Evolution of multistrata agroforestry systems in the Americas

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Introduction

Based on the remains of fruits found in paleoindian Amazon caves, Roosevelt et al., 1996 concluded that human occupants of the Amazon were using plants from different strata of the rainforest 10,000-12,000 years before the present. Species identified from the upper canopy included the Brazil nut (*Bertholetia excelsa*) and jutaí (*Hymenea* spp.), from the mid canopy achuá (*Sacoglottis guianensis*), murici de mata (*Byrsonima crispa*) and the curuá palm (*Attalea spectabilis*), and from the lower canopy , pitomba (*Talisia esculenta*), apiranga (*Mouriri apiranga*), and the tucuma palm (*Astocaryum vulgare*). Thus, the rainforest at the time of first human habitation of the Amazon was already a multistrata system where different species of different strata were being used for human sustenance (Roosevelt et al., 1996). Recent research has indicated that the transition from hunting and gathering to sedentary agriculture has been a gradual process with many intermediate phases in which some crops are cultivated and others gathered (Pringle, 1998). Various intermediates phases between hunting and gathering and sedentary agriculture are still found in the Amazon rainforest with the degree of human intervention varying from intensive, if one or all components of the system are planted, to extensive, if agents such as fire, selective cutting, animals or birds are responsible for the increased populations of an economically important perennial (Dufour, 1990; Raintree and Warner, 1986). Based on studies of present indigenous landuse systems in Latin America, three general types of traditional multi-strata agroforestry systems can be distinguished: improved fallows and dispersed trees in crop fields where several species of economically important perennials occupy different strata, plantations in which two or more woody perennial species are associated, and home gardens (Lok and Samaniego, 1998). There is some overlapping within these categories because over time, economically enriched fallows may be transformed into home gardens or permanent multistrata plantings (Raintree and Warner, 1986; Padoch and De Jong, 1987).

Multistrata economically improved fallows and dispersed trees in crop fields

Slash and burn systems are considered the most ancient fallow system practiced by *Homo* spp. since fire was used for land clearing. Improved fallows are characterised by the anthopogenous or pyrogenous selection of certain species or the planting of trees during the cropping period which alter the floristic composition of the secondary forest which follows the cropping period. These fallows may constitute multistrata agroforestry systems as apparently occurs with the Bora Indians of the Peruvian Amazon (Padoch and De Jong, 1987; Dufour, 1990). The Bora fallow may contain as many as ten species of fruit trees in addition to coca (*Erythryxolon coca*) and barbasco

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(*Lonchocarpus* spp.) a shrubby legume whose roots contain rotenone used to stun fish. Remnant trees of *Cedrela oderata* may also be maintained and the fruit trees attract animals, which are hunted for food. Because of the importance of animals both for food and seed dispersal, the Bora system is best characterised as a multistrata silvopastoral system. The existence of areas of high populations of certain economically important trees in the Amazon rainforest, such as the Brazil nut or rubber (*Hevea brasiliensis*) may be the result of seed burial by either humans or other species (Du Bois et al., 1996). In the Peten of Guatemala, associations of allspice (*Pimenta dioica*), chicle (*Manikara zapota*), ramon (*Brosimium alicastrum*), mahogany (*Swietenia macrophylla*) and jade plant (*Chaemadora* spp.) are exploited. In the highlands of Honduras, an association of frijolillo (*Senna guatemalensis*) and raspberries (*Rubus* spp.) is deliberately promoted; the fallow period may produce more income than the cropping phase.

Throughout the Americas, annual crop fields frequently contain a certain population of woody perennials which have either survived burning or are maintained because they supply useful products such as fruits or firewood. Among the species encountered are palms (*Orbygnia phalerata* and *Copernicia alba* in Northeast Brazil) (Hecht et al., 1988; Johnson and Nair, 1984), pines (*Pinus caribea*) and elderberry (*Sambucus americana*) in the highlands of Guatemala, and *Cordia alliodora* and the cohun palm (*Attalea cohun*) throughout Central America (Lok and Samaniego, 1998).

Multistrata perennial crop plantations

The association of cacao with *Gliricidia sepium* is probably the best documented multistrata system of the Americas. The Aztec term for Gliricidia, *cacahuanantl*, literally cacao-mama, which became the common Spanish name for Gliricidia, *madre-de-cacao*, indicates that these two species have been associated for the last 1000 years (Ford, 1987). Thinned natural forest or swamp immortelle (*Erythrina fusca*) are traditionally used to shade cacao in other areas of production of the Americas. A list of trees used for cacao shade in Bahia, Brazil, is given by Cabala Rosand et al. (1987), who attempted to quantify nutrient cycling in the cacao/*Erythrina* system in order to avoid excessive use of mineral fertilisers. Nutrient cycling in mixed shade coffee and cacao systems in Venezuela were quantified by Herrera et al. (1987), who speculated that the mixed shade systems originated in slavery or other tenant systems when it was necessary to produce food from the same field as that used for coffee and cacao production. It was also common to attempt to produce latex and timber from the same plantations and hence suitable species were also either planted or left when a coffee or cacao field was established (Herrera et al., 1987).

More complex multistrata systems, involving as many as seven perennial species including clove (*Szygium aromaticum*), peach palm (*Bactris gasipaes*), papaya (*Carica papaya*), coffee (*Coffea robusta*), patchouli grass (*Pogestemon cablin*), cardamom (*Elleteria cardamomum*), and vanilla (*Vanilla planifolia*), have been described in southeast Bahia, Brazil, by Alvim and Nair (1986) who do not however provide data about the evolution of these systems. Some 32 species have been reported in association with black pepper in Para, Brazil, where black (*Piper nigrum)* pepper was introduced by Japanese colonists around 1930. In northeast Brazil, where cashew (*Anacardium occidentale*) is native, it can be either gathered from natural stands where it may be associated with other species or from plantations where it may be combined with coconut (*Cocos nucifera*), *Citrus spp.*, or *Musa* spp. or used a support for black pepper (Johnson and Nair, 1985). Stienen (1990) describes many associations of indigenous perennial crops such as *Opuntia, Agave, Leucaena, Prosopis, Juglans* and *Carya* spp. in the matorrales of Northeastern Mexico. Associations involving indigenous species presumably antedate those involving introduced perennials.

Home gardens

Home gardens generally contain a larger number of economically exploited perennial species than the systems described previously. For example, 82% of all species present on one hectare managed by the Chacabo Indians of the Bolivian Amazon were exploited (Boom, 1989). Home gardens have been documented widely in areas of large indigenous populations such as the Yucatan (Herrrera Castro, 1994) and there have been several efforts to reconstruct pre-Columbian home gardens based on existing evidence such as the structure of present-day homegardens (Barrera, 1980) (see Figure 1), variation in home gardens between different indigenous communities (Rico-Gray et al., 1990) and studies of plant remains and fossils (Turner and Miksicek, 1984). Although there are a considerable number of non-native plants present in mostvexisting homegardens, about half the species are still plants which were known to pre-Columbian populations . Still, it is felt that there is a sufficient evidence to conclude that orchard-gardens existed in Classic Maya times (Turner and Miksicek, 1984: Barrera et al., 1977). Rico-Gray et al. (1990) have noted a loss in multistrata structure and the biodiversity of Mayan home gardens when they are located closer to urban areas. Several authors have speculated that the home garden and indeed all agriculture might have begun in the sort of trash heap that also produced the Terra Preta de Indio soils of the Amazon (Zech et al., 1990; Harlan, 1992; Pringle, 1998).

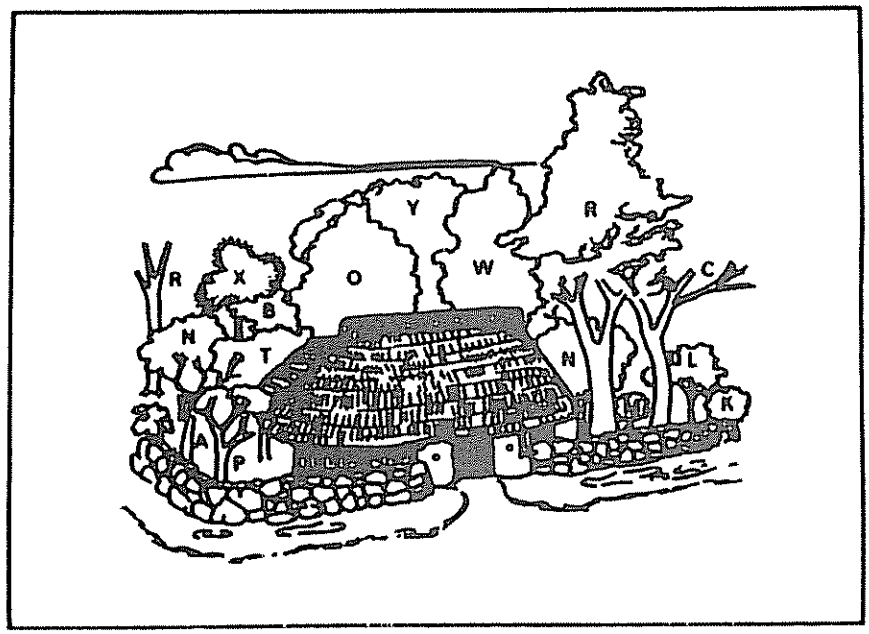

Figure 1. Traditional Mayan home garden, which includes the house (front), the kitchen (behind) and the cropping area with different plant species like A: Spondias mombin, B: Lonchocarpus violaceus, C: Bursea simaruba, L: Crescentia cujete, K:Bixa orellana, M: Capsicum frutescens, N: Plumeria rubra, O: Persea americana, P: Annona cherimola, R: Brosimum alicastrum, T: Dyospiros dignya, W: Talisia olivaeformis, Y: Manilkara sapota, X: Byrsonima crassifolia. (Barrera 1980).

Conclusions

Traditional multistrata agroforestry systems can be found throughout the Americas and reflect the evolution of sedentary agriculture through various interventions in the native vegetation such as cutting, burning or planting of selected tree and crop species. The persistence of multistrata systems in both extensive and intensive production systems demonstrates the appropriateness of the system to the ecological, economic and edaphic conditions of the American tropics. All of the systems described in this paper can be found on farms of the Ngöbe Indians of Panama (Lok and Samaniego, 1988). Although intensively managed multistrata systems do not presently occupy large areas of the Americas, the success of such systems on other continents as well as where they are already practised in the Americas indicates that they have a high potential for sustainable land use and should receive considerable research attention to develop management systems for a wide range of economically important species.

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