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An evaluation of farmers' experiences planting native trees in rural Panama: implications for reforestation with native species in agricultural landscapes

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Abstract In the Republic of Panama, reforestation with native species is of great interest, but many landholders often do not participate in tree planting projects and little information exists about landholder interest in, or experiences with, native trees. This study evaluates the experiences of farmers participating in a native species reforestation initiative in rural Panama to identify lessons learned that can guide on-going or future tree planting efforts. Based on the results of a questionnaire administered to program participants and non-participants ($n = 68$), we found that trees are important to farmers for multiple reasons, primary a variety of environmental and economic benefits. No relationship between the size of landholdings or land tenure status and the desire to plant trees was found. All participants in the program considered their experience to be positive, few had problems with their plantations, and most were interested in planting more native trees. The program's frequent and ongoing technical support was an important factor for farmers. These results indicate widespread interest in, and success with, planting native species and underscore the need to systematically examine farmers' interests and perceptions when planning, implementing, and evaluating reforestation initiatives.

Keywords On-farm trials · Project evaluation · Tree planting · Agroforestry · Silvopastoral · Smallholder farmers · PRORENA

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Introduction

In the Republic of Panama, reforestation is becoming a popular strategy to protect the country's remaining forests and to restore degraded lands (Current and Scherr 1995; Fischer and Vasseur 2000, 2002; Griscom et al. 2009; Simmons et al. 2002; Wishnie et al. 2007). The Panamanian government has taken several steps to encourage landholders to plant trees on their land, either in the form of forest plantations or as agroforestry or silvopastoral systems (Current and Scherr 1995; Fischer and Vasseur 2000, 2002; Simmons et al. 2002), by requiring that landholders replace trees that are cut and removed in logging operations, and by providing financial incentives and tax breaks for those engaged in reforestation

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activities (Simmons et al. 2002). With the adoption of the country's Tropical Forestry Action Plan in 1990, government officials also launched a series of agroforestry projects to address rural development and environmental degradation, most notably within the Panama Canal Watershed (Fischer and Vasseur 2000, 2002; Hauff 1999).

The majority of Panama's agroforestry projects and forest plantations, however, are dominated by fast-growing, exotic timber species such as teak (*Tectona grandis*) and caribbean pine (*Pinus caribea*) (Fischer and Vasseur 2000; Wishnie et al. 2007). While monocultures of exotics can produce high quality timber, they have also been found to support low-levels of plant biodiversity and may promote soil erosion (Lamb et al. 2005; Wishnie et al. 2007). Exotic species also provide limited goods and services to local landholders (Lamb et al. 2005; Wishnie et al. 2007), but initial studies in two rural communities indicate that Panamanian farmers use native tree species regularly for a variety of purposes (Aguilar and Condit 2001; Love and Spaner 2005). Moreover, the long-term sustainability of agroforestry projects dominated by exotics might be compromised, since exotic species may be more expensive to maintain than native trees (Fischer and Vasseur 2000, but also see Craven et al. 2008).

Landholders in Panama and elsewhere also have been reluctant to adopt recommended agroforestry and tree planting practices for a variety of reasons, including socio-political problems between extensionists and farmers, the small size of farms, and insecure land tenure arrangements (Bannister and Nair 2003; Degrande et al. 2006; Fischer and Vasseur 2000, 2002; Godoy 1992; Salam et al. 2000; Simmons et al. 2002; Summers et al. 2004; Walters et al. 1999). Many of Panama's small-scale farmers also are not benefiting from government incentives to promote reforestation practices, since the law is said to favor large landholders and corporate activity (Fischer and Vasseur 2000; Simmons et al. 2002). Panamanian smallholders also cite prohibitive tree harvesting requirements as a primary factor limiting their participation in tree planting (Fischer and Vasseur 2000). Since the systematic monitoring and evaluation of tree planting projects with smallholders is limited, the actual benefits and shortcomings of these initiatives remain unclear (Current and Scherr 1995; Fischer and Vasseur 2000, 2002).

In light of these and other trends, interest in reforestation with native species in Panama has increased in recent years, as native species have been found to have more positive impacts on the environment than exotics and can provide a host of services to local people (Wishnie et al. 2007). Yet native trees often are not used in reforestation projects due to a lack of both social and biophysical data about native tree species (Aguilar and Condit 2001; Wishnie et al. 2007). From a sociological perspective, little information exists about landholder interest in, or experiences with, native species, especially within the context of a tree planting program. Research, therefore, is needed to understand which native trees farmers would like to plant in a project, how, and why. Understanding traditional tree management practices and use by rural farmers can help to inform what, how, and why farmers might like to plant on their land (Arnold 1997; Arnold and Dewees 1998; Bannister and Nair 2003; Dove 1992, 1997). Low-levels of farmer adoption of agroforestry practices or participation in tree planting initiatives also demonstrate a need to examine what factors influence farmers' decisions to plant trees (Arnold 1997; Arnold and Dewees 1998; Bannister and Nair 2003), the experiences farmers have managing the trees that they plant, and what aspects of the design and management of a tree planting program that farmers like or dislike.

In this paper, we evaluate farmers' interest in, and experiences with, planting trees with a native species reforestation program in two sites in rural Panama in order to understand the lessons learned from this initiative that might inform on-going or future tree planting efforts. We analyze a series of variables related to tree management, use, program experiences, and future interests, including (1) social and farm characteristics; (2) how farmers' traditionally plant, protect, and utilize trees; (3) why farmers decided to participate in the project, their initial doubts, and the species they selected; (4) how they managed their tree plantation and the challenges they faced; (5) their opinions about the program's design and management and suggestions for improvements; and (6) their future interest in planting native trees. We draw upon the results of our analysis and initial results about native tree growth and mortality in the two study sites (Love 2008; Wishnie et al. 2007) to generate a number of recommendations regarding the

planning, implementation, and evaluation of tree planting programs.

Background and methodology

Reforesting with native trees: the PRORENA project

In 2001, a native species reforestation project (Proyecto de Reforestacion con Especias Nativas), known by its Spanish acronym PRORENA, was established in Panama as a research initiative to examine ways to more effectively approach the country's reforestation process. Situated within the Center for Tropical Forest Sciences (CTFS) at the Smithsonian Tropical Research Institute (STRI), PRORENA's overall goal is to generate research that might contribute to the development of ecologically, socially, and economically viable strategies for restoring diverse, native forest cover in degraded tropical landscapes (Wishnie 2005, 2003). Towards this goal, project staff-members have implemented a series of research activities revolving around three central themes: (1) collecting and germinating seeds of native trees; (2) testing the growth and mortality of 75 native tree species along a precipitation and soil fertility gradient (the species selection trials: see Wishnie et al. 2007); and (3) assessing the growth and mortality of native trees on local farms and documenting how farmers manage this process (the on-farm trials: see Love 2008).

While tree planting and reforestation can take many forms and address a variety of issues, PRORENA's initial goal was to demonstrate that large-scale land restoration in the tropics is technically feasible, socially attractive, and financially viable via the establishment of forest plantations with native species (Wishnie 2003). The majority of tree species selected for the species selection trials, therefore, were identified for their commercial value, although efforts were also made to include species that are used for silvopastoral and other local purposes and that demonstrate restoration potential (Wishnie et al. 2007).

The on-farm trials

Between 2004 and 2006, 35 rural landholders located in two agricultural regions planted native trees on their farms as part of PRORENA's on-farm trials. The three primary goals of the trials were: (1) to test the performance of species across a broader range of soil and topographic conditions around the species selection trials; (2) to test how a subset of species from the larger species selection trials grow on local farms; and (3) to learn directly from participants about the challenges and opportunities involved with planting natives trees on their land (Wishnie 2005). Efforts were made to work with resource-poor farmers in the trials (defined here as $\leq$10 ha), as small-scale landholders in Panama appear to be less inclined to participate in tree planting initiatives (Fischer and Vasseur 2000; Simmons et al. 2002). The trials were managed primarily by a doctoral student from the University of Alberta working with PRORENA, as well as by two US Peace Corps Volunteers (PCVs) who elected to work with the project full-time.

For comparative purposes, the on-farm trials were strategically located in proximity to two of PRORENA's larger species selection trials (Fig. 1). The trial sites encompass a total of 13 different communities, five of which are located in the Rio Hato district in the province of Coclé (La Mata, El Limon, La Loma, Palo Verde, and El Ponendero) and eight of which are located in the districts of Pedasi and Tonosi located in the province of Los Santos (Pocri, Pedasi, El Limon, Los Higos, Los Asientos, El Toro, Cañas, and El Cacao). For the purposes of this analysis, we collectively refer to the participants located in the province of Coclé as the "Rio Hato Participants" and those located in province of Los Santos as the "Los Santos Participants".

The two sites vary in a range of biophysical and socio-economic characteristics. In Coclé, average annual precipitation is 1,110 mm with 6.7 dry months per year. Soils in the region are generally sandy or silty clays that tend to be nutrient poor and shallow, and the landscape is a mosaic of grassy savannahs and small fragments of dry deciduous tropical forests (Wishnie et al. 2007). Most landholders came to the region within the past 50 years to practice subsistence agriculture, to work as caretakers for wealthy families, or to work for local tourism businesses. In contrast, Los Santos has a wetter climate with 1,946 mm of annual precipitation and 5.2 dry months per year. Soils are rich tropical alfisols, and the landscape is comprised of a mosaic of semi-deciduous forest fragments

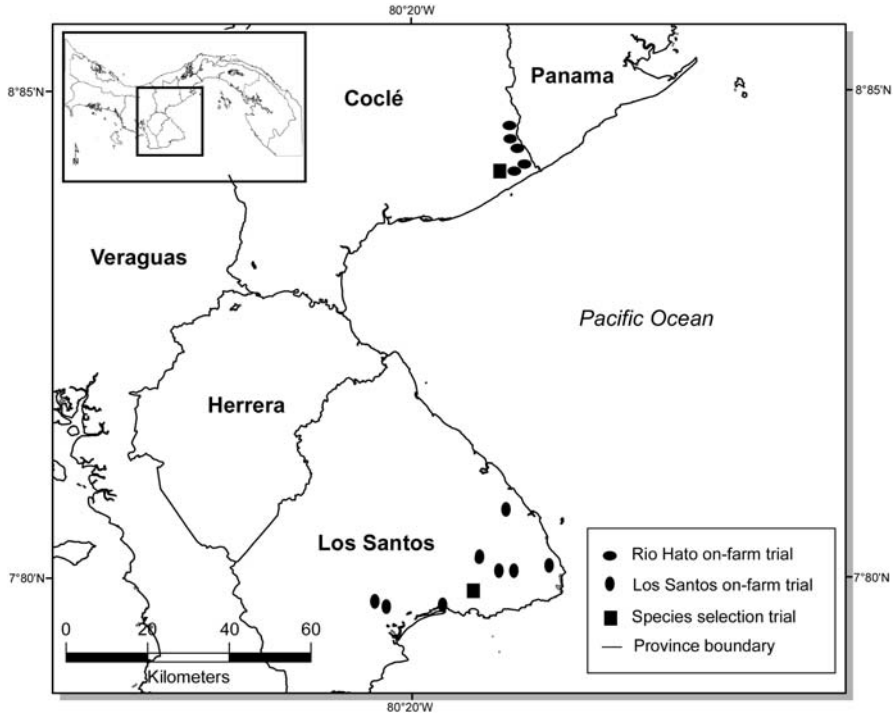

Fig. 1 Locations of the 13 communities where PRORENA on-farm trials were implemented in relation to species selection trials in Panama

and cattle pastures (Griscom et al. 2005; Wishnie et al. 2007). Most residents are second generation colonists, who deforested the region in order to practice cattle ranching, as well as subsistence or mechanized agriculture (Heckadon-Moreno 1984).

Participant selection and program requirements

Beginning in 2004, program participants were selected for the trials in three consecutive years. In both Rio Hato and Los Santos, 2004 participants were selected by permanent PRORENA field staff stationed in each region. In Rio Hato, participants were all acquaintances of PRORENA staff-members, while in Los Santos they were identified through referrals provided by local researchers and civil servants (Love 2008). In 2005 and 2006, the doctoral student managing the on-farm trials trained two local PCVs to identify and work with new participants. In both sites, the PCVs used a variety of strategies to identify participants, including informational meetings open to the public and personal visits to landholders referred by local residents and field staff from the Ministry of Agriculture. Although one of the initial goals of the trials was to work with resource-poor farmers, the majority of Los Santos participants were large-scale landholders due to difficulties finding a sufficient number of interested small-scale landholders.

Participating farmers selected both the species and number of trees they wanted to plant from a predetermined list provided by PRORENA (Table 1), all of which are included in the larger species selection trials. In total, seven marketable native timber species with high rates of survival, growth, and productivity were chosen for use in the trials to help farmers to recoup planting and establishment costs (Wishnie et al. 2007). PRORENA did not provide specific rotation ages of each tree species and decision about harvesting times were left to individual farmers. Guachapalí was selected for the additional benefit of being used to provide food and shade for cattle. Program requirements were the same between sites for the first year, but project staff tried to accommodate the interests of farmers in 2005 and 2006 by providing additional options regarding the species offered to participants, the number of trees they could plant, whether they planted in monoculture or mixed species plots, and the spacing left between trees (Love 2008). All participants had to plant in a required plantation format each year, but they were able to decide on the location and shape of the plot (Love 2008).

Table 1 Tree species offered by PRORENA and percent of farmers who wanted to plant each by year at each site

Common name	Scientific name	Los Santos			Rio Hato		
		2004 ($n = 7$)	2005 ($n = 7$)	2006 ($n = 4$)	2004 ($n = 4$)	2005 ($n = 5$)[a]	2006 ($n = 10$)[b]
Cedro espino	*Pachira quinata*	71	71	100	100	100	80
Cedro amargo	*Cedrela odorata*	57	57	NA	100	60	NA
Roble	*Tabaebuia rosea*	57	29	0	100	100	80
Guachapalí	*Samanea saman*	100	100	100	100	60	80
Laurel	*Cordia alliodora*	NA	14	0	NA	80	70
Caoba nacional	*Swietenia macrophylla*	NA	NA	100	NA	NA	100
Javillo	*Anacardium excelsium*	NA	NA	25	NA	NA	NA

Numbers in parentheses are the number of farmers participating in the on-farm trials each year

NA species not offered

[a] Two participants from 2004 also planted trees in 2005

[b] Two participants from 2005 also planted trees in 2006

Participation in the on-farm trials was voluntary, and each farmer signed a 2 year agreement with PRORENA outlining their obligations. As part of the agreement, farmers were required to provide 50% of fencing costs if needed, as well as labor required for preparing, planting, and maintaining the plantation. In turn, PRORENA provided the trees selected by participants, as well as herbicide, fertilizer, and technical assistance at no cost. Farmers at both sites also were provided a series of training sessions by PRORENA staff-members on tree planting and management techniques and Los Santos participants were given a formal workshop during the program's first year on use and management of agro-chemical and the prevention and control of forest fires. Although participants were provided initial assistance maintaining the plantation, they were expected to eventually continue the process without PRORENA (Love 2008). The agreement clearly stated that the participants are sole owners of the trees, but that they would allow PRORENA to measure the trees at least once a year for the duration of the agreement. Although the contract with the farmers participating in the on-farm trials was only for 2 years, PRORENA has no stated ending period and the project hopes to continue working with farmers as long as funding is available.

Questionnaire and analysis

A formal questionnaire was conducted with the two groups of farmers who participated in the PRORENA on-farm trials, one group in Rio Hato ($n = 15$) and the other in Los Santos ($n = 18$). Two of the original 20 Los Santos participants were not included in this analysis, since one participant died during the on-farm trials and another participant is a technical school and not a privately owned farm. Completing the questionnaire was optional for participants, but all agreed to take part. To ensure that the participants were representative of the farming communities of Rio Hato and Los Santos, an abbreviated version of the questionnaire was also conducted with a randomly selected non-participant group at each of the two sites, which are referred to as "Rio Hato non-participants" ($n = 15$) and "Los Santos non-participants" ($n = 20$). All landholders interviewed ($n = 68$) were read a description of the questionnaire, a series of instructions, and then asked to sign a consent form before participating. All respondents were guaranteed anonymity.

The questionnaire consisted of a combination of both closed-ended and open-ended questions. Closed-ended questions contained a list of pre-determined answers from which participants selected, and open-ended questions meant that participants provided answers without prompting. The questions covered household demographics and economy, tree management and use, perceived benefits and obstacles to tree planting, land use practices, land ownership, experiences with the PRORENA on-farm trials, and suggestions for improving the trials. Non-participant questionnaires were identical to those administered to

participants, with the exception of any questions that related specifically to experiences with the PRORENA on-farm trials. An additional section on potential interest in tree planting was added to the non-participant questionnaire.

All questionnaires were conducted in person, usually at the respondent's home, from January to June 2007. The same questionnaire was administered to participants regardless of the year they entered the trials. Each question was read out loud to the participants in Spanish, and then answers were immediately recorded by the interviewer. For closed-ended questions, the question and subsequent list of possible answers were read to respondents and their chosen responses recorded. Open-ended questions were also read aloud and their unprompted answers were recorded verbatim. The lead author administered the questionnaires in both sites with the PCVs who were working with the farmers. The non-participant questionnaire in Los Santos was administered by the lead author and PRORENA staff-members from the region. Non-participant questionnaires in Rio Hato were administered solely by the PCV living in the site.

Data analysis

All data were analyzed using SAS 9.1.3 (SAS Institute Inc). Comparisons were made between study sites, as well as between participant and non-participant farmers within each site. Means were calculated for farmer demographics and sizes of landholdings and were compared using a *t*-test.

Closed questions concerning household economy, land use practices, land ownership, and experiences with the on-farm trials were analyzed using frequency tables. We categorized farmer's land ownership status in accordance with Panamanian law, which states that landholders have either possessor land rights, a defacto claim to land based on a demonstrated use, or formal land title, indicating clear legal ownership of land recognized by the national government.

Responses to open-ended questions regarding tree management and use, perceived benefits and obstacles to tree planting, experiences with the on-farm trials, and suggestions for improving the trials were placed in categories and then analyzed using frequencies. To form the categories used to analyze responses to open-ended questions, themes were identified and the responses were grouped accordingly. For example, when asked why farmers participated in the on-farm trials, answers such as improving soil and water quality, ameliorating the climate, and increasing the presence of wildlife were grouped under the single category of environmental purposes.

Due to small sample sizes, Fisher exact tests were used to test for significant differences in both closed and open-ended questions (Fink 1995). Although farming methods and climatic conditions differ between study sites, few significant differences were found in the responses for the majority of questions. Where appropriate, we combined the data for participants and non-participants within each site and analyzed these data together. Significant differences that do occur between participants and non-participants within each site are highlighted in the text.

Results

Social and farm characteristics

A number of regional differences in household characteristics were identified between respondents, both participants and non-participants, in Los Santos and Rio Hato (Table 2). While the majority of

Table 2 Socio-economic characteristics of PRORENA participants and non-participants and their farms in Los Santos and Rio Hato, Panama

	Rio Hato ($n = 30$)	Los Santos ($n = 38$)
Mean age of farmers ± SD(years)	56 ± 13	56 ± 12
Male (%)	86	84
Born in site (%)	63	53
Secondary education (%)	3*	42
Land title (%)[a]	27*	82
Plant agricultural crops (%)	100	82
Practice cattle ranching (%)	7*	89
Average landholdings ± SD (ha)	10.0 ± 13.2**	93.6 ± 115.9

* Significant differences between sites at the $P < 0.05$ level using a Fisher exact test

** Significant differences between sites at the $P < 0.05$ level using a *t*-test

[a] Percent of individuals that have title to at least some of their land

respondents at both sites were males in their fifties, significantly more respondents in Los Santos had a secondary or higher level of education, whereas in Rio Hato nearly all respondents had only a primary education. In Los Santos, most respondents were the primary wage earners in the household and raised cattle for beef or dairy purposes, while some rented land to other farmers. In Rio Hato, most farmers were small-scale agriculturalists ($\leq$10 ha of land) or owners of small-scale community grocery stores and had family members working in urban areas who contributed to household expenses. Monthly incomes of respondents were significantly higher in Los Santos than in Rio Hato. There is a significant difference in income distributions between participants and non-participants (Fig. 2; Fisher exact test, $P < 0.05$), likely due to the much higher percentage of non-participants in the <$200 per month income category.

There were also regional differences with respect to land tenure status, size of landholdings, and land use practices between study sites (Table 2). Respondents in Los Santos had significantly larger total landholdings than those in Rio Hato (Table 2; Fig. 3), and on average their farms were comprised of four to five different parcels. In Rio Hato, the majority of respondents had farms that were smaller than 10 ha and tended to be comprised of only one parcel. A significantly higher number of Los Santos respondents had clear title to all or part of their land, while the majority of participants in Rio Hato had only possessor rights. Most respondents in Los Santos practiced cattle ranching, while respondents in Rio

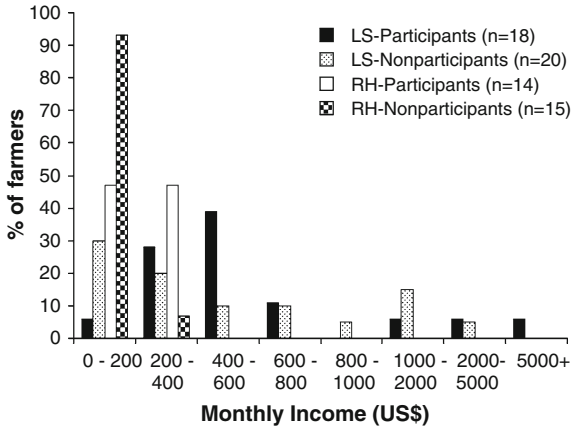

Fig. 2 Monthly incomes of farmers in Los Santos (*LS*) and Rio Hato (*RH*), Panama

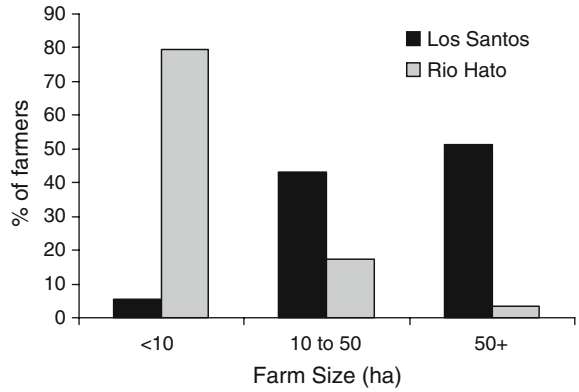

Fig. 3 Farm sizes of farmers (participants and non-participants) in Los Santos ($n = 37$) and Rio Hato ($n = 29$), Panama

Hato planted and harvested agricultural crops (Table 2).

When asked about their prior participation in reforestation projects, significantly more farmers in Rio Hato said that they participated in reforestation projects outside of the PRORENA on-farm trials than in Los Santos (Fisher exact test, $P < 0.05$). In Rio Hato, 27% of program participants and 53% of non-participants participated in reforestation projects outside of the PRORENA on-farm trials. In Los Santos, none of the farmers (participants or non-participants) have done so, most likely because there have been no other formal reforestation initiatives at the site prior to the PRORENA on-farm trials. Most reforestation projects in which Rio Hato farmers have taken part involved the planting of fast-growing exotic species for the purposes of future timber extraction, primarily eucalyptus (*Eucalyptus* sp.), acacia (*Acacia* sp.), caribbean pine, and teak (J. Slusser, unpublished data).

Traditional management and use of trees

At both sites, the majority of participants and non-participants traditionally planted native tree species around their homes for a variety of purposes, including household and traditional use (Table 3). Almost all respondents at both sites planted fruit trees around their homes or in their farms, although significantly more respondents in Rio Hato were doing so than in Los Santos (Fisher exact test, $P < 0.05$). While the majority of respondents at both sites reported planting living fences along the borders

Table 3 Tree management practices of participants and non-participants in PRORENA's two study sites, Rio Hato and Los Santos Panama

Practices	Rio Hato ($n = 30$)	Los Santos ($n = 38$)
Tree planting practices		
Planting around home (%)	100	89
Living fences (%)	63*	100
Tree plantations (%)[a]	47	34
Fruit trees (%)	100*	79
Trees mixed with food crops (agroforestry) (%)	33	21
Tree protecting practices		
Trees left in agricultural land or cattle pastures (%)	83	58
Trees left along riparian corridors (%)	77	100
Trees left as forest patches on farms (%)	87	82

* Significant differences between sites at the $P < 0.05$ level using a Fisher exact test

[a] Significantly more Rio Hato participants were planting trees in plantations than Rio Hato non-participant and Los Santos participant and non-participants

of their agricultural fields or cattle pastures, significantly more farmers in Los Santos did so than in Rio Hato (Fisher exact test, $P < 0.05$). Respondents in both sites also planted trees in plantations outside of the PRORENA trials, including both native and exotic species, and some practiced agroforestry (Table 3).

The majority of respondents at both sites (participants and non-participants) reported protecting trees on their land in a variety of ways, including by leaving individual or groups of trees in their agricultural fields or cattle pastures, by protecting trees along rivers and streams located on their farms, and by protecting forest patches on their land (Table 3). Respondents at both sites reported leaving trees along rivers and streams primarily to protect water sources, and significantly more participants in Los Santos said that they did so also to provide their cattle with shade and fresh sources of water (94% in Los Santos and 0% in Rio Hato; Fisher exact test, $P < 0.05$). The practice of leaving trees and forest fragments in pastures and agricultural fields is also related to cattle ranching, with significantly more farmers in Los Santos having done so in order to provide food and shade for cattle (71% in Los Santos and 0% in Rio Hato, Fisher exact test, $P < 0.05$).

Table 4 Primary uses of trees by participants and non-participants in Rio Hato and Los Santos, Panama

	Rio Hato ($n = 30$)	Los Santos ($n = 38$)
Construction (%)	80	87
Furniture (%)	27	55
Artisanal (%)	13	13
Firewood (%)	100*	66
Medicine (%)	70	61
Fruit/food (%)	100	95

* Significant differences between sites at the $P < 0.05$ level using a Fisher exact test

All respondents at both sites (participants and non-participants) said that trees played a very important role in their daily lives. When asked for what purposes they use trees, respondents at both sites most frequently mentioned that they used a variety of native species for human consumption, firewood, and construction purposes (Table 4). Significantly more respondents in Rio Hato said that they used trees for firewood than in Los Santos (Fisher exact test, $P < 0.05$). While most participants in both sites have not bought or sold timber in the past 5 years, significantly more non-participants in Los Santos have sold native timber from their farms than non-participants in Rio Hato (60% in Los Santos and 20% in Rio Hato; Fisher exact test, $P < 0.05$).

Project participation and species selection

When asked why they decided to participate in the PRORENA trials, participants from both sites most frequently said that they joined the project in order to plant trees for a variety of environmental purposes (Table 5), which include improving the quality of soil and water, increasing the presence of wildlife, restoring forests, and improving the climate. The majority of participants at both sites felt that there were a number of environmental problems in the region in which they live (94% in Los Santos and 80% in Rio Hato), primarily that the climate is hotter now than before, and they most frequently said that tree planting was the best way to resolve this and other environmental issues (72% in Los Santos and 67% in Rio Hato).

Table 5 Why farmers planted with PRORENA and their initial doubts in Rio Hato and Los Santos, Panama

Opinion	Rio Hato ($n = 15$)	Los Santos ($n = 18$)
Why planted with PRORENA?		
Environmental purposes (%)[a]	47	61
Cattle ranching (%)	0	22
Timber sale/use (%)	40*	6
Future investment for family/farm (%)	7	11
Initial doubts?		
Interest in planting other species (%)	7	6
Maintenance of plantation (%)	7	0
Insecure land or tree tenure (%)	13	0
Aspects of project(%)[b]	20	0
Project feasibility (%)[c]	47*	0
No initial doubts (%)	40	72

* Significant differences between sites at the $P < 0.05$ level using a Fisher exact test

[a] Includes improving the quality of soil and water, increasing the presence of wildlife, restoring forests, and improving the climate

[b] Includes PRORENA's interest in planting native rather than exotic species and planting in a plantation format, as well as who would own the trees that they planted with the program

[c] Includes the lack of experience with native species on the part of farmers and worries that the trees would not grow

Significantly more farmers in Rio Hato participated with PRORENA in order to plant trees for construction purposes and the future sale of timber than those in Los Santos (Table 5). Los Santos participants also frequently said that they participated with PRORENA in order to plant trees that will provide fruit or shade to cattle. When asked about the positive aspects of having trees in farms, 88% of participants at both sites responded that trees provide environmental benefits, but significantly more participants in Los Santos said that trees in pastures provide benefits to cattle via shade or food sources while no one in Rio Hato provided this answer (67% in Los Santos and 0% in Rio Hato; Fisher exact test, $P < 0.05$). Participants also indicated that having trees in farms improves the overall quality of life (33% in Los Santos and 60% in Rio Hato).

When asked about initial doubts they had participating in the PRORENA on-farm trials, Los Santos participants most frequently said that they had no doubts while Rio Hato participants most frequently mentioned initial concerns about the project's feasibility, including their lack of experience with native species and worries that the trees would not grow (Table 5). Other concerns included aspects of the project, such as PRORENA's interest in planting native rather than exotic species and planting in a plantation format, as well as who would own the trees that they planted with the program.

The sizes of PRORENA plantations planted by farmers at both sites were similar (Mean Rio Hato = 0.45 ± 0.08 ha and Los Santos = 0.46 ± 0.07 ha). With regard to their decision to use the land on which they planted the PRORENA trees, a significantly higher number of participants in Rio Hato cited reducing soil erosion as their primary motivation for tree planting (93% Rio Hato, 0% in Los Santos; Fisher exact test, $P < 0.05$). Rio Hato participants also said that they selected the area on which they planted with PRORENA because they were not using the land (33%) and that the land was too degraded to plant crops (20%). In Los Santos, frequently cited responses were that the land they selected was the easiest piece to fence off (33%), the easiest piece to access (28%), and a part of their farm where they wanted to improve water quality (17%).

There are variations between years within each site, as well as between sites, regarding the number of farmers wanting to plant the species that were offered by PRORENA (Table 1). In Los Santos, guachapalí was the most popular tree selected in all 3 years and participants most frequently said that they selected the tree because it provides fruit and shade for cattle (56%). The second most popular tree selected by participants in Los Santos was cedro espino, which they most frequently selected for its high quality of wood (79%). Roble and laurel were the least popular trees selected for planting in Los Santos, primarily because participants felt that there are already a significant number of these species present in the region (33 and 40%, respectively). In the year it was made available, all farmers planted caoba nacional, which they chose because of the high quality of its wood.

In Rio Hato, cedro espino and roble were the most popular species selected for planting for all 3 years, which 65% of participants attributed to their high quality of wood. Laurel was also a popular species, with 83% of the farmers who planted it saying they

chose it for its high quality timber. Several farmers in Rio Hato also wanted to plant guachapalí, but PRORENA was not able to provide the seedlings to approximately one-third of them at the time of planting. Similar to Los Santos, caoba nacional was planted by all farmers in the year it was made available to them primarily for its value as a timber species (Table 1).

Plantation management and challenges

The majority of Los Santos participants planted food crops such as corn, plantains and bananas, and yucca within their PRORENA tree plantations (78%), whereas 40% of Rio Hato participants did so. While most participants in both sites do not normally plant trees with their crops (78% in Los Santos and 67% in Rio Hato), several participants who did plant crops within their PRORENA plantation said that they did so in order to take advantage of the fertilizer being used for the trees. Of those who have planted trees with crops outside of the PRORENA trials, the majority of participants in Los Santos said that they mixed crops with native timber species, such as cedro espino, cedro amargo, and roble, whereas Rio Hato participants said they mixed crops with exotic timber species such as teak, eucalyptus, and acacia.

Almost all participants in both sites have managed their plantations, including by cleaning weeds around their trees (94% in Los Santos and 87% in Rio Hato), applying pesticides (56% in Los Santos and 50% in Rio Hato), and applying fertilizer to the plantation (78% in Los Santos and 60% in Rio Hato). In doing so, participants in both sites most frequently said that they relied upon the expertise of PRORENA staff-members (44% in Los Santos and 53% in Rio Hato). When asked how the PRORENA trees compare to their crops in terms of investments in time and money, significantly more Los Santos participants felt that the trees required less attention than their crops (72%) and were less expensive to maintain (94%) than in Rio Hato, where most participants said that they were not sure if the trees were more time consuming (47%) and only 53% said that they were less expensive to maintain (Fisher exact test, $P < 0.05$).

The most frequently cited problems by participants at both sites regarding all of the species planted were insect infestation and slow growth of the trees (Table 6). In Rio Hato, several of the participants who planted cedro amargo said that their trees were prone to insect infestations, especially leaf cutter ants (*Atta* sp.) and shoot borers [*Hypsipyla grandella* (Zeller)], and that many had dried up. Several of the Rio Hato participants who planted roble and guachapalí also said that the leaves were eaten by leaf cutter ants. In Los Santos, those who planted cedro amargo and cedro espino most frequently cited problems with insect infestation, and several of those who planted guachapalí said that their trees were growing slowly and had curved limbs.

When asked about their future plans with their PRORENA trees, significantly more participants in Rio Hato (67%) said that they plan to harvest at least one of the species in their plantation, whereas only 22% of Los Santos farmers said that they planned to do so (Fisher exact test, $P < 0.05$). At both sites, however, the majority of farmers indicated they would like to leave at least one species in their plantation (53% in Rio Hato and 67% in Los Santos). Leaving trees indicated either having no intentions to harvest the trees in the future or allowing the tree to grow for the benefit of their off-spring, which may or may not include future timber harvest. However, significantly more farmers in Los Santos had not yet

Table 6 Problems with trees indicated by farmers participating in the PRORENA on-farm trials in Los Santos (LS) and Rio Hato (RH), Panama. Numbers in parentheses are the number of farmers that planted the species*

Problems? (%)	Cedro Espino		Cedro Amargo		Roble		Guachapalí		Laurel		Caoba Nacional	
	RH (10)	LS (14)	RH (5)	LS (8)	RH (13)	LS (6)	RH (7)	LS (18)	RH (6)	LS (2)	RH (10)	LS (4)
Infested with insects	10	21	80	38	31	17	38	0	0	0	40	0
Slow growth	20	14	20	13	23	0	14	17	33	0	20	0
Mortality/disease	0	0	20	13	0	17	0	12	0	0	10	0
None	80	64	0	38	54	83	50	72	67	100	30	100

* Javillo not included since no one planted it in Rio Hato and only one person planted it in Los Santos

made plans for their trees (44% in Los Santos vs. 7% in Rio Hato, Fisher exact test, $P < 0.05$). All participants in both sites said that they will continue to manage their PRORENA plantations, and all Los Santos participants intend to let cattle enter into the plantation once the trees are large enough to survive.

Evaluating program design and suggestions for improvement

All of the participants in both sites said that they had positive experiences with the PRORENA on-farm trials. They all liked planting in the required plantation format, and the majority of participants in both sites would use this format again (83% in Los Santos and 100% in Rio Hato). While most participants in both sites did not want to plant the PRORENA trees in another way, those who expressed this interest ($n = 10$) said that they would like to have planted the trees in their living fences (40%), left more space between the trees (30%), and had mixed rather than monoculture plantations (10%). All participants were satisfied with the amount of land that they had set aside for the trials. When asked what they liked most about the trials, participants in both sites most frequently cited aspects of the program's design, including the technical assistance they received from PRORENA, the selection of species offered, that the trials focused on future benefits, that PRORENA was not a short-term program, and that it provided them with an opportunity to learn about the ecological benefits of reforesting (Table 7).

With regard to what participants did not like about the project, the most frequently cited response in both sites was related to tree growth and mortality, including that the trees were plagued with insects or fungus and that many of the trees died or were not growing well (Table 7). In Los Santos, several of the farmers also disliked aspects of planting and maintaining the trees, including the pesticide application process, difficulty planting and maintaining the trees, and insufficient time or financial resources to care for the plantation. In Rio Hato, some participants also said that they did not like planting and maintaining the trees and aspects of PRORENA, such as the delivery of trees after the set planting date and the need for more technical assistance from the project.

Table 7 Categories and frequency of response regarding positive and negative aspects of the PRORENA tree planting program by participant farmers from Los Santos and Rio Hato, Panama

Opinion	Rio Hato ($n = 15$)	Los Santos ($n = 18$)
What participants liked?		
Aspects of program design (%)[a]	67	50
Positive environmental impacts (%)[b]	20	11
Maintaining the plantation and growth of trees (%)	27	17
What participants disliked?		
Tree growth/mortality (%)	53	39
Planting/maintaining the trees (%)	20	39
Nothing (%)	27	28
Aspects of PRORENA (%)[c]	13	0

[a] Includes the technical assistance they received from PRORENA, the selection of species offered, that the trials focused on future benefits, that PRORENA was not a short-term program, and that it provided them with an opportunity to learn about the ecological benefits of reforesting

[b] Includes improving the environment and making the landscape look better

[c] Includes the delivery of trees after the set planting date and the need for more technical assistance from the project

When asked if they had any suggestions for improving the PRORENA on-farm trials, 67% of participants in Los Santos and 87% in Rio Hato said yes. The most frequently cited suggestion at both sites is that PRORENA increase their outreach activities by providing more tree planting workshops to participants, by organizing demonstrations about tree planting results, by having more meetings with participants, and by providing more information about PRORENA to participants and to the general public (Table 8). Participants also frequently suggested that PRORENA increase the number of farmers with whom they are planting trees and diversify their tree planting strategies by promoting silvopastoral systems or agroforestry systems, as well as by mixing fruit and timber species (Table 8).

Participants also indicated that they would like to plant trees aside from those offered by PRORENA for a variety of reasons (78% of participants in Los Santos and 87% in Rio Hato), including a combination of native timber and fruit species (Garen, unpublished data).

Table 8 Suggestions provided by participants to improve the PRORENA on-farm trials in Los Santos and Rio Hato, Panama

	Rio Hato ($n = 15$)	Los Santos ($n = 18$)
Increase outreach activities (%)	27	28
Increase farmer participation (%)	20	28
Diversify tree planting strategies (%)[a]	20	17
Provide more technical assistance (%)	34	6
Incorporate biophysical data about tree growth (%)	20	6
Provide long-term intervention/ assistance (%)	20	6

[a] Includes promoting silvopastoral or agroforestry systems and the mixing of fruit and timber species

Future participation in tree planting

The majority of participants in both sites said that they were more inclined to plant trees after their experience with the PRORENA on-farm trials (94% in Los Santos and 93% in Rio Hato) and that they would recommend tree planting to friends or family (94% in Los Santos and 100% in Rio Hato). When asked if they would plant again with PRORENA under the same conditions, 78% of participants in Los Santos and 100% in Rio Hato said yes. In Los Santos, participants interested in planting again with PRORENA said that they would be interested in setting aside an average of 1.8 ± 0.4 ha and participants in Rio Hato said and average of 0.8 ± 0.2 ha. At both sites, the majority of participants (89% in Los Santos and 93% in Rio Hato) said that they are interested in learning about agroforestry and silvopastoral systems. When asked of they would like to plant trees with other groups outside of PRORENA, however, approximately half of the participants at both sites said no.

Most participants in both sites believe that there are other landholders where they live who would like to plant trees (56% in Los Santos and 67% in Rio Hato). When asked why they think that more people are not planting trees, participants in both sites most frequently said that many landholders are not interested in tree planting (38% in Los Santos and 27% in Rio Hato) or lack technical expertise or experience (28% in Los Santos and 33% in Rio Hato). Participants at both sites also said that farmers in the region have little understanding about the environmental importance of tree planting (17% in Los Santos and 33% in Rio Hato), and in Rio Hato some suggested that many do not have enough land to dedicate to tree planting (14%). When asked if they feel that the national government provides incentives for people to plant trees, the majority of participants in both sites said no (83% in Los Santos and 60% in Rio Hato).

To examine additional interest in tree planting outside of program participants, non-participants at both sites ($n = 35$) were also asked about their interest in planting trees on their land. The majority of non-participants in both sites said that they would like to plant trees (60% in Los Santos and 87% in Rio Hato) primarily for a variety of environmental purposes, including protecting water supplies, improving soil quality, restoring forests, cooling the climate, and bringing more rain. The majority of non-participants at both sites (100% in Los Santos and 73% in Rio Hato) also felt that there are a number of environmental problems in the region in which they live, with Los Santos respondents most frequently citing that the climate is hotter than before (70%) and Rio Hato respondents most frequently citing water shortages during the dry season (53%). Similar to the on-farm trial participants, non-participants in both sites most frequently said that tree planting was the best way to resolve these and other environmental issues (50% in Los Santos an 70% in Rio Hato).

When the non-participants at both sites who said that they wanted to plant trees ($n = 12$ in Los Santos and $n = 13$ in Rio Hato) were asked which tree species they would like to plant, they mentioned a mixture of timber and fruit species, the majority of which are native to the region (Garen, unpublished data). Non-participants in Los Santos said that they would dedicate on average 3.1 ± 1.3 ha of their land to tree planting, while non-participants in Rio Hato said they would be willing to dedicate on average 1.2 ± 0.7 ha. Although most non-participants at both sites reported that normally they do not plant trees with food crops (80% in Los Santos and 85% in Rio Hato), the majority said that they were interested in learning more about these strategies (65% in Los Santos and 53% in Rio Hato).

When the non-participants who do not want to plant trees were asked why they felt this way ($n = 10$), respondents at both sites said that they will not see the results from tree planting in their lifetime and that they do not have the money to invest

in either planting or maintaining trees. Non-participants in Rio Hato also mentioned that they did not want to plant trees because many tree species do not grow well in the area due to the poor quality of soils and water shortages during the summer months. In Los Santos, non-participants mentioned that there is no economic security in tree planting since trees cannot be harvested for years whereas economic returns from cattle ranching are short-term, and that tree planting directly conflicts with cattle ranching and agriculture because they believe that trees in farms shade out pasture grass and crops.

Discussion

Based on the results of this analysis and the initial results on native species growth and mortality from the PRORENA on-farm and species selection trials (Love 2008; Wishnie et al. 2007), there are a number of lessons learned that can inform the planning, implementation, and evaluation of tree planting initiatives with rural farmers. While this analysis is directly relevant to the Panamanian context, the lessons learned from this case study might also help to inform the planning and implementation of tree planting initiatives in other regions.

Identifying potential tree planters

Although small-scale landholders are often considered by program developers as being unable to participate in tree planting projects due to insecure land tenure arrangements or the small size of farms (Dove 1992; Fischer and Vasseur 2000, 2002; Godoy 1992; Simmons et al. 2002; Summers et al. 2004; Walters et al. 1999), our data from Rio Hato does not support either assertion. The majority of program participants in Rio Hato were small-scale landholders (<10 ha) with possessor rights to their land, but many already have participated in reforestation programs and all said that they would like to plant again with PRORENA under the same conditions. Only one Rio Hato participant mentioned farm size or tenure status as a deterring factor for participating in the program. The majority of non-participants in Rio Hato also had small farms and possessor land rights, and an overwhelming majority said that they would like to participate in a tree planting project.

Similarly, Simmons et al. (2002) found that small landholders in Panama were 14.5 times more likely to plant trees than those in Brazil, when all other factors in their analysis were equal. This trend might reflect the history of land rights in Panama, where possesor rights to land traditionally have not been challenged by the national government and can be used to secure agricultural bank loans, so long as the landholder demonstrates active use of the land. When designing a reforestation initiative, potential tree planters should not be automatically eliminated because of small-scale landholdings or insecure land tenure arrangements, as regional histories, culture, and regulations might foster positive attitudes towards tree planting regardless of these variables (Arnold and Dewees 1998; Walters et al. 1999).

Interest in and motivations for planting trees

Similar to other analyses, our data challenge the common assumptions on the part of government officials and foresters that farmers have an aversion to tree planting and that if they are interested in tree planting their primary motivation is for future timber harvest (Arnold and Dewees 1998; Dove 1992, 1997). In Rio Hato and Los Santos, both participants and non-participants were interested in planting trees and welcomed opportunities to do so. The majority of respondents considered trees to have positive impacts on their farms, such as providing environmental and economic benefits and resources for humans and livestock, and they considered the maintenance of existing trees and planting of additional trees to be important steps toward resolving environmental problems in their region. Most respondents at both sites already plant near riparian corridors, in living fences, and near their homes, practices upon which PRORENA and other tree planting initiatives can build (Arnold and Dewees 1998). Few doubts were expressed by participants about joining the PRORENA on-farm trials, although a common concern raised in Rio Hato was that the trees would not grow given climatic and soil conditions.

The primary reason that both participants and non-participants in both sites indicated for planting trees was for environmental improvements, such as ameliorating the climate and improving water quality, and not for future timber harvest. While some of their expectations may be unrealistic, primarily that

planting trees will bring more rain, both short- and long-term issues regarding their natural environment clearly concern these farmers. Farmers in Rio Hato particularly value trees on farms for the role that they can play in reducing soil erosion, which is a problem in the Rio Hato area due to steep slopes and sandy soils.

Although not the primary stated motivation, tree planting for future timber harvest was also an important motivating factor for many project participants. In Rio Hato, for example, the majority of participants indicated that they plan to harvest the trees planted through the PRORENA program. This interest in timber harvesting may reflect the prior participation of farmers from this region in reforestation projects for timber harvesting, or overall lower household incomes than those reported in Los Santos and hence need to diversify sources of income. In contrast, Los Santos participants more often said that they planned to leave, rather than harvest, the trees that they planted with PRORENA, which might reflect the recent wave of deforestation in the region and hence a desire on the part of landholders to try to restore forest cover. However, many of the farmers in Los Santos also indicated that they had not yet made plans for their trees.

Overall, economic considerations seem to motivate participants to plant trees in both sites. For example, when asked about the mix of trees they would like to see in the project, participants mentioned fruit trees, trees that can provide shade for cattle, or trees that have high quality wood or valuable timber. Also, participants in both sites suggested that PRORENA promote silvopastoral systems, agroforestry, and a mixture of fruit and timber trees, all of which are farming practices driven by economic motivations. In Los Santos, tree planting and protection for silvopastoral purposes is more prevalent than in Rio Hato, which most likely reflects the region's cattle ranching economy. The selection of guachapalí by participants in Los Santos as the most popular tree for planting in the trials (Table 1) clearly demonstrates their interest in tree planting for cattle ranching purposes since this species provides food for cattle. In Rio Hato, some participants said that they selected the areas where they planted the PRORENA trees because they were not using the land or it was too degraded for crop production, which appears to be a risk-minimizing decision—they were not risking their best land on a new enterprise. However, as not all monetary costs of participation were covered by PRORENA, their participation in the project indicates a desire to maximize earnings on their lands, even if the gain is in the future.

Our data demonstrate widespread interest in tree planting among respondents, as well a range of motivations for tree planting outside of future timber extraction between the sites, thereby indicating the importance of conducting a comprehensive baseline study when planning a tree planting initiative that examines whether or not farmers are planting trees, how, and why in different contexts (Arnold 1997; Arnold and Dewees 1998; Beer 1991; Dove 1992, 1997; Zubair and Garforth 2006). Since farmer motivations for tree planting often varies between sites, it is important that tree planting programs account for site-specific characteristics.

Technical assistance and outreach

While considerable research on tree planting in rural landscapes has focused on what enables or hinders farmer participation in such initiatives, Dove (1992) argues that farmers need assistance with research and extension efforts more than they need motivation to plant trees. Our data supports this assertion, as participants in both sites most frequently said that insect infestation and the slow growth of their trees were the most common problems that they had with their plantations and were the two primary factors that they disliked most about the trials. Many participants in both sites also mentioned the importance of being able to plant tree species that grow best in the particular soils and climatic conditions in which they live.

Although no site-specific data regarding growth potential of native tree species in Panama had been collected when the PRORENA on-farm trials were first initiated in 2004, these data have since become available (Wishnie et al. 2007; Love 2008). Love (2008), for example, evaluates the growth of four of the species included in the on-farm trials (cedro espino, cedro amargo, roble, and guachapalí) both within the PRORENA species selection trials and the on-farm trials and found that of these four species, cedro amargo was the poorest performer due to its susceptibility to *H. grandella* infestation, which increases tree mortality and slows growth. Program participants indicate a similar experience, with cedro

amargo having the most problems from the farmer's perspective, particularly in Rio Hato.

With regard to the slow growth rate of trees, Love (2008) found that the four species they studied grew more slowly on farms than in plantations managed by PRORENA, which they attribute to lower levels of management by farmers. Further, Wishnie et al. (2007) found that teak and Acacia (*Acacia* sp.), two non-native species which are commonly used in reforestation projects in Panama, had higher growth rates than most of the 22 native species that they examined for growth performance over the first 2 years of growth. As farmers who have either participated in or seen the results of other reforestation projects in Panama are most likely to have more experience with non-native species, their expectations of rapid growth for their native trees at the outset may have been unrealistic. It is, therefore, important to incorporate educational components into native species tree planting initiatives that clarify expectations of growth potential of the species being offered to project participants.

Overall, farmers from Rio Hato reported more problems with their trees, which perhaps reflects the drier conditions and poor soil quality found in the region. Wishnie et al. (2007) show similar results, with all 22 of the native species that they evaluate displaying significantly reduced growth at the Rio Hato species selection plantation site compared to those in Los Santos and in Soberania National Park, where rainfall is higher and soils have higher fertility. Their data suggest, however, that several native species demonstrate both high restoration potential and high potential for timber production at both Rio Hato and Los Santos. Of the species included in the on-farm trials, cedro espino performed especially well at both Rio Hato and Los Santos, as did roble. Guachapalí also ranked high at both Los Santos and Rio Hato where, given that it is a nitrogen-fixing legume, it could improve soil fertility and pasture quality in addition to providing fodder and wood. Other species recommended for on-farm systems in Rio Hato, based on their rapid growth, survival, and restoration potential, include *Albizia guachapele*, *Gliricidia sepium*, *and Guazuma ulmifolia*. At the Los Santos site, *G. sepium*, *G. ulmifolia*, and *Spondias mombin* were also recommended (Wishnie et al. 2007). As more detailed information on the growth performance and survivorship of native tree species becomes available from the PRORENA species selection trials, this information should be provided to program participants and to other agroforestry technicians and farmers in the region.

Incorporating an educational component to reforestation programs can also help farmers to better understand realistic environmental benefits of tree planting, as well as planting options and methods to accomplish their goals. Since climatic and ecological conditions vary for each site, such efforts must be tailored to particular realities of each region. While most participants appreciated the opportunities that PRORENA provided to educate participants about reforestation, participants wanted more frequent and diverse interactions with technical staff, including tree planting workshops and on-site demonstrations of tree planting initiatives, which have been found to be more influential on farmers than any other extension activity (Beer 1991). Organizing educational and outreach activities within the community was also important to program participants.

Although the majority of participants in both sites expressed interest in planting again with PRORENA, most said that they did not want to work with other groups. While this finding might suggest that farmers did not want PRORENA to think they were interested in other programs, it also indicates that they have developed a trusting relationship with PRORENA and that the relationship between extensionists and farmers, therefore, must be given careful consideration when developing a tree planting program. The PRORENA on-farm trials are unique in that they drew upon the human resources of PCVs who lived with the farmers on a daily basis and were available to provide technical expertise. One disadvantage of drawing upon the Peace Corps network, however, is that the volunteers tend to leave their sites after 2 years of service. While the two PCVs working with PRORENA both extended their service for an additional year, it is critical that tree planting programs are designed to provide hands-on, consistent, and long-term assistance.

Diversifying species offered to farmers and approaches to tree planting

While most reforestation projects offer a handful of exotic species for planting, rural farmers often plant, and are interested in planting, a wide range of tree

species for varying purposes (see Albertin and Nair 2004; Arnold and Dewees 1998; Dove 1992, 1997; Hocking et al. 1996; Piotto et al. 2004; Roothaert and Franzel 2001; Snelder et al. 2007 for examples). Our data support this finding, as the majority of participants in both sites were interested in planting other native species in addition to those offered in the on-farm trials and relied upon a variety of tree species for daily livelihood practices (Garen, unpublished data). Understanding what farmers might like to plant and why, and particularly the relationship between trees and household livelihood needs and strategies, provides an important opportunity to enrich reforestation programs (Arnold and Dewees 1998; Degrande et al. 2006). As previously mentioned, however, it is equally important to ensure that the species farmers are interested in planting can survive given climatic and soil conditions of the site.

Respondents in our study from both sites also have experience with, and expressed interest in, tree planting outside of the traditional plantation format. Many farmers already experimented with agroforestry and silvopastoral techniques by planting food crops with their PRORENA trees and by planting and protecting trees on their farms for cattle. Although farmers throughout Central America often do not adopt well-researched silvopastoral systems (Dagang and Nair 2003), the majority of respondents in both sites also said that they are interested in learning more about silvopastoral and agroforestry techniques. Moreover, all Los Santos participants planned to allow cattle to enter their PRORENA plantations once the trees are large enough to survive, thereby further demonstrating their interest in silvopastoral systems. Since cattle play a prominent role in many rural economies throughout Latin America (Hecht 1993), efforts to reforest must account for this dominant land use.

Depending on the goals and scope of a reforestation program, understanding farmers interests in tree species and approaches to planting in different contexts could help to diversify what is offered to farmers, which might in turn make a project more attractive to potential participants and hence more sustainable in the long-run. While the PRORENA on-farm trials took a novel approach to tree planting in rural Panama by offering landholders the option to plant native rather than exotic tree species and by focusing on small-scale farmers, this initiative initially focused on the planting of timber species and participants were required to plant in a plantation format. As it became increasingly clear that participants were interested in planting additional species and wanted more flexibility in planting approaches, efforts were made by PRORENA staff and affiliates to diversify tree species and methods of planting during the program's second and third years. PRORENA's adaptive approach is an important attribute of a tree planting program, but our data demonstrate the opportunities that might emerge if initial steps are taken to understand farmers' needs and interests when designing reforestation programs (Arnold and Dewees 1998; Beer 1991; Dove 1992, 1997).

Recommendations

A number of recommendations can be made from the results of this analysis to help guide the planning, implementation, and evaluation of on-going or future tree planting initiatives. With regard to program planning, identifying participants is a critical component of a tree planting initiative, and the PRORENA on-farm trial participants at Rio Hato demonstrated that landholders with small farms or formal title to land should not be eliminated from this process. Once participants are identified, it is important to examine their motivations for tree planting, as we found with the farmers in our study that a primary interest in planting trees was for a variety of environmental and economic purposes and not solely future timber harvest. With this information, project staff-members can work with farmers to determine the selection of species and planting strategies that might best accomplish their particular tree planting goals. Although exotic species tend to dominate tree planting programs, such efforts might be more effective if they promote native tree species, as the farmers who participated in the PRORENA on-farm trials demonstrated a widespread interest in, and satisfaction with, planting native trees. Educational opportunities also could be identified during the planning process, which address topics relevant to participating farmers.

In addition to tailoring the selection of species and planting strategies to farmer motivations, efforts should also be made during the planning process to understand which particular tree species farmers want to plant and how. In both Rio Hato and Los Santos, for example, participants were satisfied with the selection

of species offered by PRORENA, but they were also interested in planting additional tree species not offered in the trials for a variety of purposes. Most farmers also plant and protect a variety of trees in their farms for different reasons, which might also help to inform which species should be included in a project and how they are planted. Moreover, several farmers who participated in the on-farm trials at both sites already utilize agroforestry and silvopastoral systems, which program planners should consider when determining which species to plant in a project and how. Program planners should also share the biophysical data that is available about species growth and mortality rates with farmers in different sites when determining which species will be planted and how. The time frame for a program also should be carefully considered during the planning process, as participants expressed satisfaction that PRORENA was not a short-term intervention.

During the implementation of a program, making on-going and frequent visits to participating farmers is an important factor for the success of a program, as the farmers who participated in the PRORENA on-farm trial said that they liked the technical assistance provided to them but wanted more. These outreach efforts can be personalized to each farmer or, as suggested by several on-farm trial participants, they also can be accomplished through group workshops and demonstrations. Organizing meetings among participants might also help to address problems they are facing with their trees and help to keep momentum going among participants.

Finally, program evaluation is an important component of tree planting projects and can take place at multiple stages. With the PRORENA on-farm trials, for example, a mid-program evaluation generated valuable lessons learned from this experience that can be applied primarily to the development of other initiatives. Since PRORENA will not be planting with additional producers at this time, aspects of the information from this analysis can be used as staff-members continue to work with existing participants. Yet if measuring program impacts are important aspect of a program, participants should be asked a series of baseline questions before and after the program for comparative purposes. Evaluating farmer experiences during the implementation of a program can also help staff-members to understand what aspects of the program may or may not be working for participants and could enable staff-members to make any necessary changes in an adaptive manner.

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