CASE-STUDY: BELOW-GROUND BIODIVERSITY, LAND-USE CHANGE AND SUSTAINABLE AGRICULTURAL PRODUCTION: RESEARCH IN THE ALTERNATIVES TO SLASH AND BURN PROJECT (ASB)

Coordination: TSBF, Tropical Soil Biology and Fertility Programme , Nairobi, Kenya.
Brazil: University of Lavras; University of Brasilia; CENA; ORSTOM, France; EMBRAPA Rondonia and Acre.
Cameroon: IRAD; IITA; ORSTOM, France; British Museum, UK; Queen Mary & Westfield College, UK.
Indonesia: AARD; ICRAF; Universitas Lampung; Universitas Gadja Madha; Bogor Agricultural University; BMNH, UK.

The Alternatives to Slash and Burn Project (ASB), convened by ICRAF, is a consortium of sixteen international and national institutions that has been studying agricultural intensification in the humid forest margins in Brazil, Cameroon and Indonesia. The main purpose of the project is to identify the 'best bet' production systems for these zones that optimise trade-offs between profitability and impacts on biodiversity, carbon sequestration and other environmental factors. One component of the ASB studies focuses on management of below-ground agricultural biodiversity. These studies are lead by the TSBF Programme on behalf of the ASB consortium.

Rationale and Background

A major feature of global change in the tropical regions is that of land-use associated with agricultural intensification. Soil is the habitat of a diverse array of soil organisms - bacteria, fungi, protozoa and invertebrate animals - which contribute to the maintenance and productivity of agroecosystems through their influences on soil fertility. Global food supply depends on intensive agriculture. As intensification occurs, above-ground biodiversity is reduced with the intention of increasing the economic efficiency of the system. There is increasing evidence that the diversity of the below-ground community, as well as the functions it carries out, is strongly influenced by the diversity of the above-ground biota. The biological regulation of soil processes is thus altered during the switch from 'traditional' to 'modernist' agriculture and eventually substituted by the use of chemical fertilisers and increasingly mechanised tillage. The below-ground biodiversity may also be impacted by the increased use of pesticides and fertilisers. The assumption is often made that the consequent reduction in the diversity of the soil community, including the well-documented extinction of species, may cause a catastrophic loss in function, reducing the ability of agricultural systems to withstand periods of stress and leading to undesirable environmental effects.

Large numbers of farmers in the tropical regions have limited access to inputs but are nonetheless forced by circumstances to drastically reduce the complexity of their agroecosystems in attempt to intensify production; even though the maintenance of a limited diversity of crops is widely accepted as a means of buffering farmers against short-term risk. The maintenance and enhancement of soil biodiversity may be particularly critical to the increase and maintenance of production in such conditions of 'intermediate' or 'emergent' intensification. An alternative solution is to intensify whilst at the same time retaining a greater degree of above-ground diversity. Agricultural diversification at the scales of both

field and landscape may have long-term benefits through the enhancement of functional diversity and structural complexity, particularly in degraded lands. Enhanced biodiversity and complexity above-ground also contributes to the re-establishment and multiplicity of organisms below-ground able to carry out essential biological functions; these are factors which increase resilience, sustain productivity and buffer agroecosystems against risk.

Objectives

The research on below-ground biodiversity in the ASB Project has the objectives of determining, for the zones of agricultural intensification of the humid forest margins:

1. The impact of land-use change associated with agricultural intensification on soil biodiversity.

2. The effect on agricultural productivity and other ecosystem functions of reduction in the diversity of key functional groups of soil organisms.

3. Land management practices which increase agricultural productivity and other ecosystem functions and contribute to the rehabilitation of degraded lands through enhancement of soil biodiversity.

Work conducted in the ASB Project to date has been confined to the first of these objectives but information on the other two has been obtained from other TSBF and linked programmes.

Methods.

Research on the impact of land-use change on below-ground biodiversity (BGBD) potentially involves the study of a wide range of different groups of fungi, bacteria and invertebrate animals. The ASB studies were confined to four 'Key Functional Groups' of soil biota. The principles on which this selection was made and the methods used were based on the approaches adopted by the TSBF Soil Biodiversity Network (TSBF 1997, Anderson and Ingram 1993, Applied Soil Ecology Special Issue 1997), but the two main criteria were their importance to ecosystem function (hence the term Functional Groups, FG), and the availability of standard and relatively easy methods for sampling and analysis. Hence studies have focussed on the *macrofauna*, particularly the earthworms and termites which have major influence on soil structure and water regimes through their burrowing and particle transport activities, as well as influencing nutrient cycles; the nematodes - a group of the *microfauna* with a wide range of trophic functions- which have often been proposed as sensitive indicators of land-use and changes in soil properties; and *microsymbionts* (nitrogen fixing bacteria and mycorrhizal fungi) which are important in nutrient acquisition by plants. The characterization of the biota also enables understanding of the role of the community in plant litter decomposition, SOM turnover and nutrient cycling, and effects of environmental changes.

Sampling using standard methods was conducted in benchmark sites in three countries (Brazil, Cameroon and Indonesia) by teams which combined expertise for all the functional groups. Samples were taken from replicate fields across land-use gradients which included primary and secondary forests, tree fallows, agroforestry systems, pastures, food crop systems and degraded lands.

Summary of results:
Preliminary analysis of the data from the three countries show lack of consistency of differences in diversity and abundance in functional groups among the different land use types across the range of sites. The primary factors of influence are specific soil properties and the nature and abundance of organic matter inputs. In a number of cases however significant differences among land uses with respect to the diversity and/or abundance of one of more of the groups of soil biota were found. For example, there was a drastic reduction in the number of termite species as land use intensity increased and in particular as tree biomass decline in both Indonesia and Cameroon. In the former country soil-feeding termites were totally absent from degraded *Imperata* grasslands. In Brazil,pastures derived from the forest have a significantly different soil biodiversity profile than any other type of system. The next stages in this research is to determine the significance of these changes in below-ground biodiversity for soil fertility, nutrient cycling and system productivity. This is facilitated in the ASB project by the availability of the data from the same land-use systems on above-ground biodiversity (conducted by CIFOR and partners), agronomic performance indicators and a variety soil and ecosystem properties including carbon stocks and greenhouse gas emissions.

Further details of the below-ground biodiversity studies can be obtained from:
The Director, TSBF, PO Box 30592, Nairobi, Kenya.
Information on the ASB Project can be obtained from: The ASB Programme Coordinator; ICRAF, PO Box 30677, Nairobi, Kenya **Error! Bookmark not defined.**.