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ORIGINAL RESEARCH

Tree Management and Balancing Process Among Panamanian Farmers

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Abstract

Latin American cattle ranchers have long been depicted as one of the major perpetrators of deforestation. A new conceptualization of Chayanov's Theory of Peasant Economy is employed to understand ranchers' perceptions of tree management in Panama. Chayanov's theory proposes that the family farm is governed by a balance of decisions farmers make between the utility of producing one more item, with the drudgery of producing that item. Farm visits and interviews with 54 Panamanian farmers indicates that trees are actively maintained as part of the utility–drudgery balancing process. These findings suggest that rather than seeing cattle ranchers as perpetrators of deforestation, more research that considers the benefits and trade-offs farmers confront with tree management could promote productive partnerships among parties invested in farmers' livelihoods and forest conservation.

Keywords Chayanov · Tree management · Balance · Cattle ranchers

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Introduction

Conservation biologists have long been concerned with tropical rainforest conversion to pastureland. Problems with this conversion include loss of biodiversity, CO_2 emission, soil degradation and the displacement of people (Kaimowitz 1996; Steinfeld et al. 2006; Seymour and Harris 2019). Ranchers and farmers with integrated livestock systems tend to be blamed for much of this conversion, depicted as perceiving the forest and trees as incompatible with pasture management (Walker et al. 2000; Steinfeld et al. 2006; Heckadon-Moreno 2009). However, ranchers and farmers can manage trees in the form of live fences, riparian vegetation, horticulture plots, forestry plantation, forest fragments, fallow vegetation and dispersed trees on pastures (Schelhas and Greenberg 1996; Tarbox et al. 2018; Valencia Mestre et al. 2019). Our aim is to examine the relationship between these tree landscape patterns and pasture management, while trying to understand how ranchers and farmers balance the various aspects of the farm tree landscape.

Farms can have different tree landscape patterns. *Live fences* are lines of trees tight to each other by barb wire to set paddock and territorial limits. *Dispersed trees* can be a remnant from the forest, the result of natural regeneration, or the result of planting. The density of dispersed trees on pastures can range from 8 (Harvey et al. 2006) to 400 trees per ha^{-1} (Lerner et al. 2015). In Costa Rica, 190 dispersed tree species were found in 237 ha of pastureland (Harvey and Haber 1998). *Forest fragments* have higher tree densities per hectare than the live fence and dispersed trees. Forest fragments can be managed for resource extraction or they can be unmanaged. They are usually remnants of an old growth forest. *Riparian vegetation* can be a linear strip of forest habitat with few trees, or a forest fragment hundreds of meters wide (Schelhas and Greenberg 1996). The number of species within the forest fragments depends on the size of the fragment, their management and other factors (Schelhas and Greenberg 1996; Metzger et al. 1997). *Forestry plantations* are monocultures for commercial production (Tarbox, Fiestas, and Caughlin 2018). *Horticulture plots* integrate agriculture with tree production for household use (Schelhas and Greenberg 1996). *Fallow vegetation* is composed of early succession plant species. Farmers allow fallow growth when weeds become abundant, when there is labor shortage, and/or when soil is degraded (Uhl et al. 1988; Perz and Walker 2002; Muchagata and Brown 2003).

The conventional, grass monoculture-focused model of cattle production was promoted in Latin America between the 1850 and 1950's, based on a perception of 'incompatibility' between trees and pasture (Heckadon-Moreno 2009; Van Ausdal 2009). Cutting trees was also the basis for territorial claims promoted by state policies during the 1960's and 1970's (Hecht 1985; Muchagata and Brown 2003; Heckadon-Moreno 2009). Farmers had to prove they were working the land, usually accomplished by land-clearing (Hecht 1985; Rudel 2007; Grandia 2009). Recent research demonstrates that cattle ranchers and livestock-owning farmers may vary in their perceptions over the incorporation of trees into pasture management (Harvey et al. 2011; Lerner et al. 2015). These examples complicate the general rhetoric that ranchers and farmers perceive trees as incompatible with cattle pasture management.

We examine the incompatibility notion using van der Ploeg's (2013, 2014) Peasant Balances framework which is based on Chayanov's Theory of Peasant Economy. Aleksand Vasil'evich Chayanov, a Russian rural economist from the early 1900's, developed the Theory of Peasant Economy after extensive study of the Russian peasantry. He proposed that peasant farmers (or family farmers) were governed by a 'balance' between family labor and family consumption, or the amount of mouths to feed in a family. The labor-consumption balance is related to another balance between 'utility' and 'drudgery.' Utility refers to the ability to satisfy family aspirations, and drudgery is the hardship of the labor required to satisfy those aspirations (van der Ploeg 2014, p. 1007). Chayanov (1986) observed that families produce at the intersection of two curves, the utility of a product and the drudgery involved in producing that product. He noted that while the peasant farmers participate in the market, they can decide how much to produce based on the utility–drudgery balancing process. The family worker will try to minimize drudgery, but it can self-exploit to increase production in times of need.

Chayanov's (1986) model has been used in a variety of ethnographic settings to understand if the family labor-consumption balance is a determinant of farm production (Hedican 2009). These studies often account for how demographic factors affect farm production, and have recently been applied to examine drivers of tree cover. Results suggest that this balance is not a straight forward driver of tree covers across farms (Marquette 1998; Perz and Walker 2002; Perz et al. 2006) because it does not account for the interrelationship among complex variables (Hedican 2009; van der Ploeg 2013).

We take a much broader and qualitative take on Chayanov's model. Van der Ploeg (2013) argues that the main drive of the peasant families is improved farming and income over time, which can only be achieved if the farmer is able to freely balance utility–drudgery—which is intrinsically related to the family labor-consumption balance. Balancing requires that farmers have autonomy over farm management, as opposed to being restricted by social institutions that surround the farm. The opportunities or threats that are external to the farm are not direct determinants of farm production; they are instead interpreted and translated through the balances into a form of farm management (van der Ploeg 2013).

Scholarly debates about what constitutes a peasant and their economic logic have existed since before Chayanov first published his theory (Shannin 1973). This debate is beyond the scope of this paper. We don't assume that Panamanian farmers are all the same. Latin American family farmers, including Panamanian farmers, vary in the farm size they manage, their degree of market integration, their land tenancy status, and their use of wage labor (INEC 2011). Our focus is to use the Peasant Balances framework to capture the multitude of factors that farmers account for when making tree management decisions and how these factors are adjusted.

The Peasant Balances

We qualitatively examine the management of trees as they relate to the Peasant Balances. Only the utility–drudgery balance was elaborated by Chayanov (1986), all others emerge from van der Ploeg (2013) interpretation of Chayanov's work.

Utility–Drudgery Balance

Utility and drudgery are two independent phenomena that reach an equilibrium. Utility decreases with production, while drudgery increases with production. Theoretically, farmers seek to optimize production at the intersection of the utility–drudgery curves rather than maximize production and profit (van der Ploeg 2013; Steckley and Weis 2016). Optimization happens in accordance to satisfying family needs. Natural conditions, distance to market, social norms and cultural values can influence the equilibrium point (Chayanov 1986; Durrenberger 1980; van der Ploeg 2013).

People–Living Nature Balance

Farmers and living nature have a relationship of coproduction. Farmers depend on nature which they re-shape through production, and farm production is limited by nature. Coproduction vanishes when farmers become dependent on agro-industrial products like chemical fertilizers that replace soil biology (van der Ploeg 2013; McCune et al. 2019).

Production–Reproduction Balance

Capital refers to natural resources, social relations, and other assets of the family farm. Trees are natural capital that protect the soil from erosion and water loss (Ogden et al. 2013). Farmers balance production–reproduction by making sure today's cattle production decisions will allow them to continue cattle production in the future (van der Ploeg 2013). Farmers jeopardize their ability to continue cattle production in the future when they cut all their trees to maximize cattle production today.

Internal–External Resources Balance

Internal resources are those that can be produced in the farm. External resources are those bought from the market. A farmer may rely on the market to obtain cattle or labor, but if a farm becomes heavily dependent on the market to obtain these resources they may fail to improve their livelihood. A farmer can balance their dependence on the market by creating their own resources (van der Ploeg 2013; McCune et al. 2019).

Autonomy–Dependency Balance

The autonomy-dependency balance has two sides: the peasants struggle for autonomy to improve livelihoods and the context that imposes dependency and deprivation. Autonomy is the right that farmers have to self-determine how to manage their farm. Dependency is the reliance on factors that keep them from being able to

self-determine (van der Ploeg 2013; McCune et al. 2019). Farmers can lose autonomy when they use bank credits and their focus becomes paying back the loans (McCune et al. 2019).

The balances interact. Farmers produce livestock and crops for their utility which they balance with the drudgery required to increase production. Production modifies nature, which farmers balance with skills developed to adjust to these changes. These skills aim to sustain natural capital that is necessary for future production. Natural capital, as an internal farm resource, is sustained to avoid relying on resources external to the farm. Farmers are more autonomous when they rely on internal, rather than external farm resources.

The Case of Panama

In Panama, 56% of the land area is agro-pastoral (Sloan 2015). There have been varied efforts to increase tree management in farms. Restoration ecologist and forestry scientist have examined the reforestation potential of pasture land, (Griscom et al. 2009; Garen et al. 2011; Hall et al. 2011) and silvo-pastoral projects have been incorporated through agronomist-farmer partnerships. Efforts to understand farmers' motivations to manage trees, suggest that cattle ranchers in Panama manage a great variety of tree species (Fischer and Vasseur 2000; Aguilar and Condit 2001; Love and Spaner 2005).

Environmental legislation is a factor external to the farm that can affect the balancing process. In Panama, the state authority charged with regulating the management of trees on public and private lands is called "Ministerio de Ambient" (Ministry of the Environment).[1] Federal Law 1 (3.2.94) article 94, states that farmers will be penalized if they don't have permits to burn, cut forest, cut trees and sell trees. The law states that penalties depend on the impact and socio-economic status of the farmer. Under Federal Law 24 (23.11.92) farmers can cut trees if they can prove the land transitioned from agriculture to forest under their management.

Farmers' responses to any form of regulation, whether it be state-led conservation programs or market mechanisms, may depend on perceptions about their ability to self-determine what happens on their farms (Fischer and Bliss 2008). In Nicaragua, Panama, and Honduras, conservation policy may discourage farmers from conserving or planting trees due to a tedious permit procedure (Buttoud et al. 2013; Detlefsen and Scheelje 2011). Farmers' attitudes towards tree management depends on the way environmental policy is implemented.

In 2015, the agricultural sector contributed 2.1% to the Gross Domestic Product (GDP) of Panama (Chacon et al. 2019), even though 33% of the Panamanian population lives in rural areas. In the past decade, farmers have faced eviction from their land through the creation of mines and hydroelectric dams (Runk 2012), seen decline in the market prices of their products with the increases in agricultural imports (Chacon et al. 2019), and experienced a steady decrease in government

[1] At time of research it was called ANAM or the National Authority of the Environment.

subsidies (INEC 2011; Chacon et al. 2019). These policies challenge farmers ability to improve their livelihoods.

Research Objectives

Using van der Ploeg's (2013) Peasant Balances framework, the objectives of this research are to:

- Determine farmers' motivations for managing trees, and obstacles encountered on farms that are primarily dedicated to rearing cattle.
- Examine the relationship between tree management and pasture management.
- Assess how trees fit into farmers' aspirations to improve their livelihoods.

Farmers have often been overlooked as potential partners in managing tree cover across rural landscapes (Sibelet et al. 2017). Conceptualizing farmer's management of trees as a 'balancing' process could equip conservationists with strategies to combine forces with farmers to preserve natural resources.

Methods

Population Sampling

We identified 54 farms in three provinces that were situated in what is commonly called the 'interior' of Panama. These provinces, Chiriqui, Los Santos and Cocle, were among the first to go through agro-expansion in Panama (Sloan 2015). Twenty-eight farms were in the Chiriqui province, twenty-two farms were in Los Santos and four in Cocle. We chose these provinces to capture a range of tree management styles and farmer perceptions, and controlled for proximity to paved roads, elevation, and worked with farmers that have formal land tenure. Farms were near paved roads that led to cattle auctions, larger towns, and cities. We identified family farms primarily dedicated to cattle ranching, that combined commercial and subsistence agriculture. Across all three provinces, farms were located on lowlands 6.5–349 m a.s.l., except for one outlier located at 628.5 m a.s.l. The lowlands Chiriqui is a mosaic of semi-deciduous humid forest fragments (ANAM 2011). The lowlands of Cocle and Los Santos are a mosaic of dry forest fragments (Caughlin et al. 2016).

Initially, we identified 15 farmers for interviews with the help of the Ministry of Agricultural and Livestock Development (MIDA). These farms were in the Chiriqui province, primarily managed cattle, and were part of the MIDA Demonstration Farm Program ("Programa de Fincas Difusivas"). Unstructured interviews with these initial farmers led to the design of a semi-structured questionnaire.

We contacted the 54 farmers through farmer associations and chain referral sampling (Lerner et al. 2015). Farm size ranged from 5 to 2000 ha. All farms were owned by a family, although six self-categorized as family owned 'companies' with

houses in larger cities. In Panama, cattle ranching is a male dominated activity. In this study, three participants were female and 51 were male.

Semi-structured Interviews

We used open-ended and semi-structured interviews to examine farmers' reasons for having trees on their farms (values related to trees, uses and management practices) and the obstacles for keeping trees. Interviews allowed the researcher to explore human behaviour that cannot be observed, such as values, perceptions, and motivations, (Qu and Dumay 2011). Farmers were asked to talk about all the trees within their property regardless of their location, purpose and kind of management. Farmers spoke of natural forests remnants, natural regeneration within their property, and trees they planted. We asked farmers to talk about all the landscape patterns including small forest fragments, live fences, dispersed trees on pastures, riparian vegetation, forestry plantations, horticulture and fallow areas.

All interviews were held on the famers' properties and performed by the lead author. The interviewer scheduled an initial visit to walk around the property with the farmers to learn broadly about their farm and tree management and to make general observations. These farm walks ranged from 1 to 3 h, and resulted in an open-ended discussion, where questions were asked spontaneously about the value of trees, uses, management practices, and obstacles. Farmers were then asked to participate in a follow-up, semi-structured interview, usually just after the farm walk, lasting an additional 45 min on average. Semi-structured interviews were shaped around a previously developed list of questions but also allowed for additional questions to emerge that responded to unexpected topics that emerged as the conversation moved forward (Qu and Dumay 2011). Our semi-structured interviews consisted of two main questions: "Can you explain the reason for having trees on your farm?" and "What obstacles do you perceive when managing trees on the farm?"

While answers were recorded verbatim during the more formal semi-structured interview, the consent process[2] asked farmers if anything discussed that day could be incorporated into the study's analysis. We therefore added the topics that were discussed during the farm walk to our analysis, particularly when farmers discussed things during the farm walk that they did not raise again during the more formal, follow-up interview. This meant that the actual questions asked during the more formal interview sometimes varied based on the farmer. For instance, only 30 of the 54 farmers were asked to discuss the obstacles they perceived when managing trees on their farm, because many had already started talking about obstacles throughout our farm walks. The open-ended, semi-structured questions are presented on online appendix Table 1A.

Our interviews took place towards the end of Panama's dry season of 2014 (late April) through what should have been the beginning of the wet season (late August). Farmers were warned by local news outlets that 2014 was an El Niño year which

[2] IRB approval from the University of Michigan was obtained.

would extend the dry season (Esquivel 2016). We believe this context could have influenced farmers' responses on what trees on their landscape might mean if they were expecting to be entering a potential drought.

Farm Management and Demographic Variables

All 54 farmers were asked about the extent of the farm area managed, tenure time on the properties, form of cattle production, other forms of production, number of cattle head managed, cattle breeds, grass varieties, and additional sources of forage (see online appendix Table 2A). Because of the perceived apprehension from some farmers to share more sensitive demographic information, only a subset of farmers were asked about their age (30 farmers) and about household demographics (25 farmers), such as off-farm work, hired wage labor, and number of individuals per household (see online appendix Table 3A). To retain farmers' trust, the interviewer aimed to be respectful of the farmer's time and willingness to share information.

Analysis

Despite having demographic data for only a portion of the farmers who participated in the study, we decide to analyze the entire data set because we wanted to capture the diverse perspectives on tree management and felt confident that such views were especially valuable in relation to production variables we were able to collect for all participating farmers. All interviews started by asking the farmers to explain the reasons for having trees in the farms. Depending on the farmer, this would lead the interview into various topics including obstacles, weeding, tenure history, ANAM, etc. Consequently, responses to each question were not analyzed separately. Instead, the entire transcript was analyzed for common themes. Interviews were coded and analyzed using the qualitative analysis software Dedoose Version 7.0.23. (2016) following descriptive, themed and analytical coding methods suggested by Miles et al. (2013). On the first round of coding, descriptive codes were created based on the interview questions (for example, values, forms of management, obstacles, farm management). On a second round of coding, codes were created for common themes that emerged across each descriptive code, such as different kinds of values, and the types of obstacles to tree management. These themes were later interpreted employing van der Ploeg's (2013) Peasant Balances framework. The results are presented in Tables 1, 2, and 3 as the percentage of all participants (N = 54) that expressed a value, obstacle, and their associations. Our frequency results, however, are likely to underestimate participants' perceptions, as certain themes that emerged were unprompted—common answers that emerged through open-ended discussions, based on topics that were not directly asked of other farmers. In the result section we explain if the themes were the result of questions that were asked directly, or if they emerged without prompting. Themes with their associated questions and number of responses are found in online appendix Table 4A.

In addition to tracking the qualitative themes that emerged during the farm walks and interviews, farm management and demographic data were summarized

Table 1 Farmers' perceived reasons for having trees in the farm

Reasons for having trees	Description	Percent
Live fence	Farmers use fence rows of living trees which are used to limit properties and paddocks	100
Shade for cattle and/or water conservation	Farmers that have riparian vegetation and/or shade trees that maintain the farm coolness providing shade for cattle and/or conserve streams	88
Wood (for timber and fuel)	Farmers that said they planted or conserved trees for their wood (not including live fences)	88
Fruit trees	Farmers that said they planted or conserved trees for their fruits	87
Feed for livestock	Farmers said cattle ate leaves or fruits from trees	83
Self-sustaining	Farmers said trees were used to self-sustain their farm management or livelihood	48
Added resources	Farmers said they had trees to add resources to the cattle operation	44
Stewardship	Farmers said they conserve trees for others to enjoy in the future	44
Generating cash	Farmers that say they have trees that are marketable	44
Resilience to the lengthened dry season	Trees are necessary for the extended dry seasons by conserving humidity in the soil and providing feed for livestock	30
Conserve soil, control erosion, benefits grasses, fix nitrogen, and benefits wildlife	Farmers want trees to enhance ecological services within the farm	16
Beautify the farm	Farmers want trees to beautify the farm	9

The reasons are listed from more common to least common. The percent of respondents is out of 54

Table 2 Farmers' perceived obstacles to tree management

Obstacles to tree management	Description	Percent
Weeding	Some trees are considered weeds when in high abundances	94
Shade	Shade produced by trees reduces the grass area available for cattle to eat	64
Stochastic socio-ecological factors	Pests, thieves, unpredictable weather and market conditions make it difficult to manage trees in the farm, and discourage from planting	50
Trees that are burdensome	Trees that make cattle ranching and farm management more troublesome because they produce too much shade or hurt animals	27
Environmental legislation	Objective and psychological barriers created by the way in which environmental legislation is implemented	31
Cattle trampling	Cattle trample on seedlings that are planted	20

The obstacles are listed from more common to least common. The percent of respondents is out of 54

Table 3 Definition of the Peasant Balances, how they apply to tree management, and the recorded theme associations related to each Peasant Balance

Peasant Balance definition based on van der Ploeg (2013)	Manifestation of the Peasant Balances as it applies to tree management	Theme associations related to the Peasant Balance
Utility—drudgery The utility of producing one more item *with* the drudgery of producing that one more item	Farmers balance the utility of trees for cattle production (for example shade), with the drudgery of maintaining specific tree species through planting, weeding, and protecting seedlings from cattle trampling	Tree shade as a benefit *was associated with* tree shade as an obstacle (33%) Tree spatial arrangement and productive trees *were associated with* tree shade as an obstacle (42%) Planting trees *was associated with* cattle trampling, pests, thieves, unpredictable timber market, grass outcompetes trees, labor costs, teak is bad for soil, and unpredictable weather (33%) Weeding *was associated with* lack of labor for weeding (50%) Tree as cattle feed *was associated with* trees that hurt animals or farmers and that can become weeds (31%)
People—living nature Balance between the farmer who shapes nature to produce livestock *with* nature who sets the limits to what farmers can produce	Farmers balance the process of shaping the forest to introduce pasture grasses with the process of forest regeneration which provides benefits to cattle production	Perceived lack of nature *was associated with* regeneration and conservation of forest fragments (44%) Natural regeneration *was associated with* trees that directly complement the diet of cattle (83%)
Production—reproduction Farmer must manage short term *with* long term goals to guarantee the future farm production	Farmers conserve and want to plant trees today so that there will be shade and water in the future, guaranteeing the continuity of their farm	Future farm plans *was associated with* planting and preserving trees (31%)
Internal—external The balance between resources obtained in the farm *with* resources obtained outside the farm	Farmers conserve trees because they find them more useful in the farm than selling them in the market	Tree extraction *was associated with* "trees are for internal farm use"
Autonomy—dependency Farmers' balance their ability to maintain autonomy over farm management *with* dependency on external actors	We found that farmer's autonomy to manage trees in their farm is influenced by institutional factors, including conservation policies and markets	Perceived corruption *was associated with* ANAM (31%) Teak and oil palm *was associated with* bad for soil, bad market, and neighbors had bad experiences with teak (18%)

according to identified categories. The presence and absences of landscape patterns were also recorded and summarized. These results are presented in online appendix Tables 5A and 6A. The number of farmers that fall into each category is shown in parenthesis in the result section. A list of trees that were observed or mentioned by each farmer was generated along with their reported utilities. These results are presented in online appendix Table 7A.

Results

Farm Description

The summary of farm management and demographic characteristics show variation across farms. In forty-eight farms, the interviewed farmer (head of household) lived on the farm or < 2 km away from the farm. Forty-six interviewees grew up on the farm they owned, and eight did not grow up in the farm that they owned. The majority of farmers managed a farm area of < 50 ha (N = 28), had > 1 property (N = 35), were dairy producers (N = 27), and used agrochemicals for weeding (N = 34). Reported cattle density averaged 1.32 cattle/ha (N = 36; min = 0.14 cattle head/ha; max = 3.52 cattle head/ha; see online appendix Table 5A) which is similar to the national average (INEC 2011).

The average age for a subset of 30 farmers was 56, which is slightly above the most frequent age range among farmers in Panama (45–54; INEC 2011). Farms also varied in their use of wage labor. The 25 farmers that were asked about household demographics hire wage labor. Twelve indicated that aside from themselves no other family member worked in the farm (see online appendix Table 6A). These numbers match field observations that indicate many interviewees were old men with adult sons and daughters that lived in the city.

Farmer Practices Expressed as Peasant Balances

We found evidence that farmers incorporate trees into their pasture management through a Peasant Balances framework that considers the many utilities of trees (Table 1) alongside some of the obstacles they present (Table 2), usually discussed as interrelated factors they must balance (Table 3). Farmers managed trees in live fences (N = 54), dispersed on pasture (N = 54), as riparian vegetation (N = 50), in horticulture plots around household (N = 23), in forest fragments (N = 15), in fallow areas (N = 11), and forestry plantation (N = 4). We expand on these findings below, framing farmer practices within the various Peasant Balances.

Utility–Drudgery Balance

When the 54 farmers were asked about reasons they decided to keep trees on the farm, 48 farmers said trees enhanced the “coolness” of the farm (Table 1). The term ‘coolness’ refers to the function that shade has in maintaining the humidity

of the soil, water sources, and a cool farm microclimate. Shade was also recognized for protecting cattle from heat stress and as offering resting areas for farmers. Farmers especially liked their shade trees when they offered other utilities aside from shade. The most frequently mentioned trees were those with multiple utilities (Table 7A). One farmer remarked:

> 'I like to take care of trees but when they are good trees. When it's a bad tree I don't like them. Here I have all kinds of fruit trees.'

In part, farmers appeared to prefer this multifunctionality because they diversify farming resources that are necessary to maintain farm productivity. Another farmer noted, for instance,

> 'I have the idea of making some small forests with fruit trees but just to have something. It's not for business. Right? It's to have a forest in the paddocks that will provide shade for the animals…Maybe one can put a mango, avocado. That is more or less the idea that I have for the future.'

Together, the 54 farmers talked about 106 tree species. Tree species mentioned by half or more farmers, and that had three or more functions are: Mango (*Mangifera indica*), Cedro Amargo (*Cedrela odorata*), Guacimo Negrito (*Guazuma ulmifolia*), Macano (*Diphysa Americana*), and Orange (*Citrus sinensis*; see Table 7A).

Farmers perceive that when a tree has multiple utilities, it's more valuable than when it's just used for its shade. Tree utility is balanced with the drudgery of maintaining these trees in the pasture. The drudgery of tree management begins with the paradoxical notion that while shade is necessary for cattle rearing, shade is also an obstacle because it takes up area that could be used for grass. Out of the 30 farmers that were directly asked about obstacles for keeping trees, 15 said shade was an obstacle. Shade emerged as an obstacle across 10 additional farms that were not directly asked about obstacles for keeping trees. This trade-off between tree cover and pasture area is a calculation that farmers make. For example, one farmer noted how:

> 'Coincidentally, this year I made grass and I was observing that where I threw the seed there was not much germination because there is too much shade. I have to open.'

The term 'open' refers to the management action of cutting trees so that sunlight can reach the seedlings. For many farmers, an ideal pasture will have a good balance of tree shade (with various utilities) with the grass cover (for cattle feed).

Out of the 30 farmers that were directly asked about obstacles for keeping trees, 6 said shade was not an obstacle, a statement that was often followed with a management strategy. As one farmer explained:

> 'Trees don't bother me because I prune them…and also the cattle eat peacefully under the shade.'

Through pruning, this farmer may have found a balance between tree and pasture area. A different strategy is to plant trees in rows instead of randomly dispersed on the pasture, for example,

> 'The farm is small, and with a lot of trees we are not going to have enough food for the cattle because of the problem with the shade. For that reason, we have planted in lines. It does not bother the farm and you have shade.'

Farmers that don't say shade is an obstacle, may have found a balance that suited their specific situation. By placing trees in lines, instead of evenly dispersed across the pasture, the farmer perceives the cattle will have enough shade, and the grass will have enough sunlight.

When 30 farmers were asked about obstacles to tree management, 9 said that cattle trampling was an obstacle to tree planting. This sentiment emerged in two additional farms. Farmers emphasized that building fences around planted seedlings is financially costly, as well as labor intensive because it requires considerable upkeep. One farmer explains,

> 'I told you that I planted 35 trees and I bought them from MIDA and they all grew. And when they were growing the cattle started eating them and started breaking the branches. If they are delicate, they dry out and die. The only tree that you can plant on the live fence and let grow is the orange [tree, because of its thorns].'

The drudgery perceived in tree planting is influenced by the perceived financial risk as farmers must buy fencing to keep the plants from being trampled by cattle. Three farmers explained that facilitating tree natural regeneration—a common practice—is a better strategy then planting because it reduces the financial risk and drudgery of upkeep.

All 54 farmers spoke about the laborious nature of weeding. Trees that easily regenerate are specially hard to balance with the pasture grass. These tree seedlings are considered weeds because they can outcompete the pasture. All farmers complained about the drudgery of weeding, primarily done by the farmer himself, his family, and temporary laborers. Twenty-five of the interviewees spoke of wage labor shortages while describing weeding practices. The use of chemical herbicides emerged as a tool to compensate for the labor shortage. This indicates that access to wage labor is necessary for controlling weeds in these farms, and the woody nature of trees makes weeding particularly laborious.

Harmful trees are also considered weeds. One example is the commonly found corozo palm tree (*Acrocomia aculeate*) which cattle eat and disperse. Four farmers spoke of this tree as a weed due to the hurtful thorns:

> '…it does affect the animals because of the palm leaves that can hurt the calves; when there is a large quantity it can affect in that regard.'

Farmers are left balancing the palm's utility as cattle feed, with the drudgery caused by its hurtful thorns.

People–Living Nature Balance

Farmers have a relationship of coproduction with nature by balancing the ecological process of forest regeneration with the production of grass and cattle. They reshape nature when they cut the forest to introduce the cattle pastures, but also rely on the forest's ability to regenerate trees that provide fruit, timber, cattle feed, soil conservation, and farm coolness. Farmers explained how they permit natural forest regeneration to obtain the benefits from nature.

Concerns over the loss of nature emerged. When farmers were asked to talk about reasons for having trees, 24 said they were concerned about the effect that deforestation will have on future generations. Farmers mentioned their desire to preserve trees, not just for themselves and their cattle production, but for other social and ecological reasons. This sense of stewardship comes from the observed loss of wildlife and tree cover in their communities. Below, the farmer explains the deforestation in his farm before his tenure,

> 'We did notice when we bought the farm that they were cutting a lot of trees and especially everything close to the forest. There, we conserved four hectares that are in forest and we have tried to conserve the forest as it is.'

In addition, the farmer mentioned that water streams will dry out if the forest is not conserved. Deforestation is a signal that the farmer responds to by conserving the remaining forest, dispersed timber and fruit trees on the pasture.

Although they take a long time to develop, farmers purposely allow rare and valuable timber trees to regenerate because they want future generations to enjoy their benefits:

> 'And [among] timber trees there is Quirá. Let's leave it for those that come behind because that is something that you don't see anymore, so they can learn, it is not going to exist.'

Whether in the forest fragment, around the household or in the pasture, nature sends signals to farmers to which some respond by preserving the trees.

Natural regeneration also benefits cattle production. Farmers showed trees that cattle ate during the farm walks, but rarely mentioned them during the recorded interviews. In response, 35 farmers were asked to talk about naturally regenerating trees that the cattle ate. All 10 additional interviewees mentioned trees that cattle ate. Farmers specially rely on these trees during the dry season when grass is depleted. Nine farmers also talked about the value of trees for nitrogen fixation and soil erosion protection.

Production–Reproduction Balance

Our analysis suggests that these farmers aim to sustain their farming practice in the long term. The production–reproduction balance happens when farmers must negotiate short term with long term goals. This balance is related to the

people–living nature balance, because tree regeneration is perceived as necessary to guarantee long term goals.

The production–reproduction balance appeared when 18 farmers were asked directly about their future farm and tree management plans, and emerged in 9 additional interviews. Seventeen farmers said they were planning to encourage trees because they offer shade, conserve water, increase production, or provide cattle feed. As one farmer noted,

> 'What I am trying to do is to put the trees in the center of the property and not put them on the corner … [I planted] about 600, 700 meters of fruit trees…because the cow looks for the shade more every time, because every time the summers get hotter and the winters with less water.'

This recurring comment may have been influenced by the 2014 extended dry season. Some farmers showed preparedness under the expectation that the dry seasons will become longer with the effects of climate change.

Internal–External Resource Balance

The internal–external resource balance happens when a farmer decides whether to "buy" or "make" a resource (van der Ploeg 2013). Farmers expressed that trees in the farm provide utilities that, to a certain extent, could be bought.

Twenty-four farmers that were asked to describe tree extraction practices said they did so to construct live fences, stakes, houses, and furniture. Wood is also donated to local schools and used for fuel. Although trees have cash value, among the 24 farmers, 16 said trees have more value within the farm as opposed to selling for cash, although 2 had sold trees. A recurring theme was that trees were for "internal farm use" and they were "not in the business of selling trees." This perception emerged in 5 additional farms. Commercial tree plantations were only present on 4 farms. One farmer explained,

> 'With the trees, I don't have to think that I need to buy wood to fix the fence. None of that. Instead, since they are close by, and their being a good quantity, I can use them. The fact of having the material, in the farm without having to buy them, means that you can access them quickly making the work go faster…'

The farmer is preserving trees not for commercial purposes, but to reproduce farm management by guaranteeing that they will be able to obtain lumber from within the farm. Farmers also prioritize their children's welfare over immediate income, as one farmer stated,

> 'Cedro amargo, Cedro espino, Laurel, they are wood for construction… I have several over there. The people here want me to sell it to them, but because we have children and grandchildren we have to wait to see if they are going to make a house.'

Mentioned by half of the farmers, the Macano tree exemplified the internal–external balance. Farmers frequently noted that if they did not grow Macano, they would have to buy it to fix the livestock pens.

Autonomy–Dependency Balance

Farmers face a balance between their ability to maintain autonomy over farm tree management and dependency on external actors. This tension is apparent in perceptions of tree management that are interlinked with government-led conservation policy, and market factors.

During early farm walks and interviews, the ANAM's (National Environmental Authority) policies emerged as an obstacle across eight interviews. An additional 21 farmers were asked to share their opinion on ANAM policies related to tree extraction. Out of the 21 farmers, 9 felt that ANAM's environmental regulations were inefficient, in several ways. First, to obtain extraction permits, an ANAM technician must do an inspection, but permissions are hard to secure because technicians are scant. Second, since technicians are limited, law enforcement is also sporadic, so people can engage in illegal logging. Third, farmers perceive that ANAM technicians favour and offer more assistance to farmers with more monetary or political influence. Finally, farmers also find that having to pay a fee for cutting trees is ineffective for environmental protection since decisions are not based on stated environmental conservation objectives.

The most common criticism of the ANAM authority is that farmers perceive that their efforts to conserve trees are not validated since they are often not allowed to cut the trees on their farm even if they have taken care of them. Potentially, when farmers observe that ANAM favours' the elites, they may feel that the point of the policy is not to protect the trees but instead to control them. These feelings may shift farmer's sense of autonomy over tree management, discouraging some from wanting to have more trees on their farm.

Not all farmers were frustrated with ANAM. Eleven (slightly more than half) of the respondents to the ANAM question said they did not see environmental protection laws as an obstacle to managing their trees, argued that they had no difficulty obtaining permits, and saw these laws as necessary to conserve trees. These farmers might reside in areas where they may have more access to the assistance from ANAM.

Farmer's may be responding to markets when they choose not to engage in forestry plantations because these are planted for commercial purposes. Most farmers' in our case study weren't interested in managing forestry plantations. Engaging in tree planting affects farmers' autonomy-dependency balance by increasing their dependency on wage labor to care for the trees and their dependency on environmental legislation to log those trees in the future. They also noted the risk of investing in teak and oil palm plantations including soil degradation, failure to achieve desired tree girth, and a weak markets. Farmers discussed the inaccessibility of wage labor due to its' increasing cost. For example:

> 'Experience tells us that the business of the [oil] palm is going to stay…with the big companies. At least here, they just bought the farm and everything from over there is being bought by a company from Guatemala. We cannot compete with them. We pay the workers 12 dollars a day, they pay 15 dollars. We cannot compete. And every day there is less people to work in the fields so I [would] rather have a business I can manage, that my sons can manage and not work with the palm right now…So I prefer dairy.'

Farmers explained that they will not invest in trees as commodities, but they will care for trees for their various utilities:

> 'So we do plant. Not with the goal of selling, but because they flower and they look pretty and provide shade. That is what we do here in the farm. When we can plant some type of tree in some place, we plant and they remain there for the future in case the sons want to sell it. To plant it with the goal of business right now, no.'

Seeing as most trees in their farms are not for the market—aside from some timber and fruit tree species—we interpret the existence of trees on the farms a small sign of "autonomy." Most farmers in this study don't manage the trees as simple commodities, but choose to care for them because they provide internal farm resources, increase farmers' ability to reproduce the farm operation, and improve their farm through their various utilities. The fact that trees are actively maintained on the farms we studied, shows that many cattle farmers are intentionally choosing to have more autonomy over dependency on external actors.

Discussion

The obstacles and reasons farmers offered for maintaining trees on their land are comparable to other studies in Latin America (Garen et al. 2011; Lerner et al. 2015; Sibelet et al. 2017). Live fence, shade, and wood for on farm use (for timber and fuel) emerged as the main reasons for having trees. Farmers also talked about the use of trees for fruit and fodder, adding farm resources, future generations, cash, coping with the lengthening of the dry season, providing soil nitrogen, and beautifying the farm. Tree weeding, as a necessity to maintain pastures, is the major obstacle to tree establishment and the main source of drudgery. Tree shade is perceived as a benefit for cattle, but also the second most common obstacle to tree management. Obstacles to planting seedlings, included the unpredictable weather, pest outbreaks, and cattle trampling. Finally, farmers discussed how government-led conservation policies can be an obstacle to tree management.

We've expanded on previous studies that documented tree utilities, by employing van der Ploeg's (2013) framework of Peasant Balances. Studies in Costa Rica and Nicaragua have found that shade is the main reason farmers cut trees growing on pastures (Harvey and Haber 1998; Sibelet et al. 2017). Here we asked farmers to describe all the trees on their properties including live fences, riparian vegetation, dispersed trees on pasture, horticulture, forest fragments, fallow and riparian

vegetation. This approach reveals that as farmers try to balance the *utility of trees with the shade*, they create strategies to decrease the amount of shade by modifying trees' spatial arrangement. For example, some farmers may eliminate trees in pasture areas, but balance this action by planting or conserving more trees along live fences, in riparian corridors, or close to their houses. This balancing behavior suggests that ranchers do not necessarily perceive trees to be incompatible with pasture management, but instead are balancing based on how they perceive a certain tree density is affecting their pasture.

We found that farmers *balance people and living nature* through a relationship of reciprocity with forest regeneration. Farmers use all the benefits provided by the forest and in turn allow it to continue regenerating through the management of fallows, forest fragments and isolated trees. This balance could be influenced by farmer's age and legal rights to the land. State led policies have encouraged deforestation to claim land, making forested land seem "idle" (Muchagata and Brown 2003; Heckadon-Moreno 2009; Rudel 2007). Most farmers in this study are second or third generation farmers on the land they manage, so the farm has already gone through a process of colonization. Unlike their grandparents, farmers' in this case study can allow the forest to regenerate and still have rights to their land because their land is titled. Property rights were not an issue for these farmers, but tensions between deforestation, agriculture and property rights still exist in Panama and many parts of the world (Place and Otsuka 2000; Krishan et al. 2017; Mateo-Vega et al. 2018). Agricultural censuses indicate that over 50% of farmers in our study region have their land titled. Sampling can be improved to include farmers that do not have titled land (INEC 2011).

Farmers also *balance production–reproduction* when they decide to conserve trees for future generations instead of clearing the land for agriculture. Trees on pastures are necessary for farm reproduction because they attract animals that will disperse seeds from remnant forest into pastures, guaranteeing future tree regeneration (Greenberg 1996; Ferguson et al.2003; Sandor and Chazdon 2014) and it's multiple utilities. Farmers also need to reproduce labor. Labor from both within and outside the farm is scant across the regions as expressed by farmers and evident from the national censuses (INEC 2011). Labor scarcity influences the *external-internal resource balanc*e when labor is externalized and replaced by wage labor (or commoditized labor) and chemical herbicides. Labor scarcity can be more of an obstacle for some farmers than others, as McCunes et al. (2019) showed that through social relations, labor may be reproduced even when it is scarce.

We found that environmental policy and markets influence the *autonomy-dependency balance*. For some farmers, the way government-led conservation policies are implemented can be in conflict with how they aspire to use the trees for farm reproduction or as an internal farm resource (Huntsinger et al. 2012). Such sentiments may be partially responsible for farmers not wanting trees for commercial purposes, since tree plantations depend on environmental legislation for its management. The added labor cost and perceived risk of commercial plantations further discourages them from wanting to engage in this enterprise.

While we were able to uncover patterns in the relationship between tree and pasture management, our methods also presented certain limitations. We found

it necessary to start with an open-ended discussion during an initial farm walk to establish trust with farmers before conducting a semi-structured interview, but this meant that farmers sometimes raised topics during the walks that we were not able to capture verbatim, which we mentioned in our analysis but did not code as part of our formal semi-structured interview analysis. Furthermore, the semi-structured nature of our follow-up interviews with farmers allowed farmers to raise themes that we had not expected to emerge, but it also meant that conversations with some farmers raised new questions that we were only subsequently able to ask the remaining farmers, not allowing us to systematically ask all farmers the same questions. While this approach still allowed us to see whether particular topics resonated with a large percentage of the remaining farmers, future research could use the more nuanced understanding we developed of van der Ploeg's (2013) Peasant Balances to develop a more structured interview or survey. In our study, it was not possible to know how the perceptions of the 54 farmers we interviewed translated into broad management actions across a larger landscape (Miles et al. 2013). A more established, structured survey could allow for scaled-up research to identify these links.

Conclusions

We used the Peasant Balances framework to understand how Panamanian famers incorporate trees into their pasture management. The framing focuses on the qualitative premise that the balances are necessary for farmers to fulfill their livelihood aspirations (van der Ploeg and Ye 2016). We adopted this framework to understand how trees fit into cattle rancher's livelihood aspirations, and found that farmers see trees as important to improve their farming operations. Trees are not perceived as incompatible with cattle ranching, instead farmers balance obstacles with tree utilities, and farm production with ecological processes.

Across the Neotropics, conservationists engage in research and practice that aims at increasing tree cover in the farms. The Peasant Balances framework can be used by conservationist across the region to understand how the ecological condition of the farm relates to each farmers' socioeconomic–political condition. With this understanding, conservationists could encourage conditions that allow farmers to be autonomous and conserve trees, rather than introducing extraneous programs that don't account for farmers' logics. Ultimately, this approach may require that conservationists work with farmers to improve socioeconomic–political conditions that often restrict farmers' ability to fulfill their aspirations. Conservationist and farmers could co-create policies that strengthen farmers' existing efforts to have trees in the farm.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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