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Farmers' perceptions of trees on their land in the Santa Cruz area, Biological Corridor Volcanica Central-Talamanca, Costa Rica

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Abstract

The Biological Corridor Volcanica Central-Talamanca aims to restore and maintain the biological connectivity between protected areas in Costa Rica. Trees outside forest such as live fences, dispersed trees within pastures and riparian areas, play productive and conservation roles and increase connectivity in the agricultural landscapes. The study aims to explore farmers' perceptions of trees on their land in the Santa Cruz area, north-west of the biological corridor. Semi-structured interviews with key informants and farmers were conducted. Farmers maintained trees outside forest on their land and attributed diverse values to trees including technical, through the provision of live fences or shelter for cattle, economic, as a source of timber, fuelwood or fruits, and ecological, for wildlife and watershed protection but also social, cultural, aesthetic and heritage values. They reported limitations to have trees such as lack of capital, labour and land and lack of adapted species and technical assistance. More investigations are needed especially on the relation between tree cover and landscape functional connectivity. Still, local authorities and organisations including the BCVCT's committee should ensure and encourage trees outside forest uses in the agricultural landscape through a strategic planning including the promotion of the conversion of fences to live fences, farmers training and education, technical assistance and the adaptation of existing incentives such as Payments for Ecosystem Services.

Keywords: trees outside forest, farmer perception, cattle farming system, agricultural landscape connectivity, Santa Cruz de Turrialba

Introduction

Conservation in Costa Rica is nowadays influenced by a regional emphasis on connectivity and a conservation focus on human-modified landscapes, especially agricultural systems, due to Mesoamerica's unique context: a bridge between two continents and a barrier due to its volcanic central mountain range (DeClerck et al., 2010). Part of the Mesoamerican Biological Corridor, the Biological Corridor of Volcanica Central-Talamanca (BCVCT) was created in 2003. Its main aims are to restore and maintain biological connectivity which means connect together protected areas to enable movements of fauna and flora between those protected areas and to mitigate habitat fragmentation and population isolation. For this purpose, the BCVCT's management committee has set several objectives including improving nature conservation especially soil, watershed and biodiversity protection and enhancing economic and social conditions in the area for the well-being of the population. Within the BCVCT, fragmented forests and pastures are the two main land uses with respectively 52% and 24% of the BCVCT land (Murrieta, 2006; Ramirez Chávez, 2006). Although forests' connectivity has been studied in the BCVCT, the biological connectivity within the agricultural landscape has not yet been investigated.

"Trees outside forests" have been described by Bellefontaine et al. (2002) as "trees on land not defined as forest and other wooded land". Within the agricultural landscape of the corridor, trees outside forests can be found in agroforestry systems, live fences, along roads and human settlements, dispersed within pastures and in riparian areas. Live fences are "narrow linear strips of planted trees, generally consisting of a single row of a few densely planted species" established and managed by farmers (Sauer, 1979, Budowski, 1987 cited in León & Harvey, 2006, Harvey et al., 2005). Their primary purpose is to provide fencing to restrict animal movements and they are integral components of farm production systems (Harvey et al., 2005). Dispersed trees within pastures include isolated trees, pastures trees,

scattered trees or remnant trees (Manning et al., 2006). They can have different origins: left after a forest clearance, result of natural regeneration or planted by farmers (Harvey & Haber, 1999). Riparian areas are linear elements defined by their proximity to rivers, streams and watercourses (Bennett, 2003) that can vary from a few row of trees of a couple of meters wide to a whole complex forest patch. Different studies in Costa Rica have reported the important productive and ecological roles of live fences, dispersed trees within pastures and riparian areas. Firstly, they can diversify production and income, increase total productivity and provide technical support with fencing and shade (Love et al., 2009). At local scale, they provide habitat, shelter and resources for some plant and animal species and they increase plant species richness and structural complexity (León & Harvey, 2006). At a landscape scale, they enhance the overall tree cover and increase connectivity for animals (Bennett, 2003) and genetic connectivity for tree populations (Manning et al., 2006). Finally, they play a key role in defining the composition and structural connectivity of the agricultural landscape (Harvey et al., 2005; Harvey et al., 2011). Because they play "productive and environmentally protective roles", they have been highlighted as keystone elements to contribute to both sustainable development and conservation within agricultural landscapes (Harvey et al., 2011). As a consequence, trees outside forest merit considerations as they can participate in the BCVCT's goals of improving conservation and landscape connectivity.

However, major conflicts have been reported concerning trees retention within pastures especially in the north-west part of the corridor which is mainly dedicated to pastures for dairy cattle farming (Murrieta, 2006). The agricultural landscape is managed by smallholders including small farmers and tree cover is closely related to farmers management of trees on their land. Thus, to achieve its conservation goals, the BCVCT has to work in alliance with local stakeholders including farmers and consequently understand farmers' management in order to effectively support and foster sustainable management of tree cover within the

BCVCT. This study aims to explore whether farmers in the north-west part of the BCVCT maintain trees outside forest on their land or not, their perceptions of trees on their land, their possible limitations for having trees on their land and their willingness to plant.

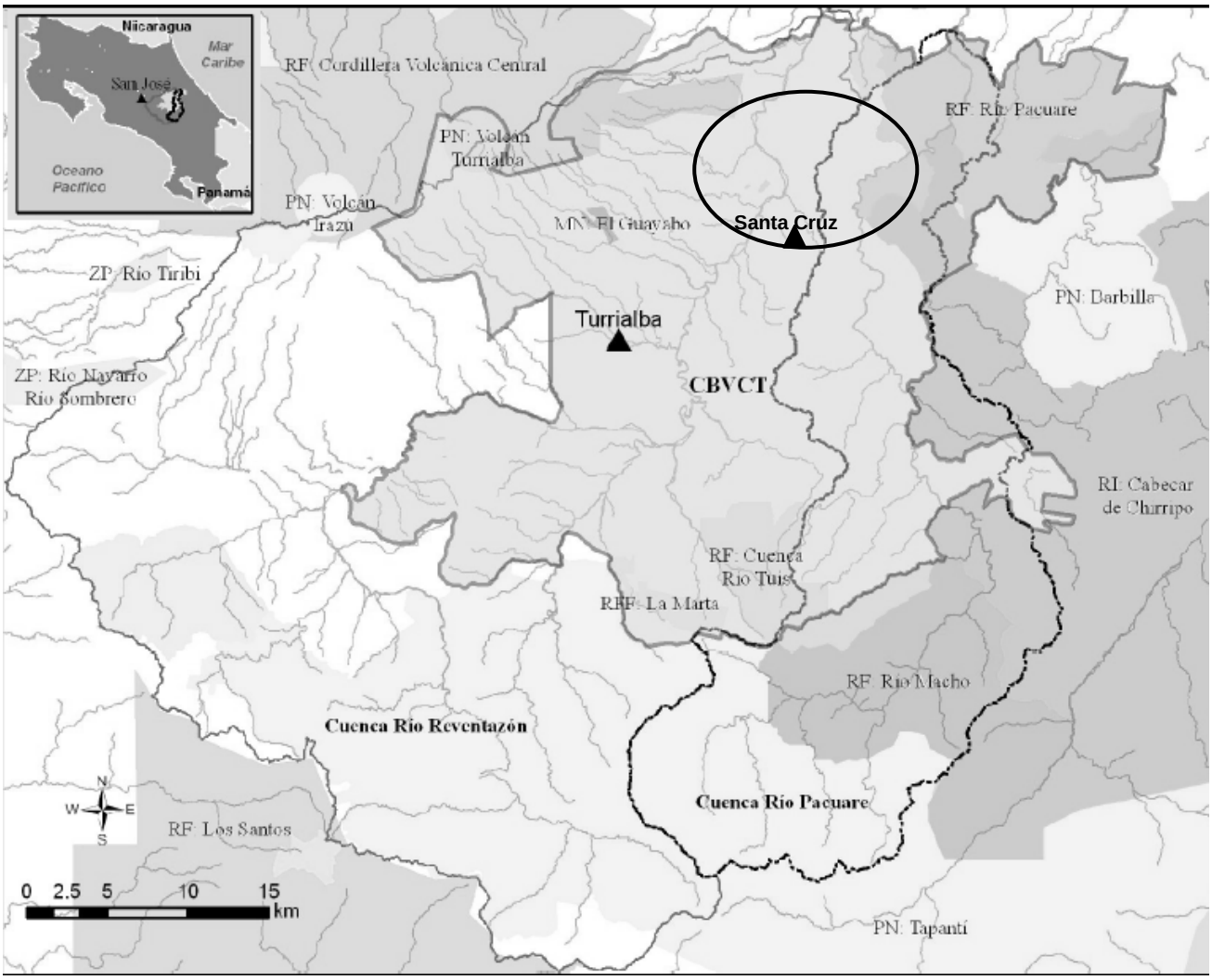
Methods

Study site

The study was conducted in the Santa Cruz district, north-west of the county town Turrialba, province of Cartago, Costa Rica. The Santa Cruz district has an area of 127,40 km² with an estimated 3944 inhabitants (INEC, 2009). The exact study site encompasses a larger territory than the Santa Cruz district and corresponds to the land of the traditional dairy-cattle activity. It includes the localities of San Antonio, El Carmen, Santa Cruz, Torito, Guayabo, Calle Vargas, Calle Leiva, Las Abras, Las Virtudes, La Pastora, El Volcan (La Picada, Finca Central, La Fuente, El Triunfo, El Tapojo) that belong to Santa Cruz district and Los Bajos, Bonilla that are north-west of Santa Teresita district. This territory is homogenous in terms of its natural resources, farming activities and main communications. Its main urban center is Santa Cruz de Turrialba.

Figure I

Map of the study area in the north-west of the Biological Corridor Volcanica Central-Talamanca in Costa Rica



The study site altitude varies from 900 to 3000 m on the slopes of the Turrialba Volcano, the temperature varies from 10°c to 19°c, annual precipitation is from 3000 to 3500 mm with an average humidity of 85% (Blanco, 2007). The Santa Cruz area is part of the North Sub-Corridor, one of the six sub-corridors of the Biological Corridor Volcanica Central-Talamanca. It is a mountainous area with a fertile volcanic soil that falls into the Wet Tropical Forest life zone (Holdridge, 1967). The Turrialba Volcano is protected by a national park of approximately 1600 ha that encompasses its close slopes. Since 2007, the volcano has erupted

gas, vapour and ashes. In 2009, its acid rain harmed a lot of vegetation in its close environment including the close farms and human settlements. Nowadays, it still smokes and visits by tourists are subject to close supervision. The area is dedicated to cattle raising specialized in dairy production and processing of traditional handmade cheese in family-owned farms. The "Turrialba cheese" has been produced for more than a century in the area and has gained an undeniable reputation in all Costa Rica.

Semi-structured interviews

The study consisted of interviews with key informants and farmers.

The key informants interviews were conducted with organisations working in the area in the agricultural and environmental sectors in order to understand current local issues related to production, land-use and tree cover and local stakeholders and local initiatives. Twelve semi-structured interviews with institutions, associations and the local offices of the Department for agriculture and the Department for environment, have been realised following an interview guide. It included questions dealing with the organisation's goals and activities and the informant's perception of the farmer's management of tree cover on farm land in the area.

The farmers interviews were conducted to explore farmers' reasons for maintaining trees on their land or not and the values they attribute to them and to investigate factors limiting trees presence and use and farmers' willingness to plant. The researcher carried out thirty farmers interviews in Spanish on farms with 24 male and 6 female farm managers. The first part of the interviews was a semi-structured interview which aimed at a qualitative exploration. The researcher followed an interview guide of open-ended questions about the farm production, management and change, farmer's participation in projects and involvement in social networks and concerning trees on their land, their origins, reasons for maintaining them or not, their trees' management practices, difficulties and willingness to plant. No predefined list

were introduced to farmers concerning their reasons for maintaining trees or the values they expressed in order to ensure they were not influenced in their answers. As quantitative data were also needed to enrich the understanding of the farming systems in the area, a short set of closed questions allowed the researcher to make sure all the necessary data on the farm and the farmer was collected. When the data had already been given through the answers of the semi-structured interview, the closed questions were not needed. Finally, the interviews ended with a tour of the farmer's land which allowed more in depth explanations about trees presence and use to be collected. The interviews lasted from an hour and a half to three hours. Contacts were made with farmers in different ways: through the local cattle farmers association and as the study went along, through haphazard sampling (farmers met by chance) and snowball sampling (asking interviewed farmers for contacts). From all the different farmers encountered, the most diverse ones were chosen to be interviewed in order to obtain the greatest diversity within the sample. Although notes were taken during the interviews, they were also recorded in full in order to allow the researcher to listen to them again to complete her notes. They were then analysed through coding for key themes which were developed from the text.

Results

Diversity of farmers interviewed

The average size of the farms surveyed was 32 ha ranging from 1,5 ha to 370 ha. The average herd size was 47 ranging from 7 to 400. Although most of the farmers lived and worked on their farm with their family and had learnt their work with their parents, the average size and herd size pointed out the large diversity of farms encountered in the Santa Cruz area. To present the diversity of the farmers interviewed, farmers were distinguished in broad outline (Table 1). The main characteristics that differentiated the farmers were their production, the

farm diversification and commercialisation they developed, their involvement in local organisations and the technological level of the farm. Five farmers categories were obtained on a scale from the category A, elementary dairy farmer that processed traditional cheese sold to a local retailer, and with the diversification of the production (category B), the increase of the farmer involvement in professional and community organisations (category C), and the increase of the technological level (category D), to category E that were farmers that were similar to entrepreneur managing a farm business that commercialised diverse products on a national market.

Table 1

Broad outline of the five different categories of the interviewed farmers

Category and number of farmers of each category within the sample		Characteristics and Strategy
A	Traditional elementary farmer (5)	Dairy cattle and traditional cheese production sold to a local retailer Basic technological level of the farm No other activities
B	Farmer adopting diversification (10)	Dairy cattle and traditional cheese production Diversifies his production with pig, poultry or vegetables Will to develop the farming activity by improvement or extension of current production
C	Farmer involved in local organisations (4)	Dairy cattle production and traditional cheese production Diversifies his production with pig, poultry or vegetable but also different type of cheese, new types of products, tourism activities Involved in local organisations, local initiatives, in relation with other stakeholders and institutions
D	Owner-manager (6)	Dairy cattle production with higher technological level Development of non-traditional activities: milk marketing, small cheese factory processing new types of cheese
E	National-level entrepreneur (4)	Dairy and meat production sold on a national market High technological level with international standards Owner with a high education level and a professional technical team.

Farmers maintained trees on their land

All farmers interviewed maintained trees on their land. The trees outside forest met in the agricultural landscape of Santa Cruz were live fences, dispersed trees within pastures, trees in riparian areas, around homes, farm's buildings and tracks and in orchards. 18 farmers (62%) expressed a will to plant more trees on their land generally in areas that were not productive including very steep slopes dangerous to cattle, on the farm boundaries, along buildings or along riparian areas. They were interested in planting trees' species which were source of timber, source of fruits and native trees that provide habitat and resources to wildlife.

Trees within pastures were generally in low densities and dispersed because they competed for light, water and nutrients with grass and were viewed as reducing pastures productivity. Concerning farmers' practices related to trees management, dispersed trees within pastures were occasionally pruned to limit the shade. Shade management has been described as a key factor influencing farmers decisions to maintain trees within pastures or not (Harvey & Haber, 1999). Similarly, in Santa Cruz, farmers selected trees on their farm land to limit shade in pastures in order to prevent excessive humidity that causes mud especially during the rainy season. Most of the trees within pastures were remnant trees. Farmers explained they didn't plant within pastures because the livestock would browse or trample the seedlings causing its death. There was a rotation of pasture but not long enough to allow saplings to grow tall and thick enough to resist livestock damages.

Few tree species were cited by farmers which can be used in live fences and they were only native species. Although the most common and traditionally used species was the native *Erythrina spp.* (poró), *Trichanthera gigantea* (nacedero) and *Drimys spp*. (quiebra muela) were also cited. In the areas of El Volcan, Las Abras and Los Bajos, *Erythrina spp*. didn't grow because of the altitude. In Las Abras and Los Bajos, *Drimys spp*. (quiebra muela) was used instead for live fences. However, no species was reported to be adapted for live fences in

the area of El Volcan. A live fence main advantage was its ability to be vegetatively propagated by cuttings which was low-cost and easy:

You look for the larger branch of the tree, you cut it, you plant it and that's all. It doesn't cost a thing and it's easy.

If I produce my own post [for live fences] I don't have to buy them, the farm saves on it.

To limit their shade the *Erythrina spp*. trees were regularly pollarded. The young branches and leaves were used as fodder, known to be very palatable for cattle. Sometimes, they were also used as a green fertilizer. Trees were pollarded every 1 or 2 times a year depending on the branches' length. The cut branches that were straight and long enough (so that the leaves were out of reach of the cattle) were used as cuttings to be planted directly in the ground after removing the side leaves in order to keep planting fences, to thicken the existing fence or to replace dead trees. After three years, the young cutting became a tree that could be pollarded in turn. The wood provided by the other cut branches was chopped and used as fertilizer or fuelwood. To consolidate the barrier, 4 strings of barbed wire were usually fixed on the living posts which was sometimes considered as a drawback as barbed wire can injure livestock. However, few farmers started to use insulators to fix an electric fence on the living posts.

Values given to trees

Reasons for having, maintaining, using or planting trees given by farmers were interpreted in terms of values given to trees by farmers (table 2). Farmers expressed diverse trees' values and especially technical, economic and ecological ones. The most expressed ones were respectively: provision of post for live fences (83%) and cattle shelter (66%), production of timber (79%) and fuelwood (55%) and wildlife (72%) and watershed protection (62%). Social, heritage, cultural and aesthetic values were also expressed. Fodder production, reported as a common use of trees outside forest in Costa Rica (Hidalgo & Kleinn, 2001),

appeared very limited in Santa Cruz and windbreak seemed absent certainly due to the climatic conditions.

Table 2

Categorisation of the trees' values expressed by farmers and amount of farmers that have expressed them in the Santa Cruz area in Costa Rica.

Trees' value	**Number of farmers that have expressed the value (n=29)**	**Percentage of farmers that have expressed the value (n=29)**
Technical value		
- Post for live fence	24	83
- Cattle shelter	19	66
- Pasture fertilisation	10	35
Economic value		
- Source of timber	23	79
- Source of fuelwood	16	55
- Provision of fruit	14	48
- Provision of fodder	5	17
Ecological value		
- Watershed protection	18	62
- Wildlife protection	21	72
- Soil protection	4	14
- Air quality	7	24
- Microclimate	2	7
Heritage	10	35
Aesthetic	13	45
Cultural	3	10
Social value		
- Sharing	2	7
- Recreational	3	10
- Medicinal	1	4

Farmers from categories A and B expressed mainly technical and economic values for trees. They valued the additional production of goods and services trees provided which represented an increase of income and productivity. The ecological value of wildlife and water protection were expressed within all categories of farmers. These values might be transmitted through communications of environmental awareness made by the local institutions and associations but also through medias. Farmers from categories C and D expressed more diverse values in addition to the technical and economic ones, including heritage, recreational, social, cultural and medicinal. Farmers from category E expressed less technical and economic values but more diverse ecological ones. They valued trees as part of the farming system providing ecosystem services that benefited the farm and the environment.

Technical Value

Trees' technical values were related to uses of trees that supported or improved farming activities such as posts in live fences, shelter for the livestock or fertilizer for pasture.

Depending on the fence function, inside the farm to divide pastures or to border the farm, farmers had different considerations. To border the farm and mark out the property, live fences had the advantages of being rooted and thus more immovable than a fence post:

> *In the farm boundaries there are live fences because it is more strict: it is unforgivable that cows get out of the farm, nobody wants the neighbour's cow to come and graze your pastures.*

To divide pastures, some farmers preferred electric fences because it only occupied one or two wire that were not barbed wired that could harmed cattle.

Farmers' use and considerations concerning live fences did not differ from results of investigation made in other areas of Central America (Harvey et al., 2005, León & Harvey 2006, Love et al., 2009). Considering its productive role and beneficial effect for

conservation, live fences were an important feature of the agricultural landscape of Santa Cruz. Key informants reported the conversion of fences in live fences would increase live fences positive impacts on conservation. Indeed, a previous study in a pasture dominated landscape in northern Costa Rica have shown the conversion of all fences to live fences would greatly increase the ecological impact of live fences and would have a tremendous impact on landscape connectivity by increasing the physical connectivity (León & Harvey, 2006).

Finally, trees were also valued as shelter mainly to give cattle shade from the sun but also from the rain: *Trees are my best cowshed.* Few farmers valued trees (especially *Erythrina spp*.) as fertilizers through nitrogen fixation or organic input of dead leaves and wood.

Economic Value

Economic values were related to production of goods including timber, fuelwood, fruits or fodder. Timber, from native or exotic species (*Cupressus spp.*, *Eucalyptus spp.* or *Pinus spp.*), was mostly used on the farm to build the house and all types of farm constructions, from the cowshed, the dairy, the cow-path in the pastures to the posts for the fences. In the isolated areas of Los Bajos and El Volcan, it was still the only available construction material as the bad state of the road limited the access. Few farmers also reported a commercial use of timber, to be sold in the neighbourhood and through the social network. It was reported as a very limited activity to increase incomes but marginal because it took time and space and due to the small scale of the exploitation was not very profitable:

> *It was a way to get me a Christmas bonus. But I'm not doing it again.* [A farmer who planted 60 cypresses and sold them at 2 years-old]

In Costa Rica, there are few data available about the economic importance of timber use of trees outside forest. However, the amount of timber provided by trees outside forest compared to the total amount of timber officially produced nationally has increased since 1990 (Hidalgo

& Kleinn, 2001). Timber is the most traded product of trees outside forest. Timber trading has to be authorised by the Ministry of Environment, Energy and Telecommunications especially through the issue of logging permits. Unfortunately, there are no clear policies concerning the management of timber as a natural resource (Hidalgo & Kleinn, 2001). However, several studies have reported the considerable potential for trees on farm land to be commercialised on the national timber market and thus provide a new source of income for small farmers (Harvey & Haber, 1999; Schleeje, 2009). Nonetheless, the potential impact of the development of such use of trees in terms of conservation has not been assessed yet.

As for the other economic values expressed for trees, there were still some households that only used fuelwood even though electric and gas stoves were common. In the highest area, farmer had fireplaces as well. Fuelwood was always provided on farm land by fallen trees, unwanted trees and wood left from pruning and if not sufficient, supplied through the social network, collected on the neighbours or family's land with their agreement. The reasons given for using fuelwood were sometimes economic but mostly cultural:

> *It is a matter of tradition, to sit close to the warm wood-stove and to save on electricity as well, but most of all for tradition. It is actually an expensive whim, to go with the car and the saw, takes time, sometimes in quite rugged area, to get fuelwood. But, it is part of the tradition.*

With regard to trees' provision of fruits, the most common fruit tree was *Psidium guajava* (guava) which grows naturally. The other fruit trees reported (orange, lemon, banana, plantain, peach, medlar, elder, fig, avocado, palm and sugar cane) were given by neighbours and family and planted close to buildings, along tracks, to produce fruits for the household used as fresh fruits, juices, jams and traditional recipes. Guavas and bananas was used to feed cattle and pigs as well. The valuation of leaves of live fencing species *Erythrina spp*. (poró)

and *Trichanthera gigantea* (nacedero) as animal fodder was marginal and their use reported as a secondary food supply in times of shortage.

Ecological Value

Ecological values were related to ecosystem services trees provided including wildlife, watershed and soil protection, air quality and distinct microclimate. As an example, concerning wildlife protection, one farmer stated: *I left this tree because quetzals and toucans come to eat the fruits, it is really nice.*

Watershed protection was especially expressed when they explained the presence of trees along the permanent watercourses and springs on their land. A common assertion was that trees along the watercourses help to prevent them from drying out:

> *I have the feeling felling a tree here [along the river] would be like deciding to dry out the river. Just pastures without trees ! I can't imagine, the rivers are going to dry out !*

In Costa Rica, the National Forest Law 7575 states that areas within 15 m from a stream or a river bank and in slopes of more than 45 degrees, are considered protected areas where trees logging is prohibited (MINAE, 1996).

During the farms' tours, the researcher observed watercourses situated in steep slopes were efficiently protected and provided patches of native forest isolated from human disturbance due to their difficult access. Although no farmer interviewed openly disapproved this law, the researcher observed the 15 m were rarely respected around watercourses that were not steep-sided. It was rather a 2 m strip occupied by a single row of trees or sometimes less that was left by farmers. Farmers' interviews shown that, even though farmers were aware of the law, the distance to be protected was not precisely known. Key informants reported the distance of 15 m was often considered by farmers "*exaggerated*" and thus rarely respected. There was no enforcement of this law or control in the field. Considering the numerous streams existing in

the hilly landscape of Santa Cruz, if the National Forest Law was respected within 15 m along streams, rivers banks and slopes of more than 45 degrees, it is likely that riparian forests would be numerous and would provide an high landscape connectivity. However, the law is vague on the type of streams and rivers concerned and the minimum limit size of the watercourse that falls under the law. As the 15 m often appeared to be exaggerated to farmers, a strict enforcement of this law would certainly appear as a requirement that is too strict and unfair to small farmers and would result in a sense of injustice towards institutions. A clarification of this law appears necessary before enforcing it as it could improve both watershed protection and landscape connectivity.

In areas close to the volcano, trees were cited as protection for pasture from the volcano's gases and for their beneficial influence on the microclimate beneath them:

> *Trees are like a big umbrella, when the volcano woke up, the pasture under them didn't get burned. Pastures don't get burned by the frost under the trees, they are necessary to protect the pastures.*

Heritage value

The heritage value covered different aspects: transmission of trees that had a timber value to give as an inheritance and an educative value for the transmission of knowledge. In the first case, they were trees that were traditionally used for construction and served as timber for children or grandchildren to build their houses. In the second case, farmers wanted to leave trees for their children to know them and their uses: *It is important that my children know it: it is a blessing from Good, each tree has its use, the cypress for example is good for timber but has no use for a lot of other things.*

The conservation of trees for the transmission of knowledge was also associated with native species that were perceived to be rare.

Other values

Trees were also maintained on farm land for their beauty and the beauty of the scenery they offer:

They were left here and now they are like an ornament.

It is something nice to help feel good.

The fruits produced by trees were sometimes considered as gift for relatives, neighbours and friends and participated in exchanges inside the social network which represented a social value. The traditional use of fuelwood to cook, sometimes to cook traditional costa rican recipes represented a sentimental and a cultural value of trees. Forested area conserved by farmers were also valued to spend spare time with the family and as a touristical attraction which represented a recreational value. Two of the interviewed farmers developed agrotourism activities on their farm. Tourists came to see farming activities and enjoyed the area: native trees, their use and the animals they attracted were part of the attraction. Although rare, the medicinal value of certain species of native trees was pointed out as well.

Few investigations have been interested in the socio-cultural aspects of trees outside forest in Costa Rica and they only reported fruit tree plantation for the household consumption in tiny orchards and close to houses (Hidalgo & Kleinn, 2001). More diverse socio-cultural values of trees was found in Santa Cruz. Although these values were more marginal than the technical, economic and ecological ones, they contributed to the valuation of trees and their maintenance by farmers.

Farmers' limitations to maintain trees on their land

Farmers mentioned three factors that limited trees presence on their land:

- Capital: farmers stated they lacked means to obtain seedlings or saplings (sources or financial means).
- Labour: it was especially expressed through the lack of time for trees management or plantation.
- Land: on small farms, farmers considered they lacked land to maintain or plant trees. According to key informants, farms were becoming smaller and smaller which increased the competition between trees and pastures.

Limitations to trees plantation and regeneration

Adapted trees species varied within the range of altitudes in Santa Cruz and farmers in the highest part reported a lack of adapted species for the provision of post for live fences.

Farmers reported difficulties to protect saplings and young trees within pastures from livestock damages and mentioned it was more feasible to conserve them in live fences. A lack of trees' natural regeneration within pastures was reported. Fencing around the seedling within pastures would prevent livestock from damaging it and increase its chances to grow. However, protecting saplings within pastures was not considered conceivable as it is time-consuming, would use more fence material and would reduce the pasture area:

Live fences can be an option for low-cost establishment of trees in pasture landscapes as they work as a protective barrier for seedlings and young trees from cattle damages (Love et al., 2009). This lack of natural regeneration within pastures might cause a decrease in the overall tree cover in the future and thus should come to the attention of local authorities and organisations.

Six farmers (21%) reported experimental plantations or transplantations they tried to propagate trees on their land. They collected seeds from a renowned native timber trees or from a rare native tree they appreciated and planted them in a set up nursery. The seedlings

were then planted in places protected from livestock. Some farmers transplanted seedlings from pastures before they got destructed by cattle to protected areas in fences or riparian areas. Nevertheless, these experiments' outcomes were not all successful which highlighted the need of technical assistance, research and development on the use of trees on farm land. Farmers reported a lack of technical knowledge on trees species and management and mentioned a lack of technical assistance:

> *A tree to help the farm would be good: to give shade and fences, but I don't know which tree I could plant and there is no one counselling us about that.*

Farmers' awareness of the biological corridor and payments for ecosystem services

Only seven (24%) of the interviewed farmers knew about the Biological Corridor Volcanica Central-Talamanca, and of these, four were informed during meetings because they were part of a local association board. Some other farmers knew about the concept in terms of allowing movements of animals within the landscape but didn't know about the Biological Corridor Volcanica Central-Talamanca.

69% of the farmers were aware of Payment for Ecosystem Services (PES) and knew they were for the maintenance of forest. Most of them considered PES concerns only large land owners. For the few farmers that owned forest in the Turrialba Volcano National Park area, PES was viewed as a welcome, profitable way to reward their forest conservancy effort. Moreover, several key informants mentioned financial means were quite limited in the Turrialba region and access to small farmers were limited by the administrative requirements and associated cost.

Opportunities for the integration of trees outside forest in the BCVCT planning

The study found trees outside forest are valued by farmers and are compatible with the current farming systems in the Santa Cruz area. As a consequence, they represent an advantageous mean to maintain and increase tree cover within the agricultural landscape of Santa Cruz. Moreover, they participate in BCVCT's objectives of water, soil and wildlife protection for the improvement of environment quality. Given that, the BCVCT, in collaboration with local authorities and organisations, has now several opportunity to integrate trees outside forest into conservation planning within agricultural landscape.

The diversity of values given to trees by farmers represent a range of opportunities to encourage and enhance farmers use and maintenance of trees on their land. While technical, economic and ecological roles of trees hold major opportunities for further development, heritage, cultural, social and aesthetic values of trees shouldn't be underestimated. Furthermore, these trees' uses participate in farmers well-being. Facilitating the purchase of trees that correspond to farmers need and concern, supporting and developing trees propagation and development and fostering home gardens and orchards can encourage the presence and maintenance of trees in the agricultural landscape. The conversion of fences to live fences can be promoted as well as traditional shade plantation. In addition, agronomic research is needed to improve the integration of trees species in densities and spatial arrangement to minimize the reduction of agricultural productivity (Harvey et al., 2008). This enhancement of trees' technical use could improve farmer adoption of live fences. Then, a strategic planning could promote tree cover in areas that lack it and between riparian areas that provide patches of native forest that need to be connected. It would meant that riparian areas are efficiently protected through the enforcement of the relevant Forest Law. The adaptations of MINAE requirements and regulations regarding riparian areas and logging

permits on farm land, could be revised and enhanced to ensure conservation but also to allow sources of income and goods that benefit social and economic conditions of farmers.

The results of the investigation shown farmers were willing to continue to maintain trees on their land and even to improve and develop their uses of trees. To plan potential actions with farmers, the BCVCT's management committee should determine more precisely its priority in terms of conservation. A lot of research is still needed to understand the relation between tree cover and landscape functional connectivity in the Santa Cruz area and in the whole biological corridor. Moreover, conservation efforts need to investigate more which and how tree cover characteristics influence species richness and abundance as well as which species are of particular interest. It is essential to qualify the functional connectivity necessary to meet the BCVCT's aim and to determine the type of tree cover and spatial arrangement needed to achieve it. Finally, pollarding and pruning have an impact on the tree cover services as it reduces the habitat and resources offered by trees, it limits colonization by epiphytes that provide additional resources for wildlife (Harvey et al., 2005) and thus, seasonal variation of trees' management can have an impact on landscape connectivity. Thus, once determined, trees' management practices adapted to conservation goals could be promoted to improve trees contribution to conservation (Harvey et al., 2005). Being a member of the BCVCT, the Tropical Agronomical Research and Higher Education Center (Centro Agronómico Tropical de Investigación y Enseñanza, CATIE) is a key partner that offers a unique opportunity to lead research on these topics through their permanent staff but also their masters' students.

Thus, collaboration with farmers to increase and ensure tree cover in Santa Cruz will necessarily involve in concrete terms:

- training and education of farmers about the conservation roles of trees outside forest;
- technical information and assistance concerning choice, adaptability, management and use of the different tree species but also research to expand the use of trees;

- adapted incentives or policies to encourage the conversion of fences to live fences and to promote use and maintenance of trees on farmers land.

Payments for Ecosystem Services (PES) are an economic incentive that can compensate additional resources and labour trees maintenance can cause or reward conservation efforts. Agroforestry contracts have been introduced in 2003 within the PES schemes to encourage small farmers to participate but to date, they are still limited and could be adapted to have more impacts on small farmers (Estrada, 2009; Porras, 2010). To encourage trees retention on farms, PES should be high enough to compete with opportunity cost for farmers, that is to say it should meet the additional cost caused by trees retention (G.Calvo, personal communication). PES were created to recognise forests provide services such as water and wildlife protection and landscape beauty (Porras, 2010). Therefore, the integration of trees outside forest in the PES scheme could compensate farmers for the services trees on their land provide in the agricultural landscape, especially in the Biological Corridor Volcanica Central-Talamanca.

Conclusion

Trees outside forest in Santa Cruz, especially dispersed trees and live fences, fulfil agronomic functions through the provision of technical services to farmers who manage them and production of goods but also have a conservation role in the eyes of the farmers principally by providing habitat and resources to wildlife and participating in watershed protection. Although there is a need for more investigations to quantify the contribution of trees outside forest to conservation and landscape connectivity within the BCVCT agricultural landscape, trees outside forest are certainly beneficial to conservation and landscape connectivity likewise in other region of Costa Rica. In collaboration with local authorities and organisations, the BCVCT's committee should foster trees outside forest retention and

encourage their use. Their integration in conservation and sustainable development planning can be done through the development of training, education and technical assistance to farmers along with the enhancement of their recognition in the PES scheme in Costa Rica.

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Appendix 1

Interview Guide for key informants

(translated from Spanish)

Hi. My name is Lucile Chamayou. I am a student from a university in England and I am currently doing a research with CATIE in Turrialba about the agricultural area of Santa Cruz. Thank you very much for agreeing to answer my questions.

Guiding questions:

1. Can you please present me your organisation and its activities ?

-> more information are asked depending on the organisation and its activities (describe your programme with farmers, goals, activities, monitoring, outcomes).

2. Can you describe the other organisations you know working with farmers in the Santa Cruz area and their activities? Other projects, initiatives ?

3. Can you describe farmers use and management of trees on their land in the area ?

-> more information are asked depending on the answer: current issues, tree cover in the agricultural landscape, farmers willingness to maintain trees, plant trees, limitations of trees presence on farm land.

4. What do you know about the Biological Corridor Volcanica Central-Talamanca ?

5. What do you know of Payment for Ecosystem services in the area ?

Do you want to add something ?

Do you have any questions ?

Thank you very much.

Appendix 2

Interview Guide for farmers

(translated from Spanish)

Hi. My name is Lucile Chamayou. I am a student from a university in England and I am currently doing a research with CATIE in Turrialba about the agricultural area of Santa Cruz. Thank you very much for agreeing to answer my questions. May I record the interview ? All the data will be kept anonymous and will be used only for my research purposes.

Guiding questions:

1. Can you please explain me your farm ?

2. Can you explain me the changes that happened on the farm since you have been working here ?

3. Can you describe me your plans for the future ?

4. Can you tell me if you are a member of an organisation, which ? why ?

5. Can you describe me in which projects you have participated ?

6. Can you explain me the different trees you have on your land ?

7. Why do you have these trees on your land ? Where do these trees come from ?

8. How do you use these trees ? How do you manage these trees ?

9. Can you tell me if you have any difficulties to have trees on your land ?

10. Explain if you would like to have more trees ?

11. Have you heard about Biological Corridor ?

12. Do you know what Payment for Ecosystem Services are ?

Do you want to add something ? Do you have any questions ?

Can we now go to visit your farm.

Thank you very much.

General data describing the farm (check list for the end of the interview):

Farm manager age: Education:

Origin of the farm: Land tenure:

Farm size:

Other land and respective size:

Farm production:

Other activities:

Herd size:

Type of cheese processed:

Way to sale:

Number of employees: