Bird Composition in Living Fences:

Potential of Living Fences to Connect the Fragmented Landscape in Esparza, Costa Rica.

by Wendy Francesconi, MESc 2006

Introduction

Many traditional agricultural practices replace natural vegetation with crop or pasture production systems, which directly reduce diversity (Swift et al. 2004). Among the agricultural practices, monocultures are more damaging to the environment than polycultures, which make agricultural ecosystems more complex and, therefore, more similar to the natural environment. Agroforestry systems are polyculture systems that have trees as one of the managed crops in the agricultural system (Nair et al. 1995). Incorporating agroforestry into monocultures could ameliorate the disturbing characteristics of conventional agriculture (Nair et al. 1995).

Agroforestry practices vary depending on the objectives and characteristics of the region (Nair et al. 1995). Agroforestry, a science that has been studied for a few decades (ICRAF 2004), employs systems that are able to generate a wide range of environmental services. The services include secondary benefits lauded by conservation biologists, such as integration of natural resources management and biodiversity conservation (Perfecto et al. 1996).

As the fragmentation of natural landscapes continues, greater biodiversity losses are expected. Since the trend for tropical forest areas is conversion into agricultural fields, the agricultural matrix determines the decline or preservation of the remaining natural areas and the associated wildlife. Replacing conventional agriculture with agroforestry is a suggested approach that could conserve biodiversity in the landscape (Schroth et al. 2004).

The ecological value of silvopastoral systems and the role of live fences for biodiversity conservation are still under examination. Live fences consist of live vegetation, their primary purpose is to divide, separate, and protect agricultural plots or livestock. However, they are also attractive to farmers because they offer fuel wood, fruits, shade, soil enrichment, and fodder for livestock, in addition to promoting biodiversity (Budowski 1987; Bennett 1999; Alonso et al. 2000; Zahawi 2005).

Live fences are thought to contribute to ecosystem function by increasing landscape connectivity through vegetative coverage and enhancing biodiversity by supplying habitat to wildlife and plants in the landscape (Figure 1). Because live fences create tree networks and divide open agricultural fields into smaller units, they allow for more interactions on the landscape, including interactions between forest fragments. Depending on the species composition and the intrinsic physical characteristics of the trees, these fences have the potential to provide refuge and habitat for wildlife while they move across the landscape (Harvey et al. 2003).

Wendy Francesconi began her undergraduate studies in Bogotá, Colombia at Pontificia Universidad Javeriana. She studied Ecology and participated in a student exchange program at Colorado State University, after which she moved to New York City - the town where she was born. Afte receiving a Biology degree from Hunter College, she began her masters program at Yale School of Forestry and Environmental Studies, where she is in her second year. She plans to pursue a Ph.D. at the School of Forest Resources and Conservation at the University of Florida.

Eumomota superciliosa (turquiose-browed motmot)
Source: Stiles and Skutch 2003

Site Description

The study took place in Esparza, a cattle grazing region in Costa Rica located at 9°58'60"N and 84°40'0"W and at altitudes of between 400 and 1,000 meters above sea level. The hilly topography of the area creates riparian forests at lower elevations. Precipitation is 1,500 to 2,500 mm per year and the mean annual temperature is 27°C, conditions that place Esparza's climate as tropical sub-humid (Camargo 2003).

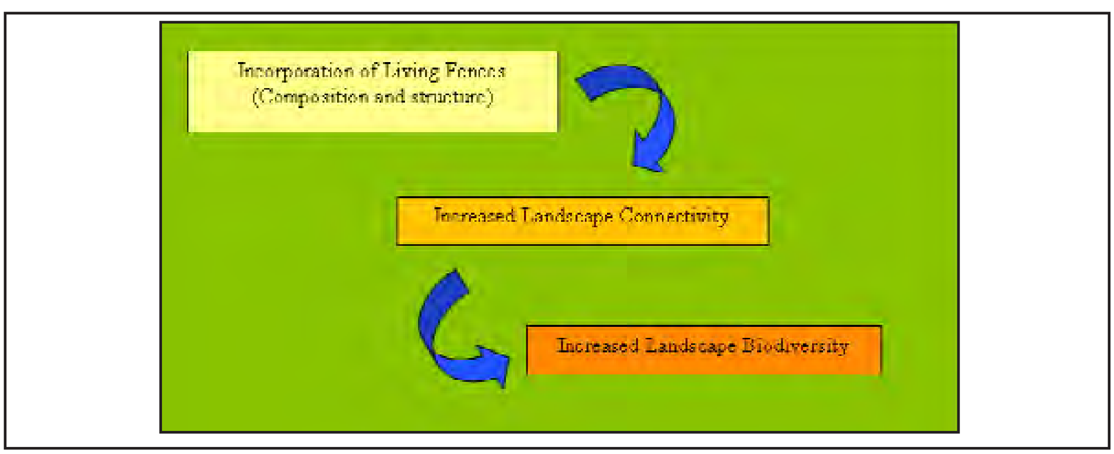
As a developing country, Costa Rica depends on agriculture, including the export of products such as coffee, pineapples, bananas, and beef. In recent decades, population growth and the need for economic expansion has expanded this industry, resulting in an increased conversion of unprotected forest habitats into agricultural lands. In fact, the export-oriented cattle industry of the 1960s and 1970s is responsible for most of the country's deforestation (Sequeira 1984). Beef production is more sustainable today because silvopastoral systems have spread throughout the country, especially among smallholder farms.

Five farms in the San Carlos and San Jeronimo districts were selected based on their live fence network designs and surrounding habitats. The natural vegetation can be defined as dry tropical forest, and the region is characterized by an abundance of flora and fauna. In general, the landscape is rich and colorful, and the hilltops of these districts provide a view of the Pacific Ocean.

Methods

Living fence networks of five silvopastoral farms were analyzed in this study. Three live

Figure 1. Function of Live Fences for the Conservation of Biodiversity in the Landscape



Satellite image of one of the silvopastoral farms used for the study. The farm, owned by Napoleon Gonzales, is located in the district of Peñas Blancas in Esparza, Costa Rica.

fences at each farm were classified into three different treatments: living fences connected, intermediate, and distant from secondary forest patches. Distance from the fences to the forest patch was 0 m to 125 m, 125 m to 250 m, and 250 m to 375 m, respectively.

Bird presence was observed in fences and at a control site in the nearest riparian forest. Point counts were used to perform the observations, using modifications based on Santivanez for live fences (2005). Five consecutive point counts were performed at each live fence, and these were located along the transect 25 meters from each other (Santivanez 2005). A total of 667 individuals of 75 species were observed at the live fence sites.

The selected live fences and control site were visited four times in four weeks during July and August. This is the rainy season and migrating birds are absent in the region. Bird presence was registered during each point count at 10-minute intervals from 6:00 am to 11:00 am, which are the hours of highest bird activity (Santivanez 2005). The order of observations at the sites was altered during the study to avoid any bias, as bird activity decreases with increasing temperature.

Live fence vegetative cover was characterized based on the methodology used by Lang et al. (2003). Number of trees within the point count area was recorded. Live fence and remnant pasture trees were identified and measured for vegetative structure and species composition. Measurements of total tree height, trunk height, diameter at breast height (dbh), and crown diameter (taken using instruments such as clinometer, tape measurer, and diameter measuring tape) were used later to compare the vegetative characteristics of each fence. The dominant tree species in most fences was Indio Desnudo (*Bursera simaruba*), and secondary species include Pochote (*Pachira quinata*) and Roble Sabana (*Tabebuia rosea*). Other less frequent species were also found, indicating fence-tree diversity.

Distance of each point count to the riparian forest was measured using a Geographic

Positioning System (GPS) unit and satellite images of the farms. The Tropical Agricultural Research and Higher Education Center (CATIE), a collaborator in this project, had previously manipulated the satellite images using Arc View 3.2 Geographic Information Systems (GIS) software, to depict living fence networks on each farm. This made the selection of the farms and fences easier, as well as the visualization of the study's design.

Conclusions

Based on our finding we can conclude that living fences promote biodiversity. Living fences are used by forest, generalist and savanna specialist bird species. The presence of birds in living fences could also be improved. After comparing the fence characterization variables against the number of bird individuals and species, we found that crown diameter, tree diversity, and

Figure 2. Species composition in living fences

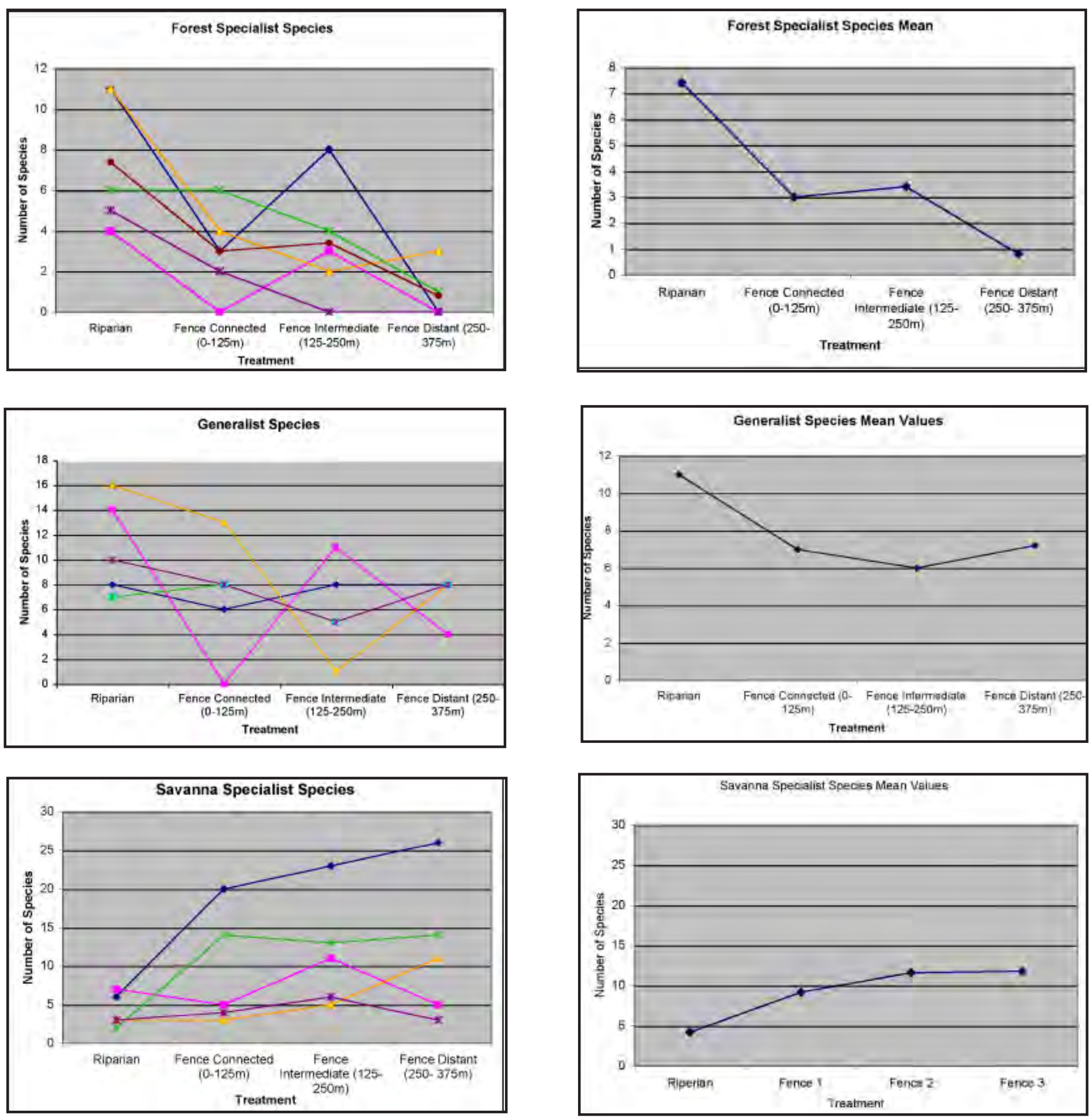


Table 1. SPSS MANOVA analysis. Multivariate test between tree characteristics and bird observations (df= degrees of freedom, F=test statistic)

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	NBirds	313.588[a]	20	15.679	4.136	.000
	SpeBirds	1274.532[b]	20	63.727	5.027	.000
Intercept	NBirds	12.394	1	12.394	3.269	.076
	SpeBirds	47.194	1	47.194	3.722	.059
NTrees	NBirds	3.949	1	3.949	1.042	.312
	SpeBirds	.074	1	.074	.006	.940
MeanDBH	NBirds	91.511	1	91.511	24.137	.000
	SpeBirds	295.313	1	295.313	23.293	.000
MeanTotalH	NBirds	.214	1	.214	.056	.813
	SpeBirds	2.975	1	2.975	.235	.630
MeanTrunkH	NBirds	8.585	1	8.585	2.264	.138
	SpeBirds	22.072	1	22.072	1.741	.193
MeanCrown	NBirds	15.395	1	15.395	4.061	.049
	SpeBirds	78.726	1	78.726	6.210	.016
SpTrees	NBirds	68.551	1	68.551	18.081	.000
	SpeBirds	192.464	1	192.464	15.181	.000
Fence	NBirds	76.347	14	5.453	1.438	.168
	SpeBirds	380.339	14	27.167	2.143	.023
Error	NBirds	204.732	54	3.791		
	SpeBirds	684.615	54	12.678		
Total	NBirds	1534.000	75			
	SpeBirds	5400.000	75			
Corrected Total	NBirds	518.320	74			
	SpeBirds	1959.147	74			

a. R Squared = .605 (Adjusted R Squared = .459)

b. R Squared = .651 (Adjusted R Squared = .521)

dbh values are significant variables that can be manipulated to affect bird species diversity and abundance. High values for these variables should result in fences that are more attractive to birds.

The effectiveness of living fences to connect the fragmented landscape is a dependent factor. Living fences have the capability to attract forest species and facilitate the movement of wildlife across the fragmented landscape, but all living fences are not equally effective. There is much variability in the design, structure, and composition of fences, which makes their evaluation very difficult. According to my results, for a live fence to be successful at connecting the fragmented landscape, the fence needs to contain trees with broad crowns, large dbh values, and various species (Table 1).

Distance to the forest patch affects the number of species present in living fences. Only few forest specialist species venture out of the forest areas and into the agricultural scenery. The number of forest species present in living fences decreases as we move away from the forest habitat. According to our results, living fences could potentially counteract the effect of distance to patches if the fences contain high values of the significant variables identified.

Differences in bird observation between the farms (Figure 2, left column) can be explained by the variability between silvopastoral systems. Besides the differences in structure and composition of the fences, some other factors that could lead to variability are the live fence network design and the number of fences on a farm. For the purposes of this study, we only compared the structure and composition of the selected fence segments, but future studies should consider the spatial design of the fences in the pasture.

Discussion

An important characteristic of living fences is tree management by farm owners. Since the main priority in silvopastoral systems is pasture availability for grazing purposes, trees in living fences are subjected to pruning. Large crowns are not a desirable feature in silvopastoral systems because they limit pasture growth, so pruning is done once or twice per year to improve pasture growth as well as use as fodder, fuel wood, and stem production for new live fences (for species with vegetative growth capability). For these reasons, farm owners have little incentive to allow full crowns to develop. In turn, this practice lowers the potential for living fences to be attractive to generalist or forest specialist species.

It is recognized that a farmer's choice to use living trees instead of dead post for fences increases landscape connectivity. Better yet, when the trees in those fences are large and diverse, they provide greater benefits to the ecosystem and to the farmer. In the same line of thought, fences that provide greater landscape connectivity are better at providing refuge to a higher number of bird species and individuals. Based on the results, crown area, tree diversity, and dbh are significant variables associated to the bird species composition in living fences. In addition, living fences could be effective at connecting the fragmented landscape, allowing some forest species to be able to move across the pasturelands to distant forest patches, but only if those fences contain the tree characteristics identified as significant.

Among the environmental services provided by living fences, landscape connectivity and biodiversity conservation are proposed as secondary services of these agroforestry systems. This is a true assumption but the contributions from living fences vary depending on the characteristics of their tree composition. Living fences are effective at providing habitat to savanna specialist and generalist species, though they do no seem very effective at providing refuge for forest species unless the fence is manage to allow a few trees to develop naturally.

The application of these findings could be used to modify management techniques of living fences. Either by altering pruning cycles or by performing selective pruning, modifications to pruning techniques can be done to allow the best bird hosting trees to continue providing landscape connectivity, which promotes wildlife conservation. Farmers usually appreciate greater biodiversity on their farms and are aware of the benefits of birds to disperse seeds and prey on parasites. I believe they would be interested in improving their living fence management practices, to enhance the conservation of wildlife.

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References

Alonso, J., G. Febles, and J.C. Gutierrez. 2000. Methods for Introducing Species of Trees as Living Fences in grazing Areas. *Cuban Journal of Agricultural Science* 34 (2): 153-157.

Bennett, A.F. 1999. Linkages in the Landscape. T*he Role of Corridors and Connectivity in the Wildlife Conservation*. Gland, Switzerland and Cambridge, UK: IUCN. p. 240-244.

Budowski, G. 1987. *Living Fences in Tropical America, a Widespread Agroforestry Practice. Agroforestry, Realities, Possibilities and*

Potentials. Doordrecht, Netherlands: Martinus Nijhoff.

Camargo, J.J. 2003. *Sistemas Silvopastoriles con Laurel (Cordia alliodora) en el Tropico Humedo y Subhumedo de Costa Rica. Agroforesteria para la Produccion Animal en America Latina – II*. Estudios FAO Produccion y Sanidad Animal.

Harvey, C., C. Villanueva, J. Villacis, M. Chacon, D. Munoz M. Lopez, M. Ibrahim, R. Gomez, R. Taylor, J. Martinez, A. Navas, J. Saenz, D. Sanches, A. Medina, S. Vilches, B. Hernandes, A. Peres, F. Ruiz, F. Lopez, I. Lang, S. Kunth, and F. Sinclair. 2003. Contribucion de las Cercas Vivas a la Productividad e Integridad Ecologica de los Paisajes Agricolas en America Central. *Agroforesteria de las Americas* 10 (39- 40): 30-40.

ICRAF (World Agroforestry Center). 2004. *International Council for Research in Agroforestry* . Nairobi, Kenya. Consulted on June 6, 2005. Available http://www.worldagroforestry.org.

Lang, I., L.H.L Gormley, C.A. Harvey, and F.L. Sinclair. 2003. Composicion de la Communidad de Aves en Cercas Vivas de Rio Frio, Costa Rica. *Agroforesteria en las Americas* 10 (39-40): 86-92.

Nair, P.K., B. Kang, and D. Kaas. 1995. Nutrient Cycling and Soil Erosion Control in Agroforestry Systems. Pp. 117-138 in *Agriculture and Environment: Bridging Food Production and Environmental Protection in Developing Countries*, edited by A. Juo. Madison, WI: American Society of Adronomy (ASA). (ASA Special Publication n°60).

Perfecto, I., R.A. Rice, R. Greenberg, and M.E. van der Voort. 1996. Shadecoffee: a Disappearing Refuge for Biodiversity. *Bioscience* 46: 598-608.

Santivanez, J.L., 2005. *Contibucion de las Cercas Vivas en la Connectividad para Mantener y Conservar Aves en un Paisaje Fragmentado en Rio Frio, Costa Rica*. Tesis Mg. Sc. Turriabla, CR CATIE. 108.

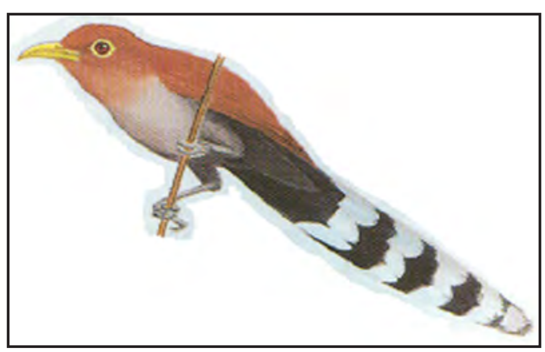
Schroth, G., G.A.B. da Fonseca, C.A. Harvey, C. Gascon, Vasconcelos, H.L., and A.M.N. Izac. 2004. *Agroforestry and Biodiversity Conservation in Tropical Lanscapes*. Washington, DC: Island Press.

Sequeira, W. 1984. *Agroforestry Systems and Rural Development in Costa Rica.* Tesis Mg. Sc. Turrialba, CR, CATIE.

Stiles, G.F. and A. Skutch. 2003. *Guía de aves de Costa Rica. 3ra. edición* Trad. L. Roselli, illus. D. Garner. Instituto Nacional de Biodiversidad, Heredia, Costa Rica. 572 pp.

Swift, M.J., A.M.N. Izac, and M. van Noordwijk. 2004. Biodiversity and Ecosyustem Services in Agricultural Landscapes – Are We Asking the Right Question? *Agriculture Ecosystems and Environment* 104: 113-134.

Zahawi, R. A. 2005. Establishment and Growth of Living Fence Species: An Overlooked Tool for the Restoration of Degraded Areas in the Tropics. *Restoration Ecology* 13 (1): 92-102.



Piaya Cayana (Squirrel Cuckoo)
Source: Stiles and Skutch 2003