plantation in relation to faunal habitat. The first stage is the initial establishment phase, when the stand is subjected to intensive silvicultural practices such as weeding, cultivation, and herbicide spraying. In this phase, the eucalypt plantations may provide occasional shelter for the animals living in the adjacent plantations or natural forests. The second stage is the crown competition phase, when shading restrains the establishment of understory vegetation and the plantation offers limited understory shelter for fauna from adjacent areas. The last phase is the natural pruning phase, where the understory reappears (provided seeds of native species are present in the ground), leading to better conditions for the local fauna (Reis and Reis 1993). Intermixing plantations in varying phases helps create better habitat conditions.

In general, (1) plantations have a less diverse fauna than indigenous forests, (2) plantations composed of exotic trees have a less-diverse fauna than plantations of indigenous species, (3) plantations can be made more favorable for animals and plants by appropriate management practices that provide desired habitat, and (4) planting in treeless areas can provide shelter that would not otherwise be available to faunal populations (Poore and Fries 1985).

2.4.2 Flora

Planting eucalypts and replacing natural vegetation has an effect on the flora of an area. This effect may result from shading, competition for nutrients and moisture, site disturbance, allelopathic effects, or the cumulative effects of changes in the soil. The extent of the impact will depend on the nature of the community the plantation replaces and the ecological characteristics of the region. For example, in an arid region eucalypt may suppress ground vegetation by competing for water, but this is unlikely to occur in an area of high rainfall (Poore and Fries 1985).

Critics of short-rotation commercial eucalypt plantations assume that eucalypts have an allelopathic effect on the other plants, resulting in the disappearance of the original native plants and local ecosystems (Poore and Fries 1985). For the same reason, there is concern that agricultural crops cannot be cultivated on lands previously occupied by eucalypt plantations or even on lands nearby (Lima 1993). It is believed that eucalypts can affect other plants directly through the inhibitory influences of leaf litter and root exudates or through the effect of litter on nutrient mineralization and soil microflora (Florence 1986).

However, a survey of the worldwide literature reveals that direct plant-chemical interactions in natural communities are probably rare (Willis 1980). Regeneration of native species in the understory of eucalypt plantations is not restricted by allelopathic effects of the litter (which can occur for a limited number of species). Native species regeneration is instead a function of (1) the amount of sunlight that reaches the ground through the eucalypt canopy; (2) competition for soil-water; and (3) the supply of seeds of native species in the soil.

Some feel that management practices on plantations will enhance conditions for native flora. For example, an intense fire in the eucalypt forest may provide, at least temporarily, a more biologically favorable soil environment for plant growth. This more favorable environment is caused by many factors, including the removal of plant competition, an increase in soil pH and availability of ash nutrients, breakdown of

inhibitory compounds, stimulated mineralization of nitrogen and phosphorus in soil, and the effect of partial soil sterilization on soil microflora. Thus, it seems that many observed effects of fast-growing eucalypt plantations might be attributed primarily to competition for soil nutrients and water during the rapid growth phase rather than any direct toxic influences the eucalypt may have on soils and other plants (Florence 1986).

Newly planted eucalypt seedlings are very sensitive to weed competition during the first few months of establishment. Therefore, it is common in Brazil to use intensive silvicultural practices such as herbicides, mechanized weeding, and other methods of site preparation, before planting begins. These practices allow the eucalypt seedlings to grow free of weed competition, at least during the earlier stage of their lives. Because of these practices, understory vegetation in the intensively managed short-rotation commercial eucalypt plantations does not normally reappear until the fourth year. Most understory vegetation will also be eliminated to facilitate harvesting and to provide proper establishment conditions for new plantation or the sprouts of the eucalypt stumps. Thus, the occurrence of understory species may be reduced in plantation areas (Reis and Reis 1993).

In some regions very aggressive grasses, such as *Brachiaria humidicola*, *Panicum maximum*, and *B. decumbens*, can occur under the eucalypt canopy. The presence of these grasses makes it difficult for other understory species to become established. However, if the eucalypt plantation is allowed to grow for longer periods of time, the original native species or ecosystems probably will reappear in the understory, as was observed in a 50-year-old *Eucalyptus saligna* plantation in Itatinga, São Paulo (Lima 1993).

There is no doubt that management practices, the eucalypt species used, length of the rotation, and the existence of nearby native vegetation will all influence understory composition in eucalypt plantations (Reis and Reis 1993). For example, in a study conducted in Belo Oriente in the state of Minas Gerais, a 16-year-old *Eucalyptus paniculata* plantation had 47 native species (30 families) in the understory, whereas a 6-year-old *E. saligna* plantation had 26 native species (20 families). The density of the native understory increased with time, and the density of the original eucalypt plantations decreased with age as a result of natural mortality. This decrease in stand density allowed more sunlight to reach the ground, increasing the regeneration of native species (Calegario 1993). The amount of understory also varies among eucalypt species. For example, it has been shown that *E. torrelliana*, which has a larger and thicker canopy, has less native understory than *E. grandis* or *E. saligna*. Further, leaves of *E. torrelliana* do not decompose easily in the litter, restricting germination of the native species seeds in the soil (Reis and Reis 1993). As with other environmental aspects, the impact of eucalypt plantations on local flora will vary with local conditions and management. It is necessary to match species to site, particularly with reference to climate and soil.

Several studies have been conducted on the environmental aspects of the large-scale eucalypt plantations in Brazil. Walter de Paula Lima of Piracicaba, São Paulo, observed recently that the existing scientific work indicates that

1. no evidence of any change in the precipitation regime in a region as a result of the establishment of eucalypts or any other tree plantations;
2. the losses of water through evaporation of the intercepted water from rainfall by the canopy is smaller for eucalypt plantations than for other tree plantations or native forest;
3. the eucalypt plantation can contribute positively to control loss of the soil and nutrients by erosion;
4. water quality is not affected by eucalypt plantations;
5. the water balance of a eucalypt plantation does not differ from other tree plantations or native forest;
6. the main species that have been used in most of the short-rotation plantations have good control of stomatic transpiration;
7. the eucalypts are more efficient in the use of water than other tree species;
8. the effects of the eucalypts, other tree plantations, and native forests on the watersheds are the same;
9. the demand for nutrients by eucalypt is high but is comparable with that by other tree species and is much lower than that by agricultural crops;

10. here is no detrimental effect of the eucalypt plantations on the native vegetation; and
 11. eucalypt plantations, as any other tree plantations, are not devoid of wildlife, and habitat can be improved by adequate management (Lima 1993).
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