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EFFECT OF DEFORESTATION ON SOIL QUALITY AND RECOVERY OF DEGRADED SOIL IN BRAZILIAN AMAZONIA

Philip M. Fearnside

Deforestation is rapidly transforming Amazonian forests into non-forest uses, primarily cattle pasture. The soil quality in these deforested landscapes is an essential factor in the productivity and sustainability of the land uses that follow clearing. Soil organic matter is an important factor in both maintaining soil fertility (by providing sites for retaining cations) and soil physical structure (by maintaining pore volume). Deforestation radically alters the balance between gains and losses of soil organic matter. Deforestation sharply increases the temperature of the surface soil, thereby increasing the rate of soil organic matter loss. At the same time, pasture grasses have abundant roots in the surface layer, thereby increasing carbon inputs to this layer from exudates and root turnover for as long as the pasture grasses remain productive. Meanwhile, carbon inputs from roots are diminished in the deeper soil layers because pasture grasses have much shallower root systems than do tropical forest trees. The soil organic matter changes in the deeper soil layers are slower than near the surface, but significant changes (decreases) can occur over periods of a decade or two. Although the concentration of carbon in deeper layers is much lower than near the surface, the much greater total volume of soil in the deeper layers means that they store a large amount of carbon.

Soil reaction, or pH, is strongly influenced by deforestation and accompanying burning. Good burns result in substantially better crop yields than poor burns. Acid soils under Amazonian forests inhibit the growth of crop plants unless pH is raised, with consequent relief of aluminum toxicity and increase in the availability of phosphorus. The strong influence of pH on crop yields can, for a time, mask the effect of soil degradation through loss of organic matter and important nutrients such as phosphorus. Repeated burning can maintain pH, but hastens the degradation of other soil properties.

- Phosphorus is generally the limiting element in Amazonia, in contrast to many other parts of the world where nitrogen plays the predominant role. Total phosphorus is usually less than 1 ppm in the surface soil (0-20 cm), and only a small portion of this is in available form. Pasture was promoted by government subsidies in the 1970s, partly on the basis of conclusions by official agencies that pasture was improving the soil and would therefore be sustainable. Unfortunately, phosphorus was not among the nutrients that improved. Maintaining pasture productivity requires a constant input of phosphorus from fertilizers. Amazonia has few phosphate deposits (only one of appreciable size), and Brazil as a whole is only modestly endowed with this critical element, virtually all of the country's phosphate deposits being already committed to maintaining agricultural productivity outside of the Amazon Region. Maintaining the area that has already been deforested in Amazonia would exhaust Brazil's phosphate deposits in less than 80 years, while converting the entire forested areas would exhaust the country's phosphates in only 11 years. Phosphates can be imported from other parts of the world (such as

North Africa), but the long-term capacity of these resources is also projected to run out within the present century.

Nitrogen can either increase or decrease with deforestation, depending on fire and other factors. A hot burn results in nitrogen loss. If soil organic matter increases (as in fertilized pastures), then nitrogen increases as well, maintaining the C/N ratio in approximate balance.

Laterization, or the formation of plinthite by deposition of iron and aluminum sesquioxides, has often been raised as a threat of deforestation. A prominent environmental sciences textbook claims that the Transamazon Highway would provoke laterization that would turn Amazonia into "the world's largest parking lot." Fortunately, laterization is only a problem when the water table is very near the surface, such that most of the region (including the Transamazon Highway colonization areas) is not at risk. Unfortunately, the debunking of exaggerated statements regarding laterization has been used with some frequency by those who promote conversion of forest to agriculture and ranching as a means of implying that soil concerns in general are unfounded. However, soil degradation is a serious limitation on continued production in deforested areas, including hardening of the soil through compaction (rather than laterization).

Soil physical properties deteriorate as compaction results both from simple exposure of the soil to sun and rain and from trampling by cattle. Loss of soil organic matter can also contribute. The compacted soil can restrict plant growth, and also results in greater runoff and erosion. Erosion removes the more fertile surface layers of soil, contributing to soil degradation. The increased runoff has consequences for the Amazon Region's water cycle and for its role in maintaining water vapor transport to neighboring regions, such as Brazil's center-south.