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THE OVERSTORY #149--Live Fences, Isolated Trees, and Windbreaks: Tools for Conserving Biodiversity

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INTRODUCTION

At first glance, many deforested tropical landscapes appear to be simple
mosaics of forest patches, interspersed with pastures and crop fields. However, closer examination reveals that many of the agricultural areas retain abundant and conspicuous tree cover, whether as individual isolated trees, live fences, windbreaks, or clusters of trees. Some of these trees are relicts of the original forest that were left standing when the area was cleared; others have regenerated naturally or been

planted by farmers. Often, the isolated trees, live fences, and windbreaks form part of agroforestry systems that the farmers manage to obtain a wide array of goods and services. Although this on-farm tree cover is often overlooked or ignored in surveys of land use (FAO 2000; Kleinn 2000), analyses of forest fragmentation patterns, and conservation efforts, it may be critical to maintaining biodiversity in the fragmented landscapes that characterize many tropical regions (Guevara et al. 1998; Gascon et al. 1999; Harvey et al. 2000).

The presence of live fences, isolated trees, windbreaks, and other agroforestry elements in deforested regions could help conserve biodiversity by serving as habitats, corridors, or stepping stones for plant and animal species, adding structural and floristic complexity to the agricultural landscape and enhancing landscape connectivity. Whereas the importance of these agroforestry elements for conservation efforts has been studied in great detail in temperate regions (Forman and Baudry 1984; Baudry 1988; Capel 1988; Burel 1996), little attention has been focused on their ability to help conserve species in deforested regions in the tropics. Until recently, even the ample literature on the effects of forest fragmentation on the survival of plant and animal populations in the tropics has largely ignored the ability of the surrounding agricultural matrix to support species diversity and enhance species persistence.

In this article, we examine the potential role of three common agroforestry elements - live fences, windbreaks, and isolated trees - in helping to retain plant and animal species and maintain the continuity of species populations and ecological processes in fragmented tropical landscapes. We focus on these elements because they are conspicuous in many regions of the tropics, are easily integrated into farm practices, and appear to hold potential for conservation efforts.

DEFINITIONS

"Live fences" refers to narrow lines of trees or shrub species planted on farm boundaries or between pastures, fields, or animal enclosures whose primary purpose is to control the movement of animals or people (Westley 1990; Budowski and Russo 1993). Live fences usually are composed of a single row of trees or shrubs that are closely planted at uniform distances and may support barbed wire (Sauer 1979; Westley 1990), although sometimes they arise from natural regeneration underneath fence lines.

"Windbreaks" refers to linear plantings of trees and shrubs (usually several rows wide) and linear strips of remnant vegetation whose primary function is to protect crops, livestock, and homes from wind damage (Finch 1988; Wight 1988). Although we focus on windbreaks, many of the generalizations about the relationships between windbreak structure and species composition and biodiversity conservation also hold for hedges.

"Isolated trees" refers to trees that are scattered in pastures, in

fields, or around homes, occur in varying densities and spatial arrangements, and have variable origins (e.g., relicts of the original forest, naturally regenerated, or planted by farmers; Harvey and Haber 1999).

IMPORTANCE OF LIVE FENCES, WINDBREAKS, AND ISOLATED TREES IN TROPICAL REGIONS

With the exception of commercial crops grown in large expanses (e.g., sugar-cane, pineapple, and banana), most tropical agricultural landscapes contain at least some trees, although the density, diversity, and spatial arrangement vary greatly between sites. Although an individual tree, live fence, or windbreak is likely to have little impact on landscape structure and be insignificant to conservation efforts, the presence of several agroforestry elements in the agricultural landscape may greatly enhance tree cover and structural heterogeneity and provide complementary habitats and resources to the remaining forest remnants, thereby contributing to biodiversity maintenance. In addition, by connecting forest patches and other patches of remnant vegetation and forming complex, integrated networks of trees across agricultural landscapes, live fences may reduce the isolation between suitable habitats and influence animal movement patterns (Estrada et al. 1993, 1998; Guevara et al. 1998).

The prevalence of these agroforestry elements in many regions suggests that they may have a significant impact on conservation efforts. For example, in Central and South American landscapes, 60 - 95 percent of the cattle farms have live fences and 25 - 93 percent of the farms have scattered, isolated trees in pastures. In a study in Veracruz, Mexico, isolated trees covered approximately 3.3 percent of the total area in a 5,509-ha landscape and created a fragmented, discontinuous canopy that nevertheless enhanced biotic connectivity (Guevara et al. 1998).

FARMER MANAGEMENT AND USE OF LIVE FENCES, WINDBREAKS, AND ISOLATED TREES

In any particular region, the abundance and distribution of live fences, windbreaks, and isolated trees reflect the history of deforestation and land use as well as the management of farm tree resources (Browder 1996; Arnold and Dewees 1998; Janzi et al. 1999). When farmers clear forests to create agricultural lands, they often retain some forest patches, strips of trees along rivers or streams, and remnant forest trees as sources of future products and services, although in some tropical regions such as the Mata Atlantica of Brazil and parts of the Wet Tropics of northeastern Australia farmers have extensively cleared the land and left little tree cover.

Isolated trees typically are retained in pastures and agricultural areas because of their value as sources of timber, fence posts, firewood, and fruits, as shade and forage for cattle, and as sources of organic

matter for improving soil fertility or because their cutting is prohibited by law (Pezo and Ibrahim 1988; Marmillod 1989; Harvey and Haber 1999; Cajas-Giron and Sinclair 2001). They may also be retained or planted to beautify the farm landscape and increase its economic value (Wight 1988; Bird et al. 1992). Windbreaks are maintained or planted primarily to provide wind protection and prevent soil erosion, although they may provide additional functions and services (Baldwin 1988; Drone 1988; Wight 1988). In contrast, live fences usually are established to delineate borders with adjacent properties, divide pastures into smaller sections for cattle rotation, and prevent animals and humans from trespassing.

When choosing which trees to retain on their farms, farmers generally select healthy trees that have valuable timber or firewood, provide fruits for humans, or serve as cattle forage (Paap 1993; Barrance et al. 2003). Farmers may also carefully determine the distribution of trees within the farm, as is the case in Honduras where maize farmers tend to limit trees to field edges to minimize shading of associated crops (Barrance et al. 2003). This contrasts with tree distributions in pastures, where trees often are widely scattered across the entire pasture to offer shade and supplementary fodder to cattle while they are grazing. Farmers may protect individual trees by clearing around the stem when they are saplings while weeding fields and pastures. To minimize competition between the trees and agricultural crops or pastures, farmers not only regulate tree densities and arrangements but also prune the lower branches of trees to reduce shade, taking care not to affect tree development (Kowal 2000; Barrance et al. 2003). Thus, tree management by farmers is likely to influence the potential of the land to conserve biodiversity.

FLORISTIC AND STRUCTURAL DIVERSITY OF LIVE FENCES, ISOLATED TREES, AND WINDBREAKS

The value of individual agroforestry elements for conservation depends, to a large degree, on their floristic composition and structural diversity. In general, the greater the floristic and structural diversity, the greater the ability of the agroforestry element to provide habitat and resources for wildlife.

--> Floristic and Structural Diversity of Live Fences

When planted by farmers, live fences tend to be simple linear plantings of trees (usually of only a single species) that are evenly spaced and periodically pollarded and trimmed (Sauer 1979; Budowski 1987). Although numerous tree species may be used, a few species account for most live fences. For example, although more than 100 species are used in live fences in Costa Rica, only 8 species account for 95 percent of the posts (Budowski and Russo 1993). In the humid zones of Central America,

northern South America, and several Caribbean countries, live fences generally consist of Erythrina spp. and Gliricidia sepium, whereas in dry areas they usually consist of Bursera simaruba, Spondias purpurea, and Leucaena leucocephala (Budowski 1987). Over time, some of the planted live fences are colonized by other plant species whose seeds are dispersed to the site by birds or other animals (Molano et al. 2002). However, because of the small area below the live fences, the open, exposed conditions, and the frequent disturbance by cattle and humans, only a limited number of plant species establish.

--> Floristic and Structural Diversity of Isolated Trees

In contrast to planted live fences, isolated trees may represent a higher floristic and structural diversity depending on the tree origin (relict, regenerated, or planted), density, distribution within the landscape, and management by farmers. Although the floristic diversity represented by isolated trees is highly variable, in some regions these trees may represent a significant portion of the original tree species present in the forest. For example, isolated trees in pastures of Monteverde, Costa Rica, represented 60 percent of the species present in the study area (Harvey and Haber 1999), whereas isolated trees in pastures in Veracruz, Mexico, represented 33 percent of the total rain-forest tree flora, albeit at greatly reduced densities (Guevara et al. 1998). In the traditional agricultural systems where farmers pollard or cut trees to provide mulch for crop production, tree diversity within the system can be quite high because many trees survive despite being pollarded and resprout in subsequent years (Wilken 1977; Hellin et al. 1999; Garcia Rodriguez et al. 2001; Barrance et al. 2003). However, in other regions where deforestation has been more complete and there are few isolated trees, the floristic diversity may be minimal: for example, in Rondonia, in the southwest of the Brazilian Amazon, 10-year-old pastures retained only 20 of the 326 plant species present in the original forest and only 6 of the 196 tree species in the current forest (Fujisaka et al. 1998).

--> Floristic and Structural Diversity of Windbreaks

Planted windbreaks generally consist of a limited number of species carefully selected for their rapid growth, ability to provide adequate wind protection, and suitability for a given climatic zone. For example, windbreaks in the highlands of Costa Rica tend to consist of primarily exotic species such as Cupressus lusitanica, Alnus jorullensis, Casuarina equisetifolia, and Croton niveus (Combe 1981; Harvey et al. 2000). In Mexico, windbreaks are dominated by Cupressus sp. on the Pacific coast, Tamarix sp. and Casuarina sp. in the semiarid areas, Casuarina sp. in the Golfo, and Erythrina sp. in the highlands of Chiapas (Wilken 1977). Windbreaks are also common features of African countries, with the genera Eucalyptus, Senna, Leucaena, Prosopis,

Casuarina, Azadirachta, and Acacia being used in dry areas (Krishnamurthy and Avila 1999). In tropical Australia, windbreaks are generally composed of Eucalyptus spp., hoop pine (Araucaria cunninghamiana), and the exotic conifer Caribbean pine (Pinus caribea var. hondurensis; Chapter 18, this volume). Unfortunately, many of these common windbreak species offer little in terms of resources for wildlife (Crome et al. 1994).

Despite the fact that the floristic diversity of planted windbreaks usually is quite limited, they can potentially facilitate natural regeneration in their understories by serving as perching and seed deposition sites for birds and other animals and providing a modified microclimate that enhances the establishment of some forest trees. A study in Monteverde, Costa Rica, found that windbreaks (consisting of Montanoa guatemalensis, Cupressus lusitanica, Casuarina equisetifolia, and Croton niveus) received 40 times as many tree seeds and more than twice as many species of seeds as adjacent pastures due to increased bird visitation, indicating the potential for windbreaks as foci for regeneration (Harvey 2000b). Surveys of the understories of windbreaks found a total of 91 tree species (including primary and secondary forest species) occurring as seedlings, just 5 - 6 years after the windbreaks were established (Harvey 2000a). Interestingly, windbreaks connected to forests had significantly higher numbers of tree species and higher densities of tree seedlings than those that were isolated from forests by 20 - 50 m (Harvey 2000a). This pattern probably reflects the greater activity of frugivorous birds in connected windbreaks (DeRosier 1995; Tucker 2001). Planted windbreaks consisting of Eucalyptus camaldulensis, Tecoma stans, and Leucaena leucocephala in Le6n, Nicaragua, similarly appeared to serve as habitats for plant regeneration, although the density and species richness of trees (33 species) in windbreak understories were low, probably because of the frequent use of fire in adjacent agricultural lands (Alvarado et al. 2001). Although it is not clear how many of the regenerating seedlings will survive and grow into mature trees, there is at least a strong potential for the windbreaks to be colonized by native species. To a large degree, the fate of the seedlings depends on windbreak management practices, especially the exclusion of cattle (Capel 1988; Johnson and Beck 1988).

FAUNA ASSOCIATED WITH LIVE FENCES, ISOLATED TREES, AND WINDBREAKS

A variety of animal species may take advantage of agroforestry elements in fragmented landscapes, using them as habitats, foraging sites, corridors, or stepping stones to cross open areas. Here we review the available information on fauna using live fences, isolated trees, and windbreaks and identify factors that influence the value of these agroforestry elements for fauna conservation.

--> Fauna Associated with Live Fences

Live fences in tropical landscapes provide perching sites, cover, and

foraging sites for some animals, including birds, bats, beetles, and nonflying mammals. For example, a total of 98 bird species (representing 54 percent of the bird species detected in adjacent forest fragments) were detected in a 6-km-long live fence consisting of Bursera simaruba and Gliricidia sepium (with a few naturally regenerated species) in Veracruz, Mexico (Estrada et al. 1997). Similarly, in naturally regenerated live fences in Colombia, a total of 105 bird species of 45 families were found, with older, more structurally complex live fences having more bird species and more birds typical of forest borders and secondary growth (Molano et al. 2002). Although live fences often are dominated by bird species typical of edge or open habitats, a few forest interior resident species, including some that rarely leave the forest, also visit them (Estrada et al. 2000). The visiting bird community includes granivores, frugivores, and insectivores that use the fences as perches and foraging sites.

--> Fauna Associated with Isolated Trees

Like live fences, isolated trees may provide habitats, perching and foraging sites, and stepping stones for a variety of animal species, particularly birds. For example, a study in Veracruz, Mexico, recorded 73 bird species visiting four isolated fig trees (Ficus yoponensis and F aurea) in pastures (Guevara and Laborde 1993), and isolated trees in Costa Rican pastures were visited by at least 27 frugivorous bird species (Holl et al. 2000). Some of the frugivorous birds are resident species that nest in pastures, whereas other birds nest elsewhere and use the trees as perching or feeding sites (Guevara and Laborde 1993; Slocum and Horvitz 2000). Similarly, isolated Eucalyptus trees in sheep paddock of New South Wales, Australia, appear to be important for a large range of bird taxa, with 31 bird species observed using paddock trees (Fischer and Lindenmayer 2002a, 2002b). Although many of these birds are open-country birds, several birds considered to be woodland species were also observed visiting the trees (e.g., striated pardalote [Paradalotus straitus], scarlet robin [Petroica multicolor], grey shrike-thrush [Colluricinla harmonica], and crested shrike-tit [Falcunculus frontatus]; Fischer and Lindenmayer 2002a, 2002b).

--> Fauna Associated with Windbreaks

Numerous detailed studies from temperate regions have shown that, depending on their floristic diversity, structural complexity, and management, windbreaks may help conserve a large number of plant and animal species, including a limited number of forest-dependent species, by providing food, cover from predators, refuge, and travel lanes (e.g., Arnold 1983; Osborne 1983; Fournier and Loreau 2001). Windbreaks tend to have the greatest conservation value if they contain a variety of native plant species and life forms, connect to intact forest or other natural vegetation, are wide (so that they contain some interior habitat), and

are protected from grazing cattle (Arnold 1983; Capel 1988; Johnson and Beck 1988; Fritz and Merriam 1993, 1996; Burel 1996). In general, the greater the structural and floristic diversity, the more ecological niches are available for other plants and animals. When windbreaks connect forest fragments or other remnant vegetation, they may also serve as corridors for some animal species (Yahner 1983; Haas 1995). The modified microclimatic conditions in the windbreaks may be more favorable than those in the open pastures or fields and provide protection from weather extremes; however, these microclimatic conditions are likely to be spatially and temporarily variable throughout the length of the windbreak. Most of the species that benefit from the presence of windbreaks are edge species that are capable of using highly modified habitats; few forest interior species appear to take advantage of windbreak habitats (Burel 1996; Corbit et al. 1999)

CONCLUSIONS

The emerging data show that live fences, windbreaks, and isolated trees may contribute to biodiversity conservation and suggest that retaining or establishing trees in agricultural lands may be a critical component of conservation efforts in fragmented landscapes. The floristic diversity conserved in these agroforestry systems can be high, and a substantial number of animal species may exploit these habitats for feeding, movement, and in some cases reproduction, although the value of each agroforestry element depends on its structure, composition, management, and position in the landscape. Many species that benefit from agroforestry systems are generalist species, but some forest specialist species usually are also present. By forming networks of natural habitats, live fences, windbreaks, and isolated trees may also enhance landscape connectivity and contribute biodiversity conservation at different scales.

However, it should be emphasized that although these agroforestry elements are useful additions or complements to the conservation of natural habitats, they are not substitutes for the original vegetation. Live fences, windbreaks, and isolated trees are not complete ecological units and cannot provide the full array of habitats or services of the original habitat; consequently, the organisms in them are likely to depend, at least to some degree, on nearby remnant habitats. Efforts to conserve biodiversity in fragmented landscapes therefore should focus on developing landscape-scale strategies that integrate the retention and establishment of windbreaks, live fences, isolated trees, and other agroforestry elements with the conservation of forest fragments, the retention of riparian vegetation, the maintenance of connectivity in the agricultural landscape, and other conservation strategies (Vandemeer and Perfecto 1997; Harvey et al. 2000; Tucker 2000; Daily et al. 2001).

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World Resources Institute, Biodiversity and Protected Areas:
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Biodiversity Support Programme: <http://www.BSPonline.org/>

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