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Understanding Relationships Between Agriculture and Native Vegetation: A Quantitative Multi-Context Analysis in the Alto Paranapanema Region of Brazil

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Summary

The Brazilian Atlantic Forest (BAF) is considered one the most important biodiversity hotspots in the world. Unfortunately, it is also one of the most threatened, and with around 60% of Brazil's population living there, it has been prone to interference and destruction by agricultural activities, resources demand and infrastructure and industry development. The Alto Paranapanema watershed is located within this biome, and it is a southeastern region of the state of São Paulo. One of this region's main economic activities are agricultural, with livestock, crop and silviculture production leading in importance. This, just in many other places in the BAF, had led to increased deforestation, being reduced down to 7.5% of its original coverage in 2000.

In the year 2012, the Brazilian government revised the 1965 native vegetation protection law called the Forest Act and established a New Forest Act, where among other changes, provided modifications to protection instruments such as Legal Reserves (LR) and Permanent Protection Areas (APP). This new law also created the Rural Environmental Registry (CAR), a mandatory inscription system for rural properties and their owners, creating a nationwide rural database. Using this data base and as well geographical information, it is possible to quantify the coverage of native vegetation (NV) as well as the protection instruments that are used for the conservation and restoration of native vegetation.

This research set out to explore the reasons for variations of these types of coverages (NV, APP, LR), to determine compliance to legal requirements and the identify and characterize the variables and relationships that might help to understand the dynamics of native vegetation coverage and protection and agriculture. Adapting a framework that aims to explain the relationships between different variables and their adoption of sustainable agriculture, secondary data was gathered and quantitatively analyzed to determine the relationships between the different factors considered.

The results showed positive relationships between the native vegetation elements analyzed and size of property. At the same time negative relationships were found with association to farmer associations such as cooperatives, financial assistance reception, and amount of machinery used. Mixed results were gathered regarding age, income, and educational levels completed. Correlations between labor and machinery, age and education, association to cooperatives and machinery, income and property size, and reception of financial assistance and cooperatives where identified, which would be appropriate to consider when planning forest and landscape restoration schemes, since these consider multi-stakeholder interactions.

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1. Introduction

The Brazilian Atlantic Forest (BAF) is a biodiversity hotspot, holding a large proportion of biodiversity. To be identified as a hotspot, these must have a high amount of endemic species, as well as be considered threatened by habitat loss (Myers et al. 2000). The Atlantic Forest has more than 20,000 plant species, of which approximately 40% are endemic and more than 1300 vertebrate species that include around 40% endemic species (Mittermeier et al., 2004). In the past, the BAF was one of the largest forest biomes in the Americas, expanding for around 150 Mha. By the year 2000, primarily due to agricultural activities, it had been reduced to 7.5% of its original primary vegetation extent (Myers et al, 2000), with an estimated recovery between 11-16% of its original coverage by 2009 (Ribeiro et al, 2009), mainly as a result of the increase in coverage contributed by the fragmented secondary forests (Metzger et al, 2009).

The extraction of natural resources, mainly in the form of Eucalyptus forestry plantations for paper pulp production and other agricultural uses, such as sugar cane, soy and cattle rangeland, is one of the direct causes for the destruction of this ecosystem (Barbosa et al, 2006), a consequence of this area having one of the largest extensions of highly fertile soil in the country. The amount of human population present in the area is also an influential factor, considering that around 60% of Brazil's population (122 million people) live there, demanding not only large areas of originally forest-covered areas, but also fresh water (Rodriguez et al, 2009). Loss of forest area dates back to colonial times, although in the last 3 decades of the 20th century the destruction accelerated, mainly thanks to industry development, resulting in the perishing of highly biodiverse habitats and an increasing fragmentation of the forest (Pinto et al, 2006). Nowadays, the largest portions of the remaining original, pristine forest are situated in the geographical areas where the potential for agriculture and settlement is more challenging, being these the more steep and elevated regions (Silva et al, 2007).

The BAF is geographically located within the tropics, with a small portion below the tropical latitudes. Regions such as these possess a high capacity for the accumulation of biomass (Beer et al, 2010), high potential for the accumulation of biodiversity (due to high number of small-range and endemic species) (Pimm et al, 2014), and its restoration has high potential benefitting people (Kaimowitz & Douglas, 2007), especially considering that many social problems and poverty are often associated with the degradation of land and biodiversity loss (Adams et al, 2004). These benefits signify a relevant array of opportunities for the restoration of a biome such as the BAF. In 2019, Brancalion et al. (2019) identified hotspots for restoration combining benefits with feasibility. Using relatively high-resolution data on biodiversity conservation, climate change mitigation, climate change adaption and water security as the benefits that would be weighed, and feasibility factors (land opportunity costs, ecological uncertainty, and forest persistence chances), the BAF scored the highest in amount of area considered a restoration hotspot, and among the highest in the restoration opportunity score.

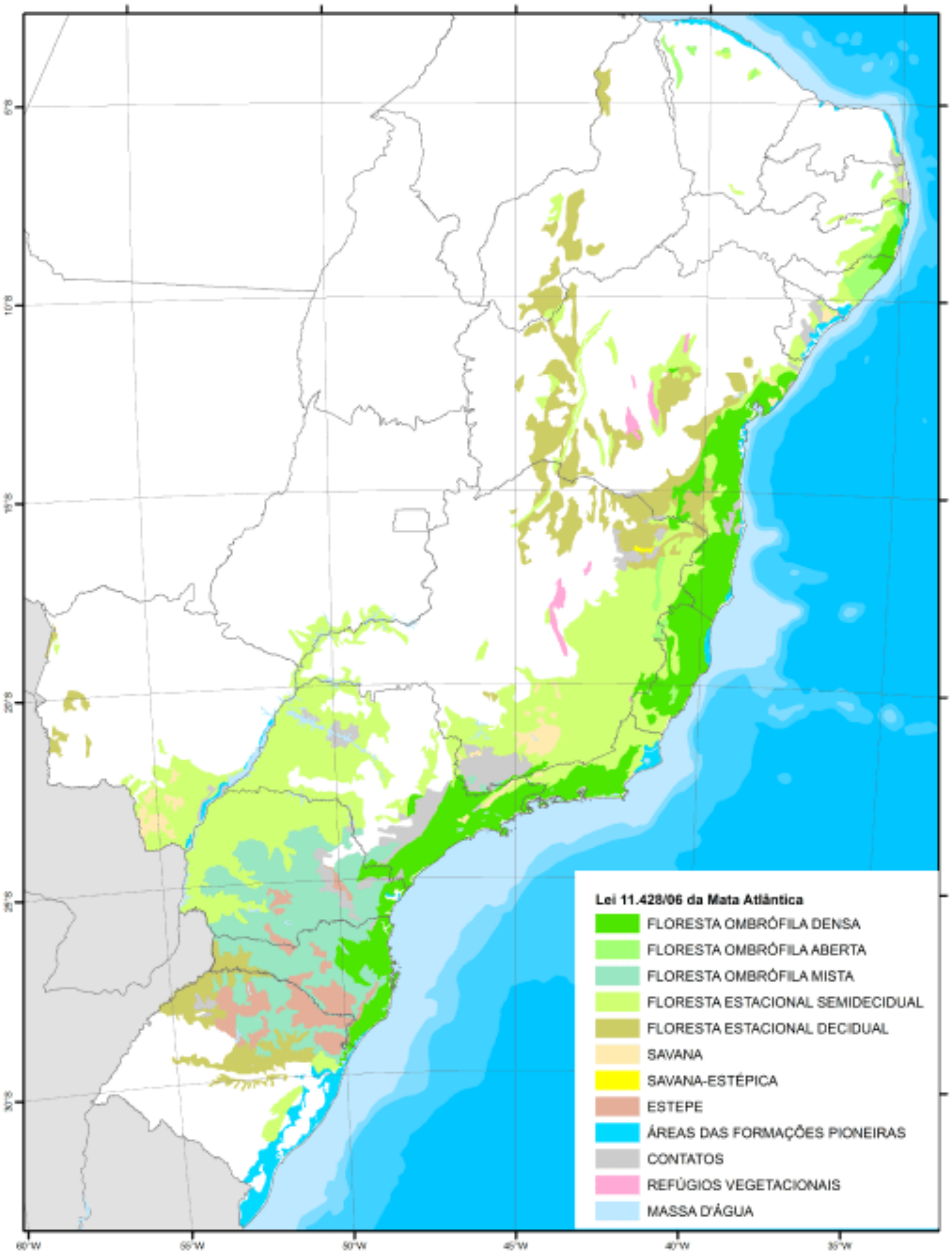

Figure 1.1: Map of the Brazilian Atlantic Forest (BAF) with its different ecosystems. Source: sosma.org.br

The Alto Paranapanema watershed is located in the southeast region of the state of São Paulo. It is composed of 36 municipalities and its biggest cities are Itapetininga, Itapeva, Itararé, Capão Bonito, São Miguel Arcanjo and Piraju. The entire watershed has a population of about 716.000 people (Brazil, 2010) and its major economic activities are livestock, crop, and silviculture production. It covers an area of 22.734 squared kilometers and a population density of 35.7 inhabitants per square kilometer. Around 15% of its area is protected through areas such as conservation units and reservoirs. An important portion of this watershed is composed of BAF, with plant species and threatened wild fauna, that is protected by state parks and environmental protections areas such as Corumbataí, Botucatu and Tejupá (SigRH). Deforestation and increase in agricultural production area in this region, while bringing higher income to producers, have also generated certain issues that have led to higher number of floods and pollution of soil and water. This has generated plans for the recovery of riparian vegetation (CBH-ALPHA, 2016).

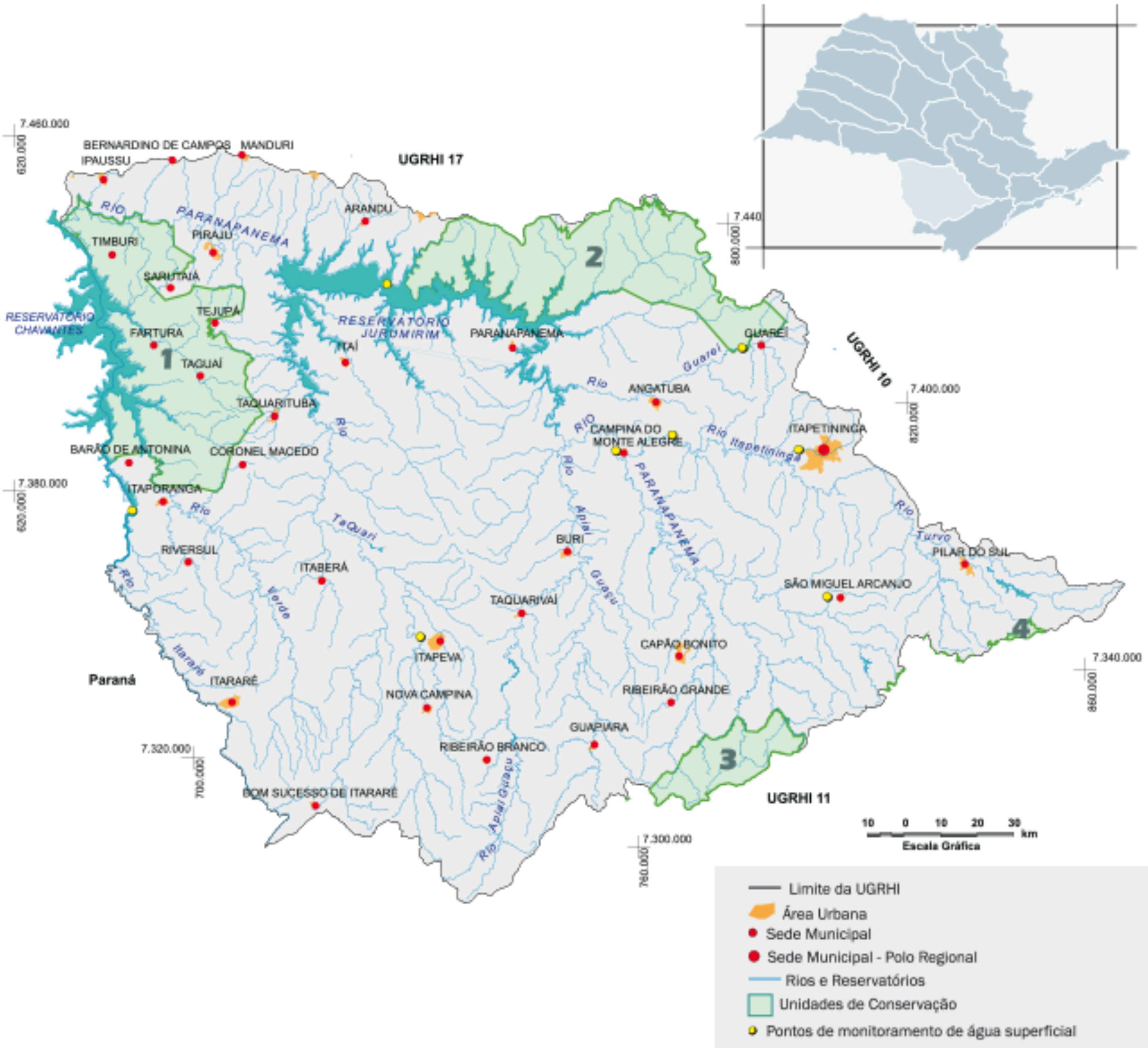

Figure 1.2: Map of the Alto Paranapanema watershed, with its municipalities, conservation areas, hydrography and reservoirs. In the top right is the location of the watershed within the state of São Paulo. Source: sigrh.sp.gov.br

In the year 2012, the Brazilian government revised a native vegetation protection law dating back to 1965 and called up to then the Forest Act. This new law was named the New Forest Act, and it establishes various measures for environmental protection including the modification of protection instruments called Permanent Preservation Areas (APP) and Legal Reserves (LR):

- APPs are environmentally sensitive areas within properties delimited by authorities (covered or not by native vegetation (NV)) where human exploitation and intervention is prohibited. These have the environmental function of preserving water resources, biodiversity, geological stability, landscapes and facilitating gene flow in species' populations inhabiting these areas. Within these areas are the strips of land surrounding many water bodies, as well as most perennial and intermittent water courses, steep slopes (of over 45 degrees), highlands that are situated over 1800 meters over sea level, tops of some hills and mountains, and edges of plateaus, among others. Properties under 4 fiscal modules are also subject to different requirements, such a less meters required for native vegetation in the borders of some water bodies (Brasil, 2012).
- LRs are defined as areas within rural private lands that have the function of ushering the protection and recovery of ecological functions and biodiversity. In the BAF these LR must cover at least 20% of rural properties or be subject to compensation schemes to cover for the deficit of LR (Brancalion et al. 2016).

The new Forest Act also institutes the creation of the Rural Environmental Registry (CAR: Cadastro Ambiental Rural), an obligatory system for the inscription of rural properties. In it, the characteristics of properties and owner information is gathered, the establishment of the aforementioned LRs and APPs and therefore making it necessary for the compliance of the legal requirements. Environmental Regularization Programs (PRA: Programa de Regularizaçao Ambiental) are also created in the new Forest Act, establishing conditions for the regularization of areas such as APPs and LRs that were deforested and used in agricultural activities up to the 7th of July of 2008 (Servicio Florestal Brasilerio, 2017). The properties where illegally cleared native vegetation for agriculture occurred to this date were subject to a special regime for regularization, allowing more flexibility and affordability for law offenders with respect to the requirements for compliance (Chiavari and Lopes, 2015).

Although there are landowners that do not meet with these requirements, there are also mechanisms to aid in their legal compliance. While some opt to restore through active revegetation and/or guaranteeing natural regeneration of native flora, it is also possible to acquire certificates (through the Environmental Reserve Quota) from other landowners that have a surplus in land with native vegetation (de Freitas et al. 2017). This may provide an economically viable way for some farmers and landowners to comply with the legally required percentage of LR, due to high opportunity costs and high restoration costs (May et al, 2015), as well as increase in land price as it becomes usable (Reydon et al, 2014). Nevertheless, it is not necessarily environmentally beneficial, since it does not need actual regeneration of native vegetation on degraded lands.

With the 2009 Bonn Challenge, the Brazilian government committed to the restoration of 12 Mha of its degraded/damaged regions (Amazon rainforest, Cerrado, Atlantic Forest, among others), contributing to the global goal of 150 Mha restored forests by 2020 and 350 Mha by 2030 (www.bonnchallenge.com). In 2011 the Atlantic Forest Restoration Pact (Pacto pela Restauraçâo da Mata Atlantica) was created. This is a multi-stakeholder initiative that aims to restore 15 Mha of Brazilian Atlantic Forest by 2050 and pledging to restore 1 Mha as contribution to the 2020

Bonn Challenge (Crouzeilles et al, 2017). According to the International Union for the Conservation of Nature (IUCN), by the year 2018, Brazil had achieved an area of restoration of over 9.4 Mha (www.infoflr.org), a figure that includes the advancements made in all the biomes targeted by the authorities in the Bonn Challenge. Regarding the BAF, the restoration area between the years 2011 and 2015 was estimated to be between 673.510 and 854,018 ha, with a trend to increase by year. With the average area in restoration of more than 180,000 ha per year, and assuming that this continues, the estimated area restored by 2020 will be between 1.35 and 1.48 Mha (Crouzeilles et al, 2017). Regarding this recovery, the Atlantic Forest Law (Lei 11428: Lei da Mata Atlantica) introduced in 2006, played an important role by setting boundaries of native vegetation, as well as the specification of the different ecosystems (types of forests, highlands, swamps, mangroves, etc.), and defining classification of producers to avoid legal loopholes that lead to deforestation, such as purposefully burning down a patch of forest and then using it for another purpose (Brazil, 2006).

Despite the previously mentioned area growth in forest cover over the recent years, the BAF remains a biome with highly fragmented habitats (Araujo et al, 2015). Habitat fragmentation can be defined as “a change in habitat configuration that results from the breaking apart of habitat” (Fahrig, 2003). This poses a threat to its biodiversity by limiting biotic interactions (trophic webs, pollination, etc.) (Burslem et al, 2005), facilitating disturbance in the organization of its ecologic communities, risking modifications in their structures and dynamics (Benitez-Malvido et al, 2016). Ecosystem health is also relevant for the benefits that they provide to humans, known as ecosystem services (ES). These can be defined as “conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life” (Daily, 1997). These can be functionally separated into 4 categories: provisioning (e.g. food, water, fuel), regulating (e.g. climate regulation and water treatment), supporting services (e.g. nutrient cycling and primary production) and cultural (e.g. recreation and aesthetic value) (MEA, 2005). Ecosystem restoration was found to enhance biodiversity by approximately 44% and the first three mentioned categories of ES by approximately 25% (Rey Benayas et al, 2009).

Farmers and landowners have historically been considered the target or beneficiaries of environmental policies, rather than key stakeholders and agents of change. In previous experiences in various parts of the world, they played major roles in reinforcing multi-landscape functionality through farming and non-farming activities (Hart et al. 2016). Attributes related to the farmers and farms themselves (intensity of production, size of farm, land-use, etc.) (Benton et al. 2003; Godar et al, 2012; Zhu et al, 2016), their more proximate context (farmer organizations, external support, etc.) (Hart et al, 2016; Alcon et al, 2019), and the more macro-scale contexts that surrounds them (Legal and economic) (Lockhorst et al, 2016; Ruggiero et al, 2019) compose a variety of characteristics of landowners and their properties that have shown to have a relationship with native vegetation cover loss and gain.

1.1 Forest and Landscape Restoration

Forest and Landscape Restoration (FLR) is defined as the "process of regaining ecological functionality and enhancing human well-being across deforested forest landscapes" (www.iucn.org). This restoration initiative aims at large-scale recovery of forest and non-forest habitats to ensure influence in the reestablishment of biodiversity, ecological processes and functions in areas where land degradation is present (Lamb, 2014). Biodiversity increase is linked to efficiency in which ecological communities perform functions such as the capturing of resources, biomass production, and decomposition and recycling of nutrients, as well as stabilizing ecosystem functions and enhancing its resilience (Cardinale et al, 2012). At the same time FLR seeks to include stakeholders of the targeted area, looking for a balance between ecosystem service restoration and the support of productive functions for agricultural and other uses that would finally positively affect livelihoods (Sabogal et al, 2015). Important issues rise in FLR implementation that challenge favorable results. One of these is the possible appearance of trade-offs instead of synergies in the outcomes of implementation. Another issue is the power imbalances between stakeholder groups that may rise in light of these trade-offs. Last are the complications in monitoring, reporting and verification of FLR results due to conceptual and methodological obscurity. To attend these issues, four guiding principles to guide FLR initiatives were proposed (i.e., (Brancalion & Chazdon, 2017): (1) The need for strategies to enhance and diversify local livelihoods, (2) the requirement for afforestation to not replace areas where native non-forest ecosystems were present, (3) the promotion of landscape heterogeneity and biodiversity in FLR approaches, and (4) the requirement for quantitative and qualitative differentiation between residual and new carbon stocks.

1.2 Forest Transition Theory

The Forest Transition Theory (FTT) shows, on a temporal and spatial scale, the way in which forest cover changes in an area over a certain period of time, in a specific region (Angelsen & Rudel, 2013). It was initially coined by Mather (1992), and it describes the different stages through which the forest undergoes changes. It states that forests start off as undisturbed, pristine forests, and as deforestation accelerates (thanks to population dynamics, increase in economic motivations for exploitation, and infrastructure improvement), forest cover starts to lose area. As this process keeps on going, forest cover reaches a point where it is no longer possible to continue the same rate of exploitation, reaching a stabilization in the loss of original forest area, where mostly agricultural (annual crops) and forestry mosaics can be found. Finally, a stage of negative deforestation (forest gain) takes place, where new forests (not necessarily the same composition as undisturbed forests) start to grow (Ametepeh, 2019).

1.3 Research setup and research questions

Due to the Covid-19 pandemic situation difficulties arose during the process of information gathering. The original plan of research and the subsequent contingency plans became increasingly challenging to execute. In the original plan, qualitative data would have been collected, by interviewing farmers in relation to normative aspects of forest recovery on their properties. Covid-19 has led to a significant deviation in the way the research would have been conducted. Since more quantitative data was available for analysis, the qualitative research was translated to a quantitative one and changing from analyzing normative norms and perceptions to legal and measurable parameters (APP, LR and NV). Due to these reasons the research questions were forced to change. The new research questions formulated for the development of this thesis were:

- ➔ *Do characteristics of the landowners and producers, their land and their context affect the presence of the protection units of Permanent Preservation Areas (APP) and Legal Reserves (LR) and native vegetation (NV) in their properties?*
    - o *How are these relationships characterized?*

In the following sections, the theoretical framework based on previous literature will be explained, as well as its components that address institutional, economic, social and environmental conditions. The following chapter includes methodology, where the specification of the gathering of data through secondary sources is described, followed by the operationalization of variables and the statistical resources used to analyze the data obtained. The subsequent chapter includes the results of the analyses performed, starting with the property-scale data and moving on to the municipal scale data that was scrutinized. The succeeding section is the discussion, where the results are interpreted and linked to the framework. In the end the limitation, conclusion and future research recommendations are laid out.

2. Theoretical Framework

The "Onion Model"

Various models exist to analyze holistic views of agriculture and their stakeholders. However, many of those frameworks perform only at the macro level, giving overviews not compatible to individual-scale results (Hekkert et al, 2017; El Bilali, 2019). Schoohoven & Runhaar (2018) developed a holistic model in which aspects of individual actors in relation to their economic activities can be analyzed. This model specifies these aspects and shows how they are connected. Four conditions (motivation, ability, demand and legitimation) (Runhaar, 2017) are identified for farmers to adopt agro-ecological practices in European Agriculture (specifically Andalusia, Spain) are identified and used as the core of the framework. Agro-ecological farming is defined as a holistic way of farming that takes into account ecosystem processes and ecosystem services to achieve improvements in environmental and economic performance (Wezel et al, 2014). Surrounding this, Schoonhoven and Ruhnaar constructed an onion model, which is a framework that identifies and illustrates the influence and impact of outer layers on the inner layers, while also influencing the outcome of the central concept (Bothma et al, 2015). These layers illustrate the dimensions or contexts (the individual and the external contexts, which is divided into direct and distal) in which different factors act. This model is comprised of different factors and characteristics that were divided into 4 categories (economic, social, informational, political), that were then attributed to the different dimensions. These were examined to determine connections with each other and their interactions with the four previously mentioned conditions (fig. 1).

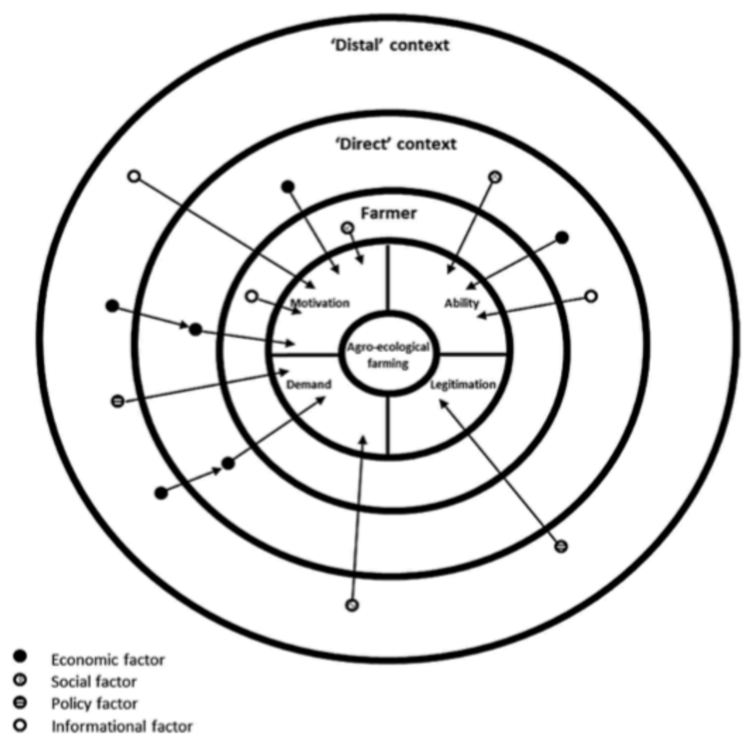

Figure 1.1. Conceptualization of the onion model proposed by Schoonhoven & Runhaar (2018).

Although this model is particularly developed for European agriculture and agro-ecological adoption, it may be applied to other contexts such as the Brazilian case of the instruments that the New Forest Act uses. The differences laid in the focus of the core of each framework, considering that agro-ecology is focused on the delivery of agricultural productivity while providing environmental solutions, and this study pivoted from the protection instruments required by Brazilian legislature that in turn aim for the delivery of environmental benefits as well as ecosystem services. Nevertheless, the model itself was tailored and adapted to what is needed in this research.

In contrast to the original model by Schoonhoven & Runhaar (2018), the different conditions (Motivation, ability, demand and legitimation) were substituted by the central concepts of the study: (a) Legal Reserves; (b) Native Vegetation; (c) Permanent Preservation Areas; and (d) In-site compliance to Legal Reserve quota. These four themes were used to give an overview of the current situation of native vegetation coverage and legal conservation and restoration instruments within the properties of the Alto Paranapanema watershed. These are tools critical to forest and biodiversity conservation, as well as for preservation of ecosystem services, thus fitting as the central points of the framework.

Since these protection instruments refer to private rural properties, it seemed necessary to include the landowners within the analysis. These are ultimately the key actors in the effort achieving forest conservation and restoration in rural areas (Hart et al, 2016) so the understanding of intrinsic characteristics and contextual aspects in relation to conservation protection instruments like APPs and LRs seems adequate to be used to illustrate the current situation in the region in this regard.

With this as the centerpiece of the research, the "onion model" is tailored to an attempt to visualize relations between different characteristics of the agents concerned, their direct context, their distal context, and the protection instruments analyzed (fig. 2). With regard to the outer layers, these are separated into three: (1) the innermost is comprised by the individual characteristics of the subjects and their properties; (2) the middle layer considers the direct context with which the subjects interact, including relationships between farmers/landowners and their social network, 3) the outermost layer contemplates a more distal context, with factors that the subjects have little influence on and that shape the landscape in which they operate (e.g. Economic and legal characteristics).

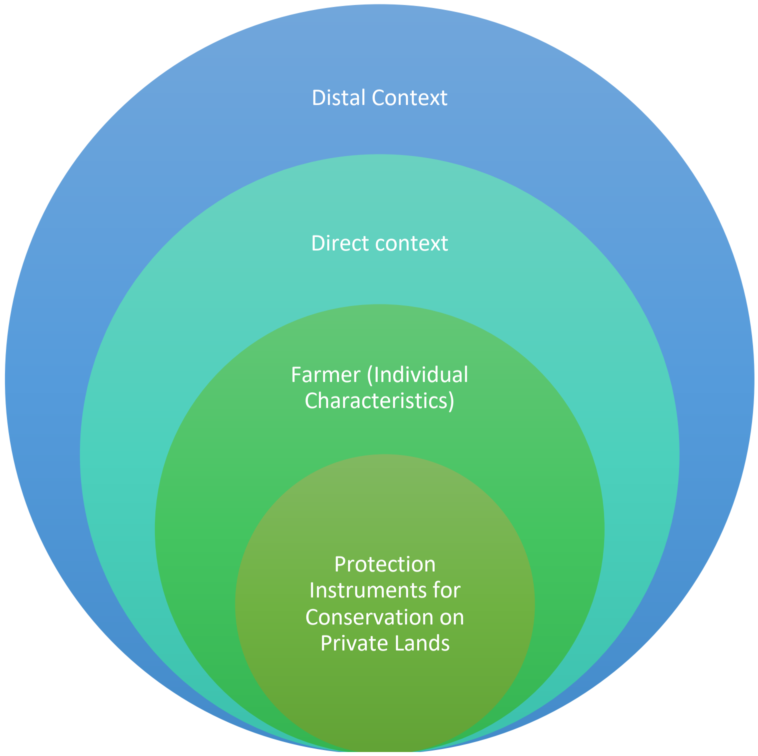

Figure 1.2. Conceptual framework of the adapted onion model to be used in the thesis.

Regarding the contexts that end up influencing APPs, LRs, Native Vegetation and Compliance, factors must be addressed to determine the effects that these layers might have on the restoration of native vegetation. To achieve this, an array of properties for each layer are specified:

1) Individual characteristics:
    a) Size of properties: Since there is higher spatial and economic feasibility, despite the higher clearance of native forests, percentages of properties with native vegetation tend to be higher when compared to smallholders (Godar et al, 2012), the hypotheses for the test were that there will be direct relationships between property size and percentage of LR and NV within the property, with larger properties having a higher percentage. This therefore led to a similar hypothesis for compliance of LR, where there would be a direct relationship with large properties having higher rates of compliance. The hypothesis for the test between size segments and their percentage of properties with no APP was that there was going to be an inverse relationship. Since APP depends more on the geographical characteristics of the property, larger estates are more likely to include APP area within its limits.
    b) Age of producers: Farmer age may vary widely, and this raises the question if this could present a relevant difference for the presence of protection instruments. There have been mixed findings regarding age, with literature showing younger producers having a

positive relationship, as well as not having showed a significant role in sustainable management (Liu et al, 2018).

c) Level of education: Literature has shown that low levels of education levels can lead to risk-averse conducts, showing reluctance to steer away from traditional, status-quo methods in agriculture (Vignola et al, 2013). It was hypothesized that having higher levels of education had a positive relationship with the presence of conservation instruments.
d) Household per capita income: It has been seen in literature that higher-earning producers are more likely to engage in more sustainable practices (Prokopy et al, 2008). Therefore, higher income is expected to have positive relationship with APPs, NV and LRs.
e) Average Machines Used per Property: An elevated use and improvements of machinery tends to indicate an increase in the productivity of the farm and the intensity of farming (Reid, 2011), therefore it was of interest to see if this was linked significantly to the central point of this study. If there is more productivity, it can mean that there is more productive area, this led to a hypothesis of a negative relationship between increasing machinery use and LRs, APPs and NV.
f) Average workers hired per property: Amount of labor required can also indicate the intensity of practices although not always directly (Shively & Pagiola, 2004), thus it could be relevant to the degree of presence of the used units within this study. At the same time, it could also mean that as more workers are required, less machinery is used. Thus, mild negative relationships were expected.

2) Direct context:
   a) Association to cooperatives: These organizations can play crucial roles in the willingness of farmers to adopt beneficial ecological initiatives. Not only do they tend to vouch for better socio-economic conditions for small-scale farmers, they have also been seen influential in environmental management of agronomical activities at local and even international scales (Hart et al, 2016). It was hypothesized that being associated to cooperatives has a positive relationship with the presence of conservation instruments.
   b) Land proprietorship: Since there are differences in percentage of landowners within producers, and at the same time differences in the percentages of types of land cover, explorative tests were performed to observe possible relationships.
3) Distal context:
   a) Acquisition of financial assistance: Incentives, subsidies and assistance have been shown to increase the commitment that farmers have towards conservation and restoration (Lockhorst et al, 2011). While incentives such as payment for ecosystem services can be observed in Brazil, and while they can be effective, they have shown slow increase in restoration (Ruggiero et al. 2019). Since other factors, such as identity, responsibility and altruism have also been observed to affect restoration commitment by farmers (Chapman et al. 2020), it is hypothesized that incentives have a slight positive relation with the presence of conservation instruments of native vegetation.
   b) Reception of technical information: In terms of sociodemographic factors, knowledge of the farmers has been identified as one of the most important influencers in the adoption of environmental measures (Sanchez et al. 2016). The way this knowledge is handled is also relevant since it can bring improvements in developing further knowledge and in turn enhance capabilities for implementation (Padel et al. 2010). At the same time, technical

information can be acquired through different societal actors (Government, NGOs, Universities, farmer associations, etc.) and through a wide range of channels (government programs, television, reading material, etc.). A positive relation between information acquisition and LR, APP and NV was expected.

Achieving an overview of these factors and assessing the type of relationship (positive, neutral, negative) that they could have on protection instruments for conservation and restoration can provide useful insights into the dynamics of how properties present native vegetation.

3. Methodology

This thesis is centered around the understanding of the relationships that various characteristics intrinsic to the landowners and producers, their direct context and wider socioeconomical and administrative aspects have to the present status of NV, APPs and LRs in the Alto Paranapanema basin.

Native vegetation is defined as area in the primary stage and the initial, medium or advanced secondary regeneration stage of forest formations and associated ecosystems (Brazil, 2012). These include but are not limited to native vegetation contained within APPs and LRs. At the same time, with the new Forest Act it is possible to include APP within LR regardless of property size, supposing that these APPs are not involved in environmental easement and that they are in process of recovery with no further conversion of land into farming area (Sao Paulo, 2020). When considering LR, NV, APP and compliance, the criteria was as follows (Brancalion et al. 2016):

- NV: Areas covered by native vegetation and/or in process of recovery. In many cases these include APPs and LRs, particularly when these exhibit coverages of native vegetation or are in the process of recovery.
- APP: Areas that, even if not covered by vegetation, must be preserved. These are determined by their geographical characteristics (hilltops, steep slopes, streams, ponds, water springs, etc). These parameters are established by the current legal requirements and must be reported in the CAR.
- LR: Areas within private property that were declared as LRs by the producers and hence manifested in the CAR files that were retrieved. As mentioned in the previous chapter, these can include APP area as well, under the conditions stipulated.
- In-site compliance of LR: This parameter determines if there is the necessary proportion of LR within each property, which is 20% in the Atlantic Forest biome. It is important to stress that this is an in-site analysis, since there are schemes to compensate for lack of LR on the properties (compensating off-property or buying or leasing environmental reserve quota). This means that it is possible that results of non-compliance in-site does not mean that these producers are not complying elsewhere.

A quantitative analysis is used to statistically test the relationships between property sizes and the coverage of forests (native vegetation, LR and APP) and to visualize the degree of the interaction that they may have, where it could be negative, positive, neutral, and strong or mild. There is literature available that attends to the factors that were intended to be analyzed (Leite et al, 2020; Liu et al, 2018), but not at the spatial scale of the Alto Paranapanema basin or the municipalities that compose it.

The following section is centered on the data collection, the processing of data and the statistical methods used in the data analysis for the later application of the framework proposed to attend to the research questions.

3.1 Data Collection & Processing

To achieve the desired analysis, the data about different factors was required. The dataset about property size, permanent preservation areas, legal reserves and native vegetation was to be acquired at the property level scale, since that sort of information is available online through secondary databases like CAR (Cadastro Ambiental Rural). This information was available as GIS (Geographic Information System) files. This was required to couple units such as legal reserves, permanent preservation areas and native vegetation areas to their respective properties using the program ArcGIS. Some challenges were present at this stage, where the same units were present in more than one property, and since there was no division of these depending on the property, this resulted in getting information where both properties possessed the entirety of the unit. To correct for this, the properties that were smaller than the specific protection instruments that they were coupled with were disregarded.

In the data set, each declared property had a specific code (COD_IMOVEL) and each unit (LR, APP and native vegetation areas) had an identification code (IDF). With ArcGIS it was possible to geographically couple these together into a table with their respective areas to then determine how each property was conformed and how much area they had of the different units.

The unit of measurement of property size used was mainly fiscal modules (MF). These are land size references that vary depending on the municipality by federal law 6.746/79 (BRAZIL, 1979), taking into account land use, consumer market accessibility, and ecological characteristics (Leite et al. 2020), balancing the amount of land with the potential for profitability that one can actually gain from a certain area. Law 8.629 (Brasil, 1993) determines categories in accordance to ranges of number of fiscal modules that make up properties. The segments determined were: very small: less than one fiscal module (<1); small between one and four (1-4); medium: between four and fifteen (4-15); and large: more than fifteen (>15).

For most of the other variables (education level, age, association to cooperatives, financial assistance, legal condition of producers, technical information acquisition, machinery use, amount of personnel hired, land use), the data from the Brazilian Institute of Geography and Statistics (IBGE) was extracted, using the information from the most recent agricultural census dating back to 2017. Additional information was extracted from the results of the demographical census of 2010 (last published census available to date), like population and household per capita income. This information was available at the municipal level, but not at property level.

Using SIDRA (Automatic Recovery System of the IBGE; www.sidra.ibge.gov.br), it was possible to determine the specificity of the variables to be used. Depending on the data available, it was possible to use some datasets in different manners. In the following list the datasets that were available as segmented information were possible to use as ordinal variables:

1. Education level of producers was divided into 5 different groups: (1) Never attended school; (2) Attended up to the end of first cycle or primary education; (3) Attended up to the end of second cycle or secondary education; (4) Attended superior education

(Universities and technical institutes); (5) Possession of post-graduate degrees such as Masters and/or PhD.

2. Age of producers was divided into 4 segments: (1) Up to 25 years of age; (2) Between 25 and 45 years old; (3) Between 45 and 65 years; (4) Over 65 years old.
3. Household per capita income information was already divided into 8 groups: (1) No income (2) Up to ¼ of the minimum salary per person within the household; (3) Between ¼ and ½ of the minimum salary; (4) From ½ to 1 minimum salary; (5) Between 1 and 2 minimum salaries per member of household; (6) From 2 to 3 minimum salaries; (7) Between 3 and 5 minimum salaries; (8) More than 5 minimum salaries per capita.

The information available was presented in the number of producers (variables 1 and 2) or households (for variable 3) and corresponded to each size segment. The total numbers in its entirety were provided as well, thus being able to obtain the percentages. Using that information, it was intended to safeguard proportions taking into account the differences in sizes between the different municipalities.

The remaining factors that were to be considered within the study were available in specific nominal categories, but for the sake of simplifying the analysis, the following variables were adjusted as follows:

4. Association to cooperatives: This element takes into consideration the association of producers to not only cooperatives, but syndicates, associations and movements of producers, as well as residents' associations. These are all grouped together to consider if the influence of these types of conglomerates generates a significant change regarding compliance, LR, NV and APP.
5. Financial Assistance: For this parameter the totality of the producers receiving assistance is considered, regardless of the origin or financing agent.
6. Technical information acquisition: This variable accounts for any assistance, orientation or information that producers receive, wagering out these specifications as well as the form of acquisition, and leaving the analysis to whether producers received technical information or not.
7. Land proprietorship: In the municipalities composing the Alto Paranapanema basin, the secondary data available showed that most producers were also the proprietors of the land but showing some differences between the overall percentage (many had rates of over 90% of proprietorship and some were below 65%). Therefore, this variable was adjusted to test if this has a relationship with the amount of land destined to native vegetation, LR, and APP.
8. Average machines per property: Information regarding the number of machines used per municipality was at disposal, so this allowed the confection of the indicator of how many machines per property. Machinery was considered as a whole, accounting for tractors, seeding machinery, combines, fertilizer equipment and others.
9. Average workers hired per property: Just like the previous variable, the total number of employed personnel is available per municipality. With the total number of properties by municipality it is possible to see the average number of personnel per property. Amount

of labor required can also indicate the intensity of practices although not always directly (Shively & Pagiola, 2004), thus it can be relevant to the degree of presence of the used units within this study.

3.2 Analysis

With the data gathered from CAR, a total of 2,126,747.523 hectares of property area were analyzed, covering the Alto Paranapanema watershed. The general sample size was made up of 31,418 properties, dispersed throughout 36 municipalities. Out of these properties, 409,654.87 hectares were permanent preservation areas, roughly around 19.26% of the total land cover. Native vegetation area composed 329,350 hectares (15.49%) and legal reserves 265,935.51 hectares (12.50%).

Table 3.2.1: Size of fiscal modules by hectares, per municipality.

Municipality	Hectares per Fiscal Module
Angatuba	22
Arandu	22
Barão de Antonina	20
Bernadino de Campos	20
Bom Sucesso de Itararé	20
Buri	20
Campina do Monte Alegre	22
Capão Bonito	16
Cerqueira Cesar	22
Coronel Macedo	20
Fartura	20
Guapiara	16
Guareí	22
Ipaussu	20
Itaberá	20
Itaí	20
Itapeninga	22
Itapeva	20
Itaporanga	20
Itararé	20
Itatinga	30
Manduri	20
Nova Campina	20
Paranapanema	22
Pilar do Sul	16
Piraju	20
Riberão Branco	16
Riberão Grande	16
Riversul	20
São Miguel de Arcanjo	16
Sarutaiá	20
Taguaí	20
Taquarituba	20
Taquarivaí	20
Tejupá	20
Timburi	20

The total fiscal modules analyzed in the study is 96,720.8, and as seen in table A, the determined number of hectares per fiscal module in each municipality is specified. The range between Alto Paranapanema municipalities was between 16 and 30. This was determined by the National Institute of Colonization and Agrarian Reform (INCRA), which took into account: (a) the type of predominant land use, (b) the income generated by that type of land use, (c) other types of land use that, while not being predominant are considered significant in terms of income generated or area used, and (d) the concept of family ownership (EMBRAPA, 2012).

Table 3.2.2: Number of properties analyzed, per type of unit (Protection Instruments) and per segment.

Type of unit	<1	1-4	4-15	>15	Total
LR & Compliance	4161	3661	1859	951	10646
Native Vegetation	8092	5802	2291	957	17952
No APP	15765	8578	3116	1222	28681

Depending on the availability and eligibility of data, different sample sizes were used. For legal reserves and in-site compliance there were a total of 10,646 properties analyzed, native vegetation had a total of 17,952 and permanent preservation areas 28,681 properties. The majority of the properties for each type of unit were in the segment with less than 1 fiscal module, with the number of properties descending as the segments incremented in size range.

To measure the different relationships at the property level, different tests between property sizes and permanent preservation areas, legal reserves, native vegetation and in-site compliance were conducted. The intention was to determine if there was a difference between the different segments of property size and the percentage of possession of these different protection instruments within each property. The program SPSS was used for the statistical analysis.

In first place, in case data was not normally distributed it was normalized using the inverse distribution function in SPSS (Templeton, 2011) for the later one-way analysis of variance (ANOVA). This technique is used to determine if there are differences between the ordinal independent variable (fiscal module segments) regarding the continuous dependent variables (percentage of LR and percentage of native vegetation). This test achieves this by comparing the means of each segment and determines if there is significant statistical difference from each other by comparing the variance within and between the groups using one-way ANOVA (Fisher, 1992). Going further into these results an LSD post-hoc test was used to punctually determine which fiscal module segments presented significant differences among each other. For the percentage of properties with 0 APP within each segment a descriptive analysis of frequencies is used to visualize this value.

In-site compliance to LR requirements was converted into a binary variable and then analyzed using Chi-squared test to determine if there is a significant relationship between this type of compliance and the fiscal module size segments. An assumption had to be made in this regard where this was measured with only the in-site LRs, since those were the limits of the data available (producers can comply with this requirement by other means).

For the remaining variables, data was only available at the municipal level. Using the data already collected from the properties it was possible to gather total and average information regarding LR, NV, APP and compliance to the necessary quota of 20% of the properties being covered by LR and assign them to the 36 municipalities. In this matter, assumptions needed to be made to continue with the analysis, such as treating municipalities as individual cases of the sample. This led to the consideration of all the producers within a municipality as equal when using some variables that were measured in averages and total percentages.

For the first three of these variables that were available as segmented information (education, age and household per capita income), Spearman correlation analysis was conducted. In this test there is no assumption of normality of the data and it is appropriate to carry out with ordinal independent variables such as the ones that were used.

With other variables (Association to cooperatives, financial assistance, technical information acquisition, proprietorship of land, machinery, employed personnel, and land use) where the information was not property-specific as well as not ordinal and given solely at the municipal level, it was necessary to conduct tests of linear regression to determine the direction and significance of these relationships with the central points of the framework.

Table 3.2.3: Statistical tests performed per variable analyzed.

Variable vs LR, NV, APP and Compliance	**Statistical Test**
Size	ANOVA & Post Hoc LSD (Exception: Chi square for compliance)
Age	Spearman correlation
Education Level	Spearman correlation
Household per Capita Income	Spearman correlation
Association to Cooperatives	Linear regression
Reception of Financial Assistance	Linear regression
Technical Information Acquisition	Linear regression
Land Proprietorship	Linear regression
Average Machines per Property	Linear regression
Average Workers Hired per Property	Linear regression

Finally, Pearson correlations analysis between age and education level, and between all the variables analyzed with linear regression, were also performed, to determine interactions between these parameters and identify possible synergies or discords between these.

These collected results contribute to understand the underlying relationships between the different factors presented and LR percentages, in-site compliance to LR quota, NV percentages of properties and properties without APP, and ultimately forest restoration of BAF in the Alto Paranapanema basin in Brazil.

4. Results

In this section the results of the statistical analyses performed are laid out and explained. This starts with the results from the ANOVAs and LSD Post Hoc to visualize interactions between size and LR, NV, APP, followed by a Chi square analysis for the compliance variable. After that the variables that had information available at the municipal level are analyzed, starting with Spearman correlations, analyzing the effect of age, education level and household per capita income. Lastly, significant linear regressions are interpreted for the variables of association with cooperatives, reception of financial assistance, technical information acquisition, land proprietorship, average machines per property, and average workers hired per property.

4.1. Legal Reserve Percentage per Property

A one-way ANOVA was conducted to compare the effect of property size (segmented in fiscal module segments) on the percentage of legal reserve in each property.

Table 4.1.1: One-way ANOVA table for the percentage of LR coverage per size segment. NormPrctgLR is the normalized data of LR percentage fit for an ANOVA.

ANOVA

NormPrctgLR

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6425.425	3	2141.808	11.249	.000
Within Groups	2026499.17	10643	190.407		
Total	2032924.59	10646			

In table 4.1.1, a significant effect of segment size on the percentage of LR is shown at the $p<.05$ level, where F is 11.249 and p is 0.000, rejecting the null hypothesis that there is no influence of the independent variable (fiscal module segment) versus the dependent variable, i.e. percentage of LR. A Post-Hoc comparison (Least Significant Difference, LSD) test is used to identify the differences between fiscal module segments (table 4.1.2).

Table 4.1.2: LSD Post-hoc analysis of One-way ANOVA for LR percentage in each size segment.

Multiple Comparisons

Dependent Variable: NormPrctgLR
LSD

(I) Fiscal Module Segment	(J) Fiscal Module Segment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
<1	1-4	1.02163*	.31258	.001	.4089	1.6343
	4-15	.37915	.38449	.324	-.3745	1.1328
	>15	-1.78456*	.49509	.000	-2.7550	-.8141
1-4	<1	-1.02163*	.31258	.001	-1.6343	-.4089
	4-15	-.64248	.39251	.102	-1.4119	.1269
	>15	-2.80620*	.50134	.000	-3.7889	-1.8235
4-15	<1	-.37915	.38449	.324	-1.1328	.3745
	1-4	.64248	.39251	.102	-.1269	1.4119
	>15	-2.16372*	.54907	.000	-3.2400	-1.0874
>15	<1	1.78456*	.49509	.000	.8141	2.7550
	1-4	2.80620*	.50134	.000	1.8235	3.7889
	4-15	2.16372*	.54907	.000	1.0874	3.2400

*. The mean difference is significant at the 0.05 level.

Table 4.1.2 shows segment size of more than 15 fiscal modules differed significantly with all other segments, with p values for all three comparisons. Additionally, the segment of less than 1 fiscal module (between 16 and 30 hectares depending on the municipality), also showed that there are significant different with segment 1-4 with p values of .001. The segment of 4 to 15 fiscal modules did not show any other significant difference, other than the ones previously mentioned.

4.2. Native Vegetation Percentage per Property

A one-way ANOVA was also conducted to proceed with the analysis of segment size with percentage of native vegetation.

Table 4.2.1. One-way ANOVA table for the percentage of NV coverage per size segment. NormPrcntgVN is the normalized data of NV percentage fit for an ANOVA.

ANOVA

NormPrcntgVN

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1469553.24	3	489851.081	24.855	.000
Within Groups	353749340	17949	19708.582		
Total	355218893	17952			

In this case the null hypothesis was also rejected, indicating there was a significant effect of segment size on the percentage of native vegetation. It could be seen that at the p<.05 level, F is 24.855 and p is .000 (table 4.2.1). To examine the differences in comparisons between segments an LSD Post-Hoc test was performed.

Table 4.2.2. LSD Post-hoc analysis of One-way ANOVA for NV percentage in each size segment.

Multiple Comparisons

Dependent Variable: NormPrcntgVN
LSD

(I) Segment size in fiscal modules	(J) Segment size in fiscal modules	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
<1	1-4	12.58911*	2.36884	.000	7.9460	17.2323
	4-15	3.44574	3.28771	.295	-2.9985	9.8900
	>15	-26.90179*	4.77578	.000	-36.2628	-17.5408
1-4	<1	-12.58911*	2.36884	.000	-17.2323	-7.9460
	4-15	-9.14337*	3.46303	.008	-15.9312	-2.3555
	>15	-39.49090*	4.89812	.000	-49.0917	-29.8901
4-15	<1	-3.44574	3.28771	.295	-9.8900	2.9985
	1-4	9.14337*	3.46303	.008	2.3555	15.9312
	>15	-30.34752*	5.40271	.000	-40.9373	-19.7577
>15	<1	26.90179*	4.77578	.000	17.5408	36.2628
	1-4	39.49090*	4.89812	.000	29.8901	49.0917
	4-15	30.34752*	5.40271	.000	19.7577	40.9373

*. The mean difference is significant at the 0.05 level.

LSD post-hoc (table 4.2.2) revealed that most comparisons between segments had significant differences, with the segment of >15 differing once again with all the other categories with p values of .000. This also could be said for the 1-4 segment, that showed significant differences with all other segments with p values of .00 when compared with <1 and >15 and showing a p value of .008 with respect to 4-15. Only the comparison between <1 and 4-15 didn't show significant differences.

4.3. Compliance of In-site Legal Reserve Quota per Property

With the conversion of compliance of LR within properties into a Boolean Yes/No variable, the use of a Chi-square test was necessary to determine whether this variable is independent from the size of property variables.

Table 4.3.1: Crosstabulation of each variable in the in-site compliance with each size segment.

In Site Compliance of LR ratio * Fiscal Module Segment Crosstabulation

Count

		Fiscal Module Segment				
		<1	1-4	4-15	>15	Total
In Site Compliance of LR ratio	No	2509	2204	1075	499	6287
	Yes	1652	1457	784	452	4345
Total		4161	3661	1859	951	10632

In table 4.3.1, frequencies of each binary variable are displayed per size segment. All segments presented a higher amount of properties that did not reach the quota of compliance of 20% of the total land possessed.

Table 4.3.2: Chi-square results for compliance versus size segments. df means the degrees of freedom. Asymptotic significance is the P value. Significance level is 0.05.

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	22.846[a]	3	.000
Likelihood Ratio	22.619	3	.000
Linear-by-Linear Association	16.784	1	.000
N of Valid Cases	10632		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 388.65.

Table 4.3.2 shows the results of the Chi2 test, in which $\chi(3) = 22.846$, $p = 0.000$. This indicates that there was statistically, size segments of properties and in-site compliance to required LR quota are not independent from one another, with a significant association between them.

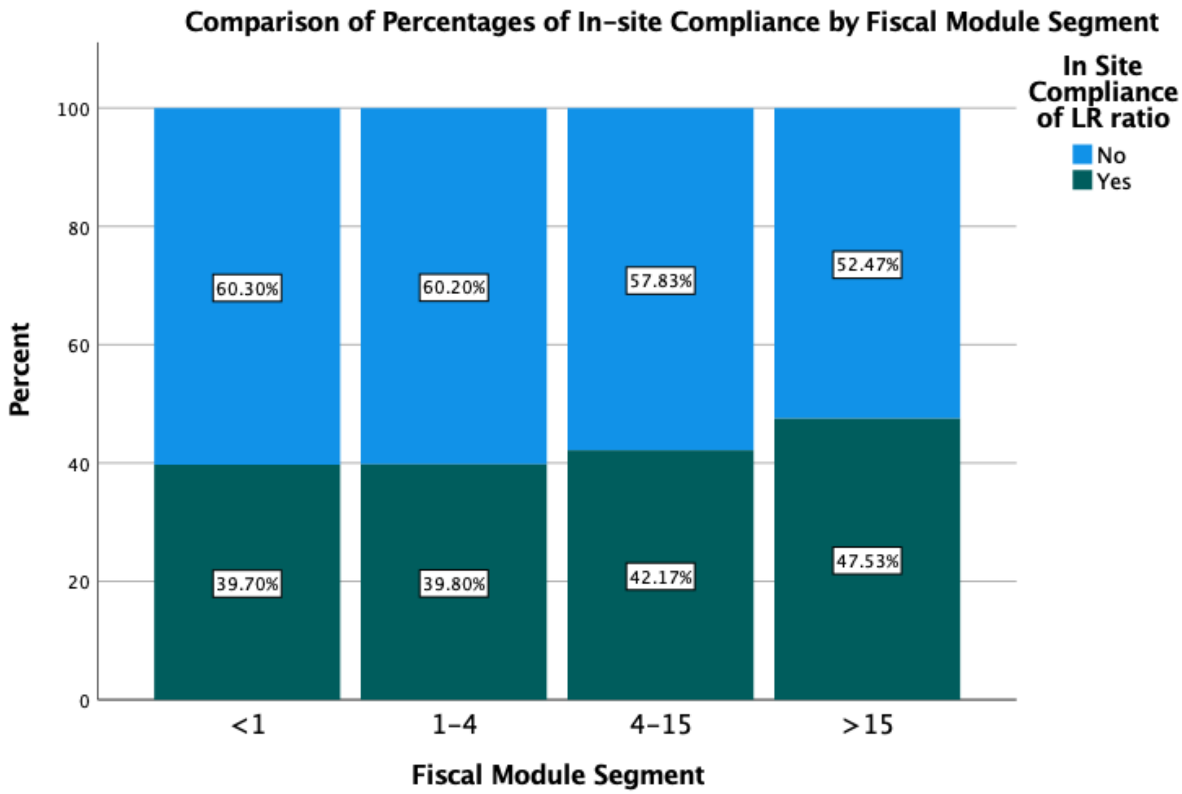

Figure 4.3.1: Bar chart comparison (percentages) of in-site compliance versus non-compliance, by fiscal module segment. Numbers within green bars indicate the percentage of in-site compliance to LR ratio within each segment, and the numbers in the blue bars are the percentages of properties that do not comply in-site.

Figure 4.3.1 illustrates the proportions of in-site compliance to LR ratio, showing a decrease in this margin as the fiscal module size segments increase, where compliance is lower in the smaller segments, but increases as properties grow. Coupled with the results from the Chi square tests, which indicate that there in an association between compliance and size of property, it could be implied that as properties grow, in-site compliance to LR ratio becomes more common, and vice versa.

4.4. No Permanent Preservation Area (APP) Coverage

The case of properties with no reported APP in the Alto Paranapanema watershed showed that in smaller properties it was substantially more common to lack the presence APP.

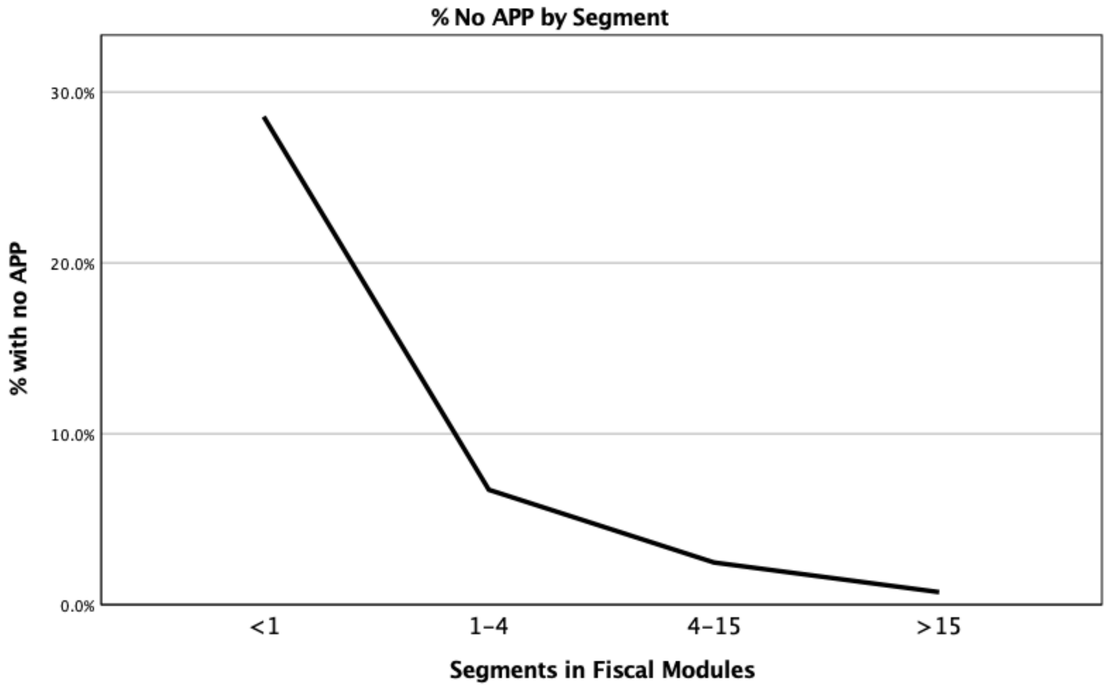

Figure 4.4.1: Percentage of properties without APP, per fiscal module segment.

As it is shown in figure 4.4.1, properties within the segment of less than one fiscal module had a much higher rate of absence, with 28.6% of all properties within this range not having APP. As properties grew, lack of APP decreased, with segment 1-4, 4-15 and >15 showing rates of 6.7%, 2.5% and 0.7%, respectively.

In the following sections, the age, education level and household income per capita were tested through Spearman correlation to determine its effect on LR, VN, no APP and in-site compliance to LR (dependent variables). This information was gathered at the municipal level, in contrast with the previous sections where the information was available at the property level.

4.5. Effect of Age

The results are the analyses of average values of age segments per municipality when tested against the different dependent variables. Using the property data available, the average per municipality could be calculated for each dependent variable as well. The municipal averages where used as samples (n=36). Each age segment presented a determined number of producers and this was converted into a percentage that each segment had out of the total producers per municipality.

Table 4.5.1. Spearman correlation of municipal percentage of producers for each age segment tested vs average percentage of LR property coverage. Different segments of producers were analyzed (up to 25 years old, between 25 and 45, between 45-65, and over 65).

Correlations

			Average % of LR per property	% of producers up to 25	% of producers from 25 to 45	% of producers from 45 to 65	% of producers of more that 65
Spearman's rho	Average % of LR per property	Correlation Coefficient	1.000	.514**	.589**	-.260	-.552**
		Sig. (2-tailed)	.	.001	.000	.125	.000
		N	37	36	36	36	36

From table 4.5.1 it can be observed that the age of producers has a significant (p<.01) positive correlation (r=.514; p=.001) with the average LR in property by municipality. Between the age range of 25-45 there was also a significant (p<.01) positive correlation with percentage of LR can be observed, while producers older than 65 years have a negative significant (p<.0005) correlation with percentage of LR (r=-.552). Producers between 45 and 65 years also have a negetative correlation to percentage of LR (r=-.26), but this correlation is not significant (p=.125).

Table 4.5.2. Spearman correlation of municipal percentage of producers for each age segment tested vs average percentage of NV property coverage.

			Average % of NV per property	% of producers up to 25	% of producers from 25 to 45	% of producers from 45 to 65	% of producers of more that 65
Spearman's rho	Average % of NV per property	Correlation Coefficient	1.000	.555**	.579**	-.161	-.632**
		Sig. (2-tailed)	.	.000	.000	.349	.000
		N	37	36	36	36	36

Positive significant (P< 0.01) relationships with percentage of NV (r=.555 for producers up to 25 years old and r=.579 for producers between 25 and 45) could be seen for producers up to 45 years old, with p values of <.0005. At this same level, producers of more than 65 year of age showed a significant (p<.01) negative relationship with NV, with values of r of -.632 and p of <.005. No significance effect was found for producers between 45 and 65-year-old range (table 4.5.2).

Table 4.5.3. Spearman correlation of municipal percentage of producers for each age segment tested vs average percentage compliance within each municipality.

			% of compliance per municipality	% of producers up to 25	% of producers from 25 to 45	% of producers from 45 to 65	% of producers of more that 65
Spearman's rho	% of compliance per municipality	Correlation Coefficient	1.000	.547**	.607**	-.307	-.555**
		Sig. (2-tailed)	.	.001	.000	.069	.000
		N	37	36	36	36	36

Results regarding age segments versus percentage of in-site compliance of LR quota (table 4.5.3) were similar to the previous tests regarding age segments. At p<.01 producers of up to 25 and between 25 and 45 showed positive correlation coefficients with significance with p values of .001 and <.0005 respectively (r=.547 and .607). There was a negative correlation (r=-.555) with <.0005 p value in the segment of producers of more than 65 years of age. Once again, no significant correlation was observed between producers in the 45 through 65 segment and compliance.

Table 4.5.4. Spearman correlation of Average municipal percentage of each age segment tested vs average percentage of properties with no APP per municipality.

Correlations

			% of properties with no APP	% of producers up to 25	% of producers from 25 to 45	% of producers from 45 to 65	% of producers of more that 65
Spearman's rho	% of properties with no APP	Correlation Coefficient	1.000	-.261	-.473**	-.160	.529**
		Sig. (2-tailed)	.	.123	.004	.350	.001
		N	36	36	36	36	36

The lack of presence of APP is negatively correlated (r=-.473) to the segment of producers between the ages of 25 and 45, showing significance at the p<.01 level with a p value of 0.004 (table 4.5.4). The interval of age of producers of more than 65 years of age showed a positive relationship with r value of .529 and p value of .001 (significant a p<.01).

4.6. Effect of the Level of Education

Nonparametric Spearman correlations were conducted to determine if there were significant relationships with the different the percentage of producers for each level of education with data that was available at the municipal level (n=36). In this section the percentage of each municipality was compared to the municipal mean value of LR, NV, no APP and compliance of properties. Primary education means up to the first cycle of education, secondary education is the end of second cycle, superior education is tertiary or higher education.

Table 4.6.1. Spearman correlation of municipal percentage of each education segment tested vs average percentage of LR property coverage.

			Average % of LR per property	% of producers that never attended school	% of producers with primary education	% producers with secondary education	% of producers with superior education	% of producers with master and/orPhD
Spearman's rho	Average % of LR per property	Correlation Coefficient	1.000	.292	.388*	.006	-.601**	-.238
		Sig. (2-tailed)	.	.084	.019	.973	.000	.162
		N	37	36	36	36	36	36

A significant positive correlation is seen with an r value of .388 is (shown in table 4.6.1) between producers with primary education (first cycle) and LR proportions of property, at p<.05 and p value of .019. Tertiary education shows a negative relationship (r=-.601), significant at p<0.01

with p value <.0005. No other significant relationships were observed regarding other education levels.

Table 4.6.2. Spearman correlation of municipal percentage of each education segment tested vs average percentage of NV property coverage.

			Average % of NV per property	% of producers that never attended school	% of producers with primary education	% producers with secondary education	% of producers with superior education	% of producers with master and/orPhD
Spearman's rho	Average % of NV per property	Correlation Coefficient	1.000	.240	.330*	.099	-.575**	-.253
		Sig. (2-tailed)	.	.159	.050	.564	.000	.137
		N	37	36	36	36	36	36

As detected in table 4.6.2, there is a significant positive relationship between primary education and native vegetation at p<.05, with r value of .330 and p value of .05. Negative correlation coefficient r of -.575 resulted from the analysis between producers with superior education and native vegetation presence at a p<.01 level with p value of <.0005. No further significant relationships were perceived.

Table 4.6.3. Spearman correlation of municipal percentage of each education segment tested vs average percentage compliance within each municipality.

			% of compliance per municipality	% of producers that never attended school	% of producers with primary education	% producers with secondary education	% of producers with superior education	% of producers with master and/orPhD
Spearman's rho	% of compliance per municipality	Correlation Coefficient	1.000	.297	.408*	-.004	-.627**	-.223
		Sig. (2-tailed)	.	.079	.014	.982	.000	.191
		N	37	36	36	36	36	36

A significant positive correlation of primary education and compliance was seen at the p<.05 level (r=.408 and p value of .014). At the p<.01 level, superior education showed a p value of <.0005 and r value of -.627. Significant results in the remaining levels were not observed.

Table 4.6.4. Spearman correlation of municipal percentage of each education segment tested vs average percentage of properties with no APP per municipality.

			% of properties with no APP	% of producers that never attended school	% of producers with primary education	% producers with secondary education	% of producers with superior education	% of producers with master and/orPhD
Spearman's rho	% of properties with no APP	Correlation Coefficient	1.000	-.236	-.100	-.173	.246	-.024
		Sig. (2-tailed)	.	.165	.563	.313	.149	.890
		N	36	36	36	36	36	36

No significant correlations were observed between the percentage of each level of education in each municipality and the percentage of properties within each municipality that have no APP area (table 4.6.4).

4.7. Effect of Household per Capita Income

Nonparametric Spearman correlations were performed to examine if there were significant relationships with the different the percentage of producers for each segment of per capita income with data that was available at the municipal level (n=36). In this section the percentage of each municipality was compared to the municipal mean value of LR, NV, no APP and compliance of properties. The household income levels per capita are measured in minimum salaries and segments were determined (since data was available in this format) as no income, up to 25% of minimum salary, between 25-50% of minimum salary, between 50% and 1 minimum salary, between 1 and 2 minimum salaries, between 2 and 3 minimum salaries, between 3 and 5 minimum salaries, and finally over 5 minimum salaries.

Table 4.7.1. Spearman correlation of municipal percentage of each household per capita income segment (measured in minimum salaries) tested vs average percentage of LR property coverage.

			Average % of LR per property	% of home with no income	% of homes with <25% minimum income per capita	% of homes with 25% -50% minimum income per capita	% of homes with 50% to 1 minimum income per capita	% of home with 1-2 minimum incomes per capita	% of home with 2-3 minimum incomes per capita	% of home with 3-5 minimum incomes per capita	% of home with >5 minimum incomes per capita
Spearman's rho	Average % of LR per property	Correlation Coefficient	1.000	.581**	.675**	.680**	-.603**	-.686**	-.620**	-.541**	-.381*
		Sig. (2-tailed)	.	.000	.000	.000	.000	.000	.000	.001	.022
		N	37	36	36	36	36	36	36	36	36

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.7.1 shows that there is a trend of significant relationships with LR percentage at p<.01 with p value of <.0005 up to and including the 2-3 minimum incomes per capita segment. The lower segments (no income, <25% and 25-50%) show significant positive correlations, while 0.5-1 up to and until 2-3 minimum incomes per capita show negative r values. Significant negative relationships with LR percentage were observed at the 3-5 and more than 5 incomes per capita at p<.01 (r=-.541; p=.001) and p<.05 (r=-.381; p=.022) respectively.

Table 4.7.2. Spearman correlation of municipal percentage of each household per capita income segment tested vs average percentage of NV property coverage.

			Average % of NV per property	% of home with no income	% of homes with <25% minimum income per capita	% of homes with 25% -50% minimum income per capita	% of homes with 50% to 1 minimum income per capita	% of home with 1-2 minimum incomes per capita	% of home with 2-3 minimum incomes per capita	% of home with 3-5 minimum incomes per capita	% of home with >5 minimum incomes per capita
Spearman's rho	Average % of NV per property	Correlation Coefficient	1.000	.542**	.675**	.638**	-.593**	-.646**	-.569**	-.527**	-.443**
		Sig. (2-tailed)	.	.001	.000	.000	.000	.000	.000	.001	.007
		N	37	36	36	36	36	36	36	36	36

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Similar to what was seen in the analysis between LR and income segments, a trend of significant positive relationships were observed between the lower income per capita segments at p<.01 with p values of .001 for no income (r=.542), and <.005 for the less than 25% and the 25% through the 50% segments (r=.675 and .638 respectively). At p<.01, negative relationships were detected all the remaining segments of household per capita income, with p values of <.0005 for the 0.5

to 1 minimum salary per capita, the 1 through 2 and the 2 to 3 segments (r=-.593; -.646; and -.569 respectively). The 3-5 minimum salaries per capita and more than 5 groups showed higher p values (.001 and .007) and slightly lighter correlation coefficients (-.527 and -.443).

Table 4.7.3. Spearman correlation of municipal percentage of each household per capita income segment tested vs average percentage compliance within each municipality.

			% of compliance per municipality	% of home with no income	% of homes with <25% minimum income per capita	% of homes with 25% –50% minimum income per capita	% of homes with 50% to 1 minimum income per capita	% of home with 1–2 minimum incomes per capita	% of home with 2–3 minimum incomes per capita	% of home with 3–5 minimum incomes per capita	% of home with >5 minimum incomes per capita
Spearman's rho	% of compliance per municipality	Correlation Coefficient	1.000	.608**	.693**	.693**	-.620**	-.697**	-.620**	-.546**	-.408*
		Sig. (2-tailed)	.	.000	.000	.000	.000	.000	.000	.001	.013
		N	37	36	36	36	36	36	36	36	36

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The same trend as the previous tests with household income per capita intervals could be seen in the case of compliance. The lower three segments (no income, less than 25% and 25% to 50% of minimum salary) show positive correlation (r=.608, .693 and .693 respectively) at the p<.01 level with them all having shown p values of <.0005. The following three segments (0.5 to 1, 1 to 2, and 2 to 3) also had p values of <.0005 but showed negative correlations (r=-.62, -.697 and -.62 respectively). The 3-5 minimum salaries per capita and more than 5 groups showed higher p values (.001 and .013) and slightly lighter correlation coefficients (-.546 and -.408).

Table 4.7.4. Spearman correlation of municipal percentage of each per capita household income segment tested vs average percentage of properties with no APP per municipality.

			% of properties with no APP	% of home with no income	% of homes with <25% minimum income per capita	% of homes with 25% –50% minimum income per capita	% of homes with 50% to 1 minimum income per capita	% of home with 1–2 minimum incomes per capita	% of home with 2–3 minimum incomes per capita	% of home with 3–5 minimum incomes per capita	% of home with >5 minimum incomes per capita
Spearman's rho	% of properties with no APP	Correlation Coefficient	1.000	-.370*	-.408*	-.275	.415*	.315	.237	.117	-.031
		Sig. (2-tailed)	.	.027	.014	.105	.012	.061	.164	.495	.856
		N	36	36	36	36	36	36	36	36	36

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Differing with the previous tests, the results showed that there were significant negative correlations between not having APP area and the two lowest intervals of household per capita income (no income and less than 25% of the minimum salary). The r values for the no income segment was -.37 and for less than 25% was -.408, both with significance at the p<.05 level (p values of .027 and .014 respectively). Additionally, at the p<.05 level there was a significant positive relationship in the 0.5 to 1 minimum salary segment, with r value of .415 and p value of .012 (table 4.7.4).

4.8. Results of Linear Regressions

Performing bi-variate linear regressions, the relation between percentage LR, NV, no APP and in-site compliance were tested as dependent variable with the following independent variables: association to cooperatives, reception of financial assistance, proprietorship of the land within producers, acquisition of technical information, average machinery used per property and average workers hired per property. This data was also gathered at the municipal level. Therefore, the municipal averages for each of these variables were used to make the regressions (n=36). Just like the previous correlation tests, the municipal average of percentage of LR, NV, no APP and compliance were used in this analysis. Only the statistically significant results are reported in this section.

4.8.1. Association to Cooperatives

Significant linear equations were found for association to cooperatives (F=5.107 and p value= 0.03, R^2 0.131) with regard to percentage of LR in properties. In figure 4.8.1.1, it could be seen that the relation between association to cooperatives and percentage of LR is negative, meaning that as producers become members of farmer associations, the percentage of LR tends to decrease.

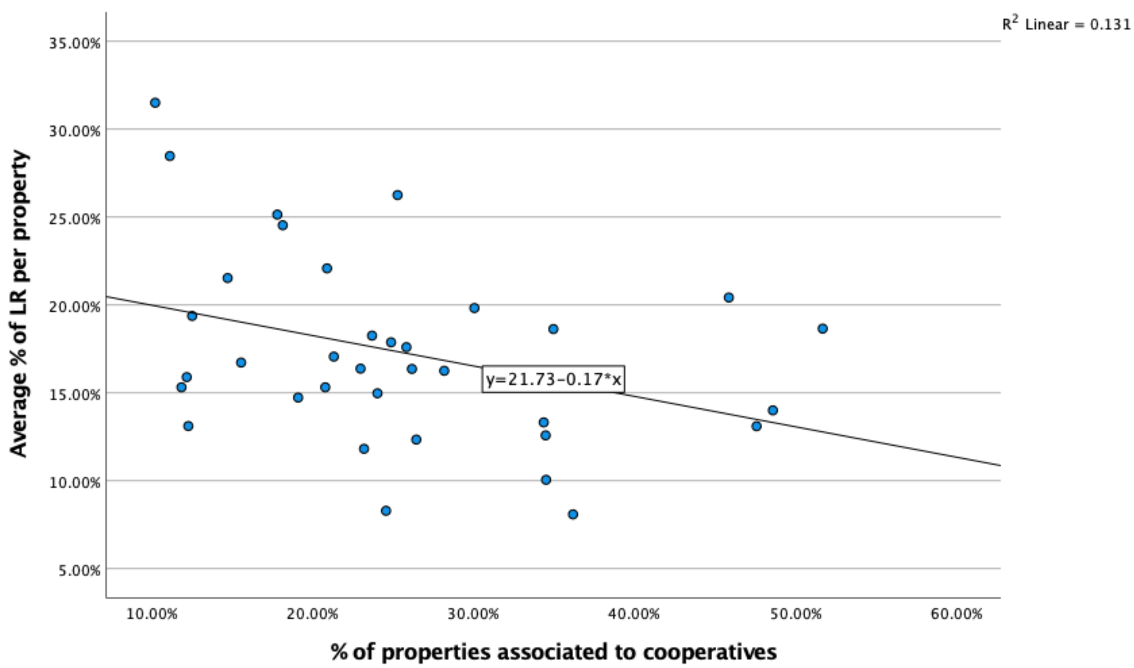

Figure 4.8.1.1. Scatterplot of linear regression of independent variable (percentage of properties with association to cooperatives) and dependent variable (average percentage of LR per property per municipality). Regression line is included with its equation.

Significant results were also found in association with cooperatives (F=4.392; p=.044; R square= .114) and NV. Similar results as LR were observed in the linear equation, with a negative slope, meaning that association to cooperative have a negative effect on NV as well (figure 4.8.1.2).

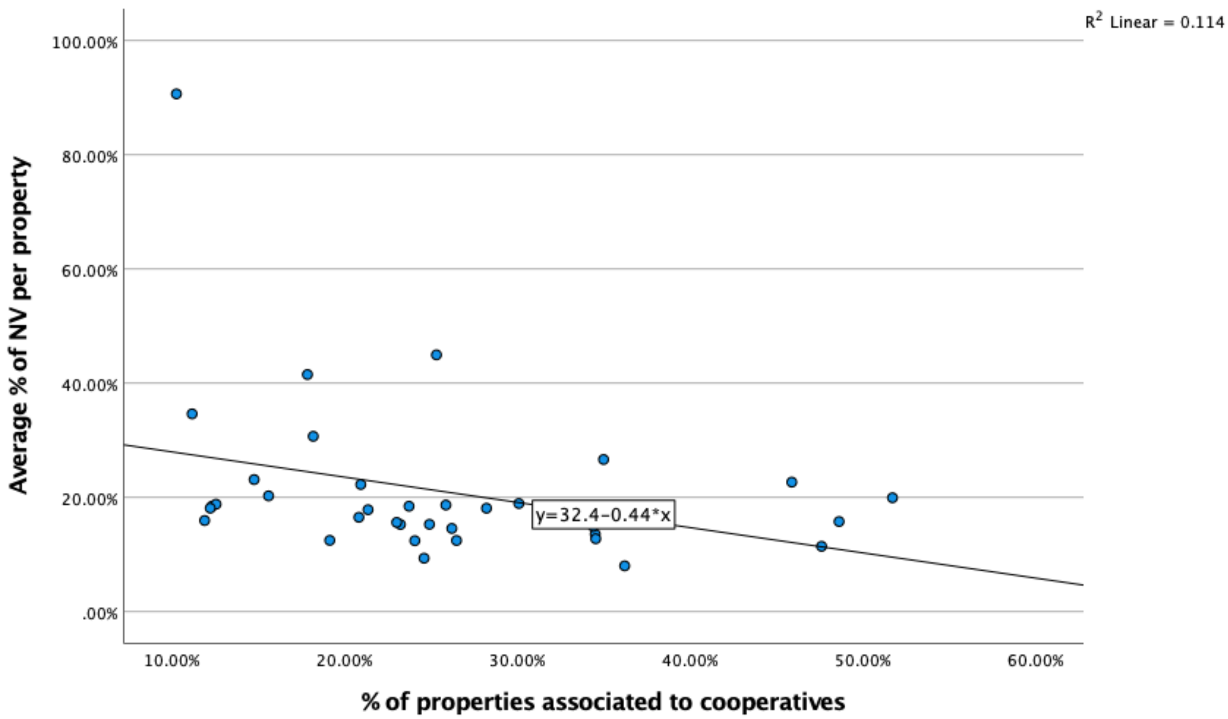

Figure 4.8.1.2. Scatterplot of linear regression of independent variable (percentage of properties with association to cooperatives) and dependent variable (average percentage of NV per property per municipality). Regression line is included with its equation.

The results also showed significant regression equations when examining association with cooperatives (F=4.191, p=.048; R^2 =.11) and compliance to LR, with a negative relationship (figure 4.8.1.3).

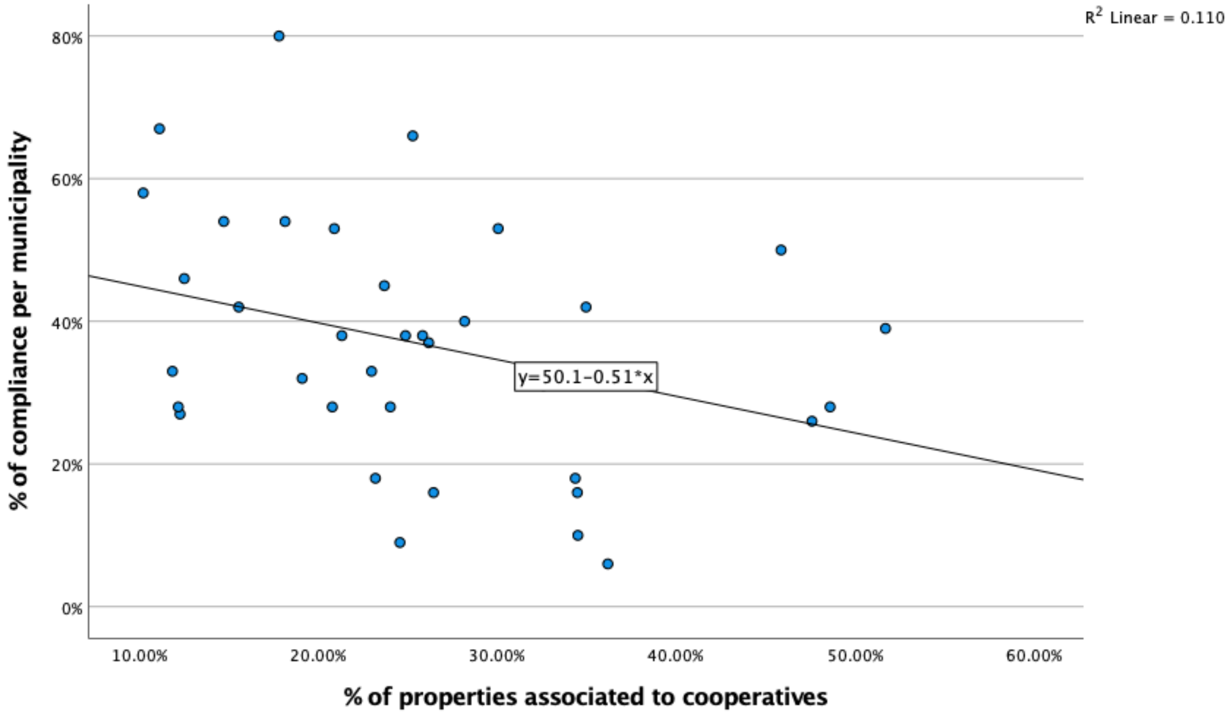

Figure 4.8.1.3. Scatterplot of linear regression of independent variable (percentage of properties with association to cooperatives) and dependent variable (average percentage of in-site compliance of LR per property per municipality). Regression line is included with its equation.

4.8.2. Reception of Financial Assistance

Reception of financial assistance showed significant relationship with percentage of LRs in properties (F=8.284 and p=.007, R2 =0.196), showing negative relationships (Figure 4.8.2.1).

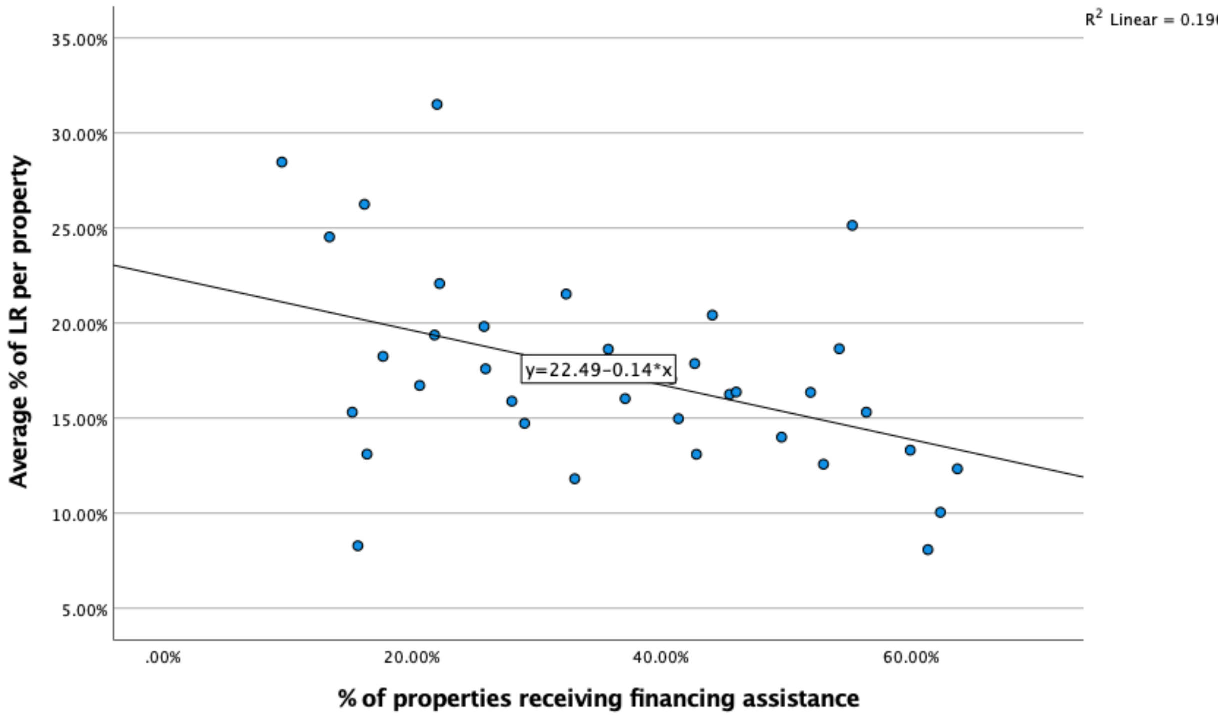

Figure 4.8.2.1. Scatterplot of linear regression of independent variable (percentage of properties that receive financial assistance) and dependent variable (average percentage of NV percentage per property per municipality). Regression line is included with its equation.

A similar relationship (F=7.783, p=.009 and R2 =0.186) was found with regard to compliance to LR, with a negative slope (figure 4.8.2.2).

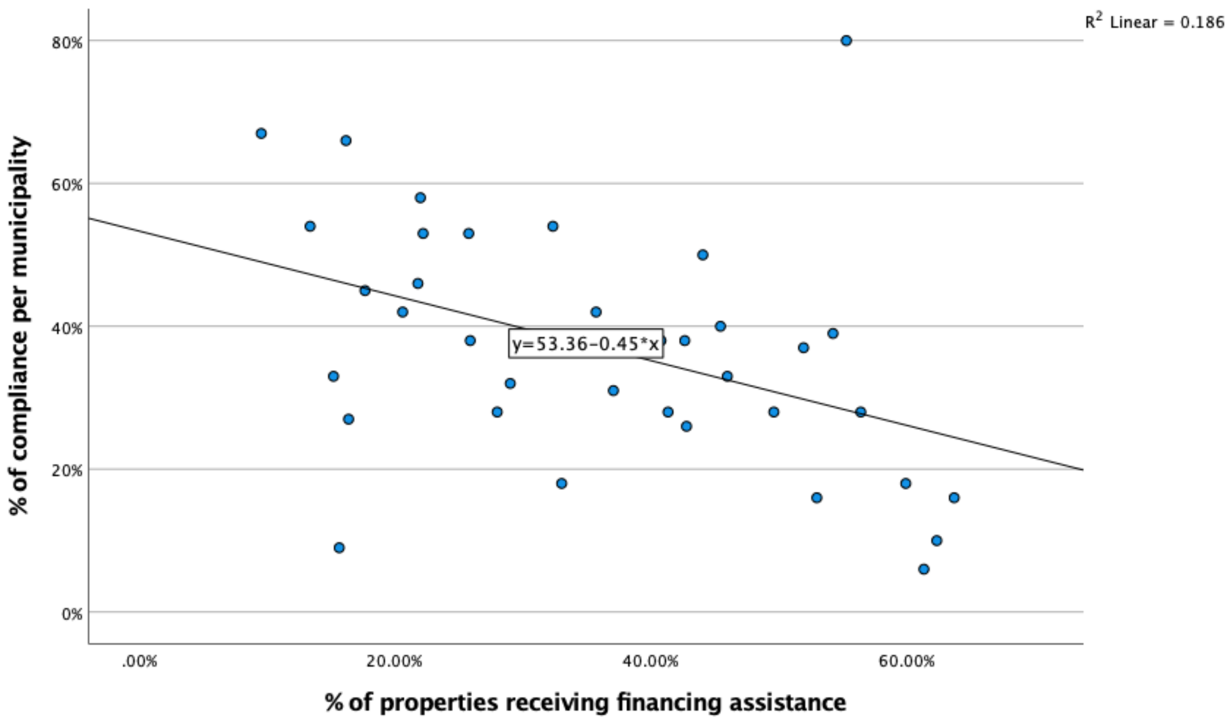

Figure 4.8.2.1. Scatterplot of linear regression of independent variable (percentage of properties that receive financial assistance) and dependent variable (average percentage of in-site compliance of LR per property per municipality). Regression line is included with its equation.

4.8.3. Average Machines per property

Average machines used per property showed significant relationship with LR ($F=5.702$, $p=0.023$, $R2= 0.144$), NV ($F=6.518$; $p=.015$; $R2$ of .161) and compliance to LR ($F=4.363$; $p=.044$; R square of .088). These also were observed to be negative relationships (figures 4.8.3.1; 4.8.3.2; 4.8.3.3).

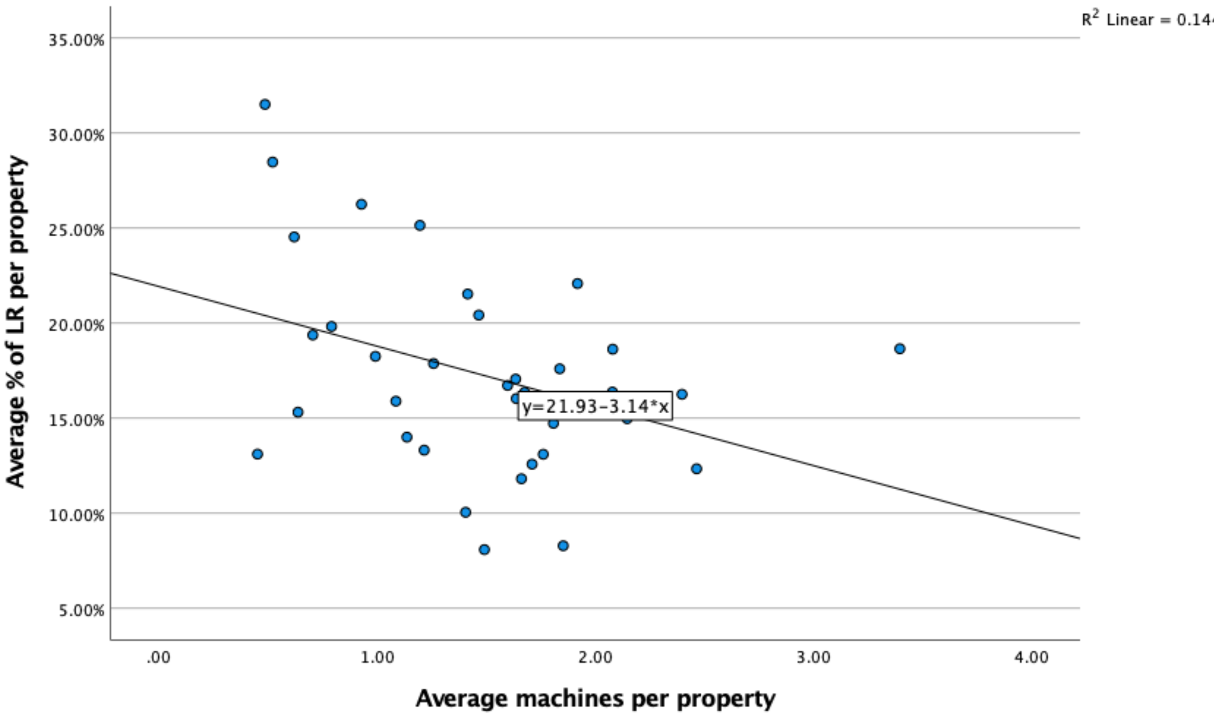

Figure 4.8.3.1. Scatterplot of linear regression of independent variable (average number of machines used per property) and dependent variable (average percentage of LR percentage per property per municipality). Regression line is included with its equation.

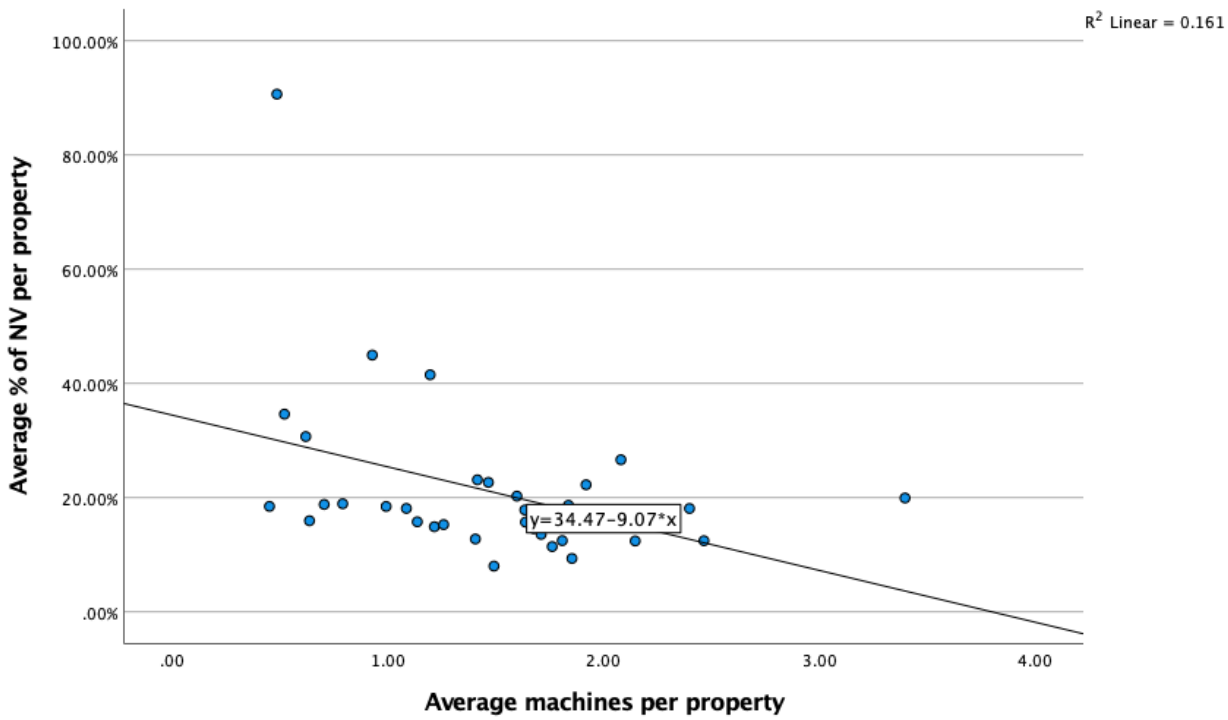

Figure 4.8.3.2. Scatterplot of linear regression of independent variable (average number of machines used per property) and dependent variable (average percentage of NV percentage per property per municipality). Regression line is included with its equation.

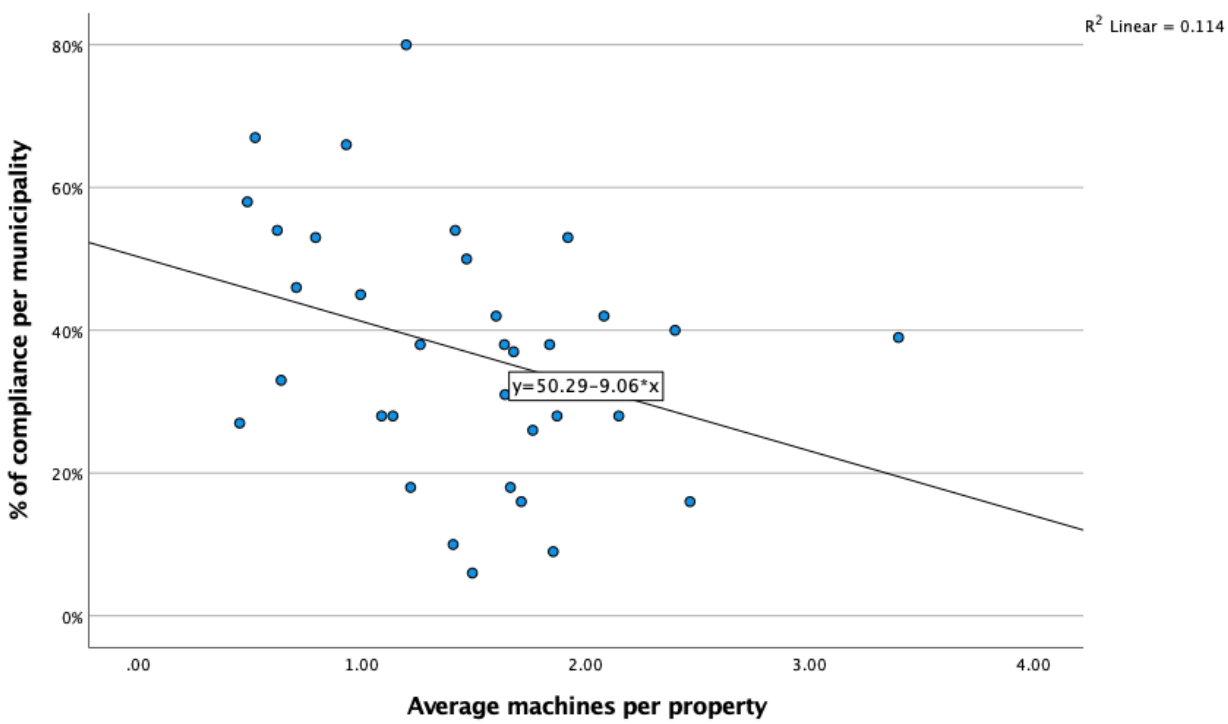

Figure 4.8.3.2. Scatterplot of linear regression of independent variable (average number of machines used per property) and dependent variable (average percentage of LR in-site compliance per property per municipality). Regression line is included with its equation.

No significant results were gathered between the previously listed variables and the absence of APP, and no significant relationships were found between the rest of the variables (technical information acquisition, proprietorship of land, average workers hired per property (appendix 1).

4.9 Correlations Between Variables

Correlations between variables were conducted to attempt to identify possible positive and negative interactions that these might have. Spearman correlations were conducted between age segments and education levels, as well as analyses between association to cooperatives, reception of financial assistance, proprietorship, acquisition of technical information, average machinery used in properties, and average workers hired in properties.

The municipal percentage of age of producers showed significant ($p<.01$) negative correlations coefficients with the segment of up to 25 years of age ($r=-.483$; $p=.003$) and the 45 to 65 age segment ($r=-.507$; $p=.002$) with the percentage of producers with tertiary education. The age segment of more than 65 showed a significant ($p<.01$) positive relationship, with r value of .621 and $p<.0005$ (Appendix 2a).

Regarding association with cooperatives, it showed significant ($p<.01$) positive correlations with reception of financial assistance ($r=.62$; $p<.0005$) and average machines per property ($r=.457$; $p=.005$). Receiving financial assistance also showed positive significant ($p<.01$) relationships with average machinery used per property ($r=.498$; $p=.002$). Average machinery used per property showed significant ($p<.01$) positive relationship with average workers hired per property ($r=.668$; $p<.0005$) (appendix 2b).

Property size and household per capita income segments were also analyzed, indicating significant positive relationships with higher income segments (between 3 and 5 minimum salaries ($r=.364$ and $p=.029$) and more than 5 minimum salaries per capita ($r=.44$; $p=.007$)), suggesting that the property area grows as the per capita household income increases. Significant ($p<.01$) negative correlation were found with the income segment of 50% to 1 minimum salary per capita ($r=-.428$) (appendix 2c).

5. Discussion

The focus of this study was to analyze and describe the interactions and relationships between intrinsic and contextual characteristics of farmers, producer and/or landowners, and the present status of native vegetation (NV) of the Brazilian Atlantic Forest in the Alto Paranapanema watershed region. This took into account the current extent of the NV in the private properties, as well as legal instruments for nature conservation and restoration (Permanent Preservation Areas (APP) and Legal Reserves (LR)). The following sections explain the effects that each variable had on the previously mentioned protection instruments. The results obtained aimed to contribute to the understanding of geographic, sociodemographic, legal, and economic aspects with regard to the possible association between these and the current state of land use for the recovery of the BAF.

5.1 Effects of property size

The size of properties showed that it had influence on the presence of native vegetation. This was observable in the results, which indicated that larger properties had significant differences with respect to the smaller ones and these tended to have higher percentages of NV and LR, as well as visibly much lower cases of no APP on property (figure 4.4.1). Consequently, higher rates of in-site compliance of LR were detected as properties grew in size. Properties of larger size are often associated with higher efficiency of production (Rios and Shively, 2005) and with lower costs of production due to reduced fixed costs per hectare (Carter, 1984), making it easier for the reduction of input costs per area. This frees up space and resources for the possibility to facilitate more area for environmental conservation within farms. This works inversely for smaller properties, where the economic conditions make smallholders more inclined to use a greater portion of their available land, in many cases due to matters of livelihood (Leite et al, 2020). The results corroborate what previous literature indicated, with larger properties showing higher amounts of coverage of NV, LR and in-site compliance.

It can also be argued that the elevated amount of smaller properties with no reported APP in CAR is mostly due to the fact that APP is not an instrument to comply to by a specific quota of the property, but mandatory to specific areas of certain geographic characteristics (Brazil, 2012). Small and very small properties compose around 84.9% of the properties analyzed for APP (almost 55% for properties less than 1 fiscal module, and almost 30% for properties between 1 and 4 fiscal modules). This could mean that even though many small properties are remitted to areas subject to APP such as steep slopes and high altitudes, around 20.8% (28.6% for very small and 6.7% for small) are located in places with no APP, which is a substantially higher number than the 2.5% of medium and 0.7% of large properties that do not present APP. This difference could be since the smaller properties have a smaller chance to include land with these characteristics, it seems like a reasonable hypothesis for the elevated absence of APP, especially in the size segment of less than 1 fiscal module.

It is worth clarifying that this does not mean that smallholder farms are contributing more to deforestation. In fact, wealth of farmers and size of property has been shown to be positively correlated to deforestation (Pacheco, 2009). This is also reflected in the contribution to the deficit of LR and APP, where Guidiotti et al. (2017) showed that for the state of São Paulo, properties with up to 4 fiscal modules of area made up 20% of this deficit while constituting around 80% of the total properties in the state.

5.2 Effect of Age

The age of farmers analysis ended up showing that the municipalities that had higher percentages of properties of relatively young farmers (up to 45 years old) tended to have more LR, NV and compliance, as well as less properties with no APP reported. The properties of producers older than 65 showed an inclination towards having less NV and LR and more with no APP within their land, and a negative interaction with compliance to LR. There are behavioral studies that suggest that age can be an important factor when engaging in environmental schemes. This could be explained by differences in farming philosophy, where younger farmers were more likely to create more or new habitats for wildlife in their farms, whereas older farmers were found more likely to privilege pragmatic reasons such as income (Wilson, 1997). This was observable even in financially unrewarding but environmentally relevant programs, where younger farmers had an increased interest in participating due to reasons such as conservation and nostalgia (Wilson, 1996b). The results were obtained with average municipal data, so these do not actually attend to the individual property level. These results aim to suggest tendencies using this municipal information but to achieve more trustworthy analyses, these must be further explored on a smaller scale.

5.3 Effect of Education Level

The literature indicates that producers with higher level of education tend to be more prone to the adoption of environmentally sound practices, whereas farmers with lower completed levels of formal education were found to be less likely to engage in environmental schemes (Wilson, 2006b). The results of this study indicated contradictory results to what has been found in some previous research, finding significant positive relationships between percentage of producers within each municipality with primary school level of education and the presence of NV, LR and compliance to LR quota. Furthermore, the percentage of producers with tertiary education showed the opposite, with negative relationships with compliance, NV and LR. Previously, De Souza Filho et al. (1999) did try to predict the adoption of sustainable practices of farmers through different models, with a sample of similar conditions regarding education (majority with up to primary school education). Their results suggest that education was not a determining factor when discriminating between adopters from non-adopters of sustainable practices in agriculture.

5.4 Effect of Household per capita Income

Household per capita income takes into account not just producers themselves, but their families as well, considering family size within the calculation of income. The results showed significant correlations for LR, NV and compliance, presenting positive interactions with the lower income segments (all segments up to 50% minimum salary per capita). The opposite occurred as income grew higher, starting as 50% and up to more than 5 minimum salaries per capita, showing negative interactions with NV, LR and compliance. Since larger farms are positively correlated to income (appendix 2c), this is contradictory with the spatial data used for the analyses of size and NV, LR and compliance, and might be due to the biases that arise when using data at the municipal and not the property scale. Nevertheless, some of these results can be explained in literature, as mentioned in Pacheco (2009), wealth is identified as a positive correlate with regard to deforestation. This is mentioned as product of the land use that they apply, where cattle farming tends to be one of the main reasons for elevated income and deforestation. Since, on average, cattle farming demands more area than temporary and annual crops: the higher the income of producers, the more likely that they have a higher proportion of cattle within their farms (Caviglia-Harris, 2005). This might lead to more area that is needed to be allocated towards pastureland, and hence the positive correlation with deforestation. Lower income producers face different situations, where the lack of resources to expand cattle ranches to increase income mean that they resort to other alternatives and even have to rely on subsistence farming, decreasing their demand for land.

5.5 Effect of Association to Cooperatives

It has been argued that cooperatives tend to have a positive effect on engaging with restoration and environmental schemes (De Souza Fliho et al. 1998), where less conventional means to institutionally cooperate and share information played an important role in the adoption of sustainable ways of farming. Additionally, these associations can play a role in funneling and grouping efforts to also look out for livelihoods and asymmetries of power, covering for multiple aspects that producers, especially smallholders, have issues with (Ball et al. 2014).

Cooperatives are seen as contributors to environmental stewardship and livelihood improvement, mainly through education and training that they provide, nevertheless, peer-to-peer relationships through farmer associations such as cooperatives were found to have negative influence with regard to NV, LR and compliance. A possible explanation could be that cooperatives often have the capacity to offer better business opportunities and conditions for members, with better prices for their products as well as more buyers. They can also provide low-cost input availability such as fertilizer and pesticides (Mojo et al. 2015). This can lead to the extension of production under these favorable economic conditions, and therefore generate more resource and land use.

5.6 Effect of Reception of Financial Assistance

Financial assistance in this case involves all schemes available, including social programs like PRONAF, NGO assistance, private companies, payments for ecosystem services (PES), among others. These kinds of programs have different objectives and emphases. PES seek to help the recovery of biodiversity and landscape while at the same time include social and economic benefits. By procuring the necessary actions to be partaken by farmers and landowners, an ecological service can be conserved and/or recovered (Ferraro and Kiss, 2002).

NGOs, private companies, banks, government institutions also provide vast availability of funds for economic assistance, with different purposes depending on their own agendas. In the results, reception of financial assistance had a negative correlation with LR and compliance. This could be explained largely because programs of subsidies, grants and credits are more focused on productivity with lower number of these actually focused on sustainability or reforestation. PES while presenting advancements, they are moderate benefits and reductions of negative impacts (Börner et al. 2017), it appears to not be enough to offset the negative effect of other financing opportunities.

5.7 Effect of Machinery

The negative relationship between average machinery used per property and LR, NV and compliance can be explained due to the fact that higher amounts of machinery indicate higher intensity of agriculture (Reid, 2011). Agriculture intensity decreases when properties are sustainably managed (Amacher et al. 2004). As machinery use increases, this then can be considered an indicator of more intense and extensive use of the property, leading to the decrease in native vegetation coverage. This coincides with the positive correlation detected between average amount of machinery used per municipality and average amount of workers hired per property by municipality, were increase in number of workers can also be an indicator of higher intensity of farming (Shively & Pagiola, 2004).

The correlations found between variable s may be able to explain some of the findings in the independent analyses performed. Positive correlations between association with cooperatives, reception of financial assistance and average machinery used may illustrate a possible synergy between these variables that led to the negative relationships that these had with LR, NV and compliance of LR.

5.8 Adapted Onion Model

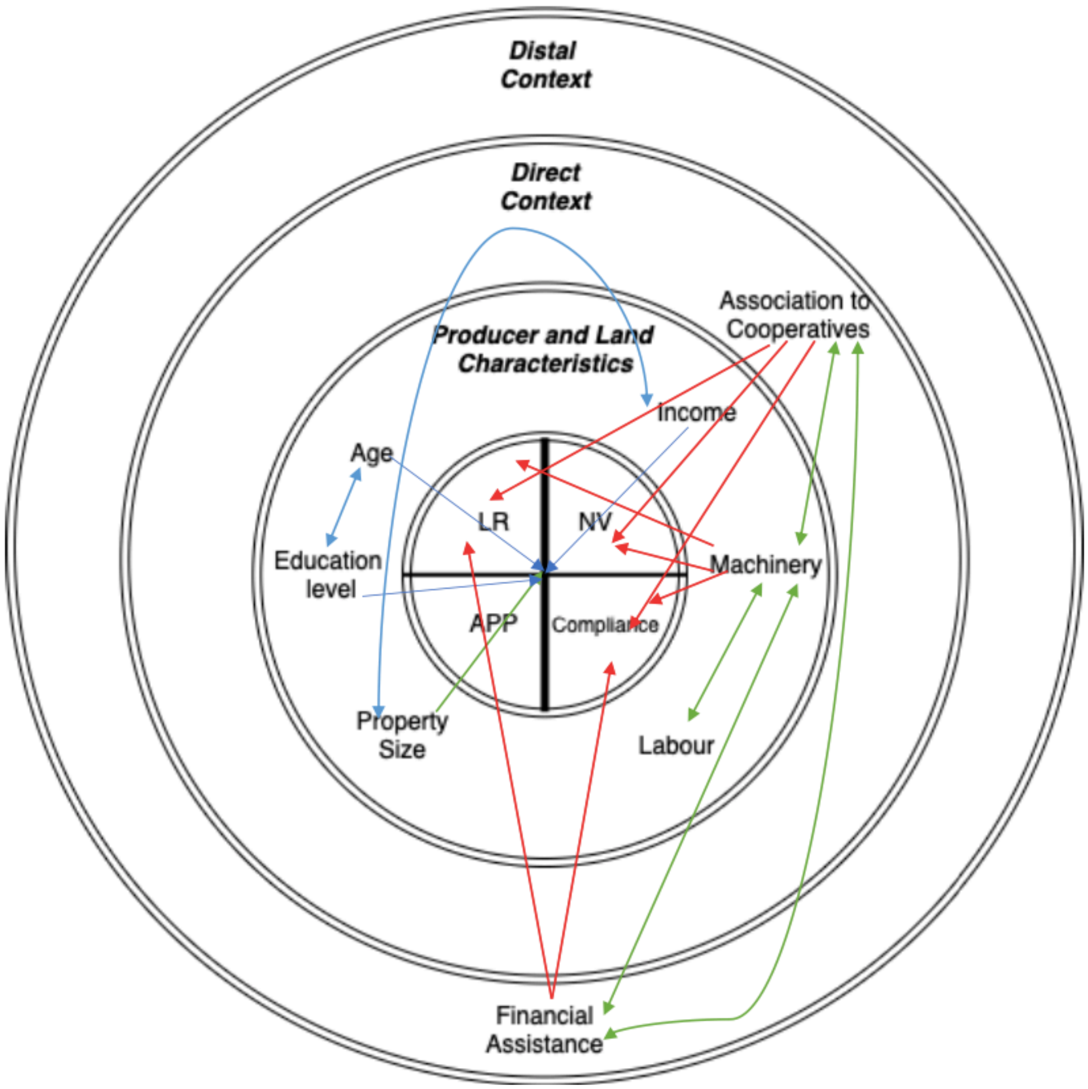

Figure 5.8.1. Adapted Onion Model. Adapted from the framework proposed by Schoonhoven and Ruhnaar (2018). In the center of the figure, the focus of the analysis of this thesis (APP, LR, NV and compliance) interact with the surrounding layers (contexts) depending on the variable in question. The arrows that point to the intersect in the center means that they interact with all 4 of the variables. At the same time, the correlations between some variables can also be observed. Besides looking at connections between factors, the nature of the interaction is also visible (Green: is positive relationship; Red: Negative relationship; Blue: Depending on the segments analyzed, the relationships can either be negative or positive). Source: Author.

The onion model (figure 5.8.1) illustrates the results of the analyses done in this thesis. These results were in some cases contradictory with previous literature (education, income, financial assistance, associations to cooperatives). As it can be observed in the model, variables that display negative relationships with financial assistance, use of machinery and association to cooperatives are, at the same time showing positive correlations between each other, suggesting that these could be aspects to consider (as well as labor) when assessing native vegetation, and legal schemes for forest and landscape restoration. The more intrinsic characteristics that were taken into account in this analysis (age, education, income, property size), albeit mixed (negative and positive).

Table 5.8.1. Listing the relationships between the different independent variables (row) and LR, NV, APP and compliance. Blank spaces are non-significant relationships. (+) positive relationship; (+/-) both positive and negative depending on the ordinal segment analyzed (Data was ranked in categories); (-) negative relationship. Interactions between independent variables not listed.

Effect of:	LR	NV	APP	Compliance
Property Size	+	+	+	+
Age	+/-	+/-	+/-	+/-
Educational level	+/-	+/-		+/-
Household income per capita	+/-	+/-	+/-	+/-
Association to cooperatives	-	-		-
Reception of financial assistance	-			-
Land propietorship				
Technical information acquisition				
Average machinery	-	-		-
Average workers hired (labor)				

5.9 Limitations

There were limitations in the processing of data. First, areas in the geographic analysis were repeated, with ArcGIS accounting for these twice and forcing the removal of some data to correct for this problem. This was due partly to overlapping issues of properties and also the extension of certain areas like LR, NV and APP that extended past the limits of one property and were present in more, with the program accounting for these twice. Due to this also some problems with the data arose, with the appearance of APP areas that corresponded to a certain property, but that was bigger than the property itself, making difficult to account for and therefore were cleaned from the database. These errors are currently analyzed in another project related to the BAF in the watershed. Some other problems surged when in certain municipalities (especially Riberão Grande), very high amounts of property entries in the CAR system were canceled or rejected, thus affecting the amount of data available and creating uncertainty in the data used. It is worth mentioning that, as for the results of the analyses with the data that was available at the municipal scale, these results are based on the municipal data and not on specific smaller-scale data, and therefore are more meant to show certain tendencies, but not for conclusive results for farmers and producers. The compliance factor that was analyzed also face some limitations, since there are mechanisms to comply to legal requirements that do not take into account the presence of native vegetation on each property, this was solved by specifying that compliance was only considered within each property.

5.10 Conclusions

This thesis set out to explore and understand the different factors and variables that, through different contexts affected the presence of native vegetation of the Brazilian Atlantic Forest, and more specifically the Alto Paranapanema watershed region. To analyze native vegetation, instruments presented in Brazilian legislation were used, namely Permanent Protection Areas, Legal Reserves, and native vegetation (which may or may not include there two previously mentioned instruments). In addition, compliance to legal reserve quota was also analyzed to visualize the current status of native vegetation with regard to legal requirements. With this in mind, the research questions were formulated as followed:

- ➔ *Do characteristics of the landowners and producers, their land and their context affect the presence of the protection units of Permanent Preservation Areas (APP) and Legal Reserves (LR), native vegetation (NV) and compliance to LR quota within their properties?*
    - o *If so, which characteristics of producers and land affect LR, APP, NV and compliance?*
    - o *How are these relationships characterized?*

To address these questions, the onion model proposed by Schoonhoven and Ruhnaar (2018) was adapted for the purposes of this thesis, variating from a qualitative analysis, to a quantitative one. Data collection consisted of secondary sources like CAR, IBGE and SIDRA and statistical analyses were performed to gather the results.

Regarding the first two questions, it is concluded that there are relationships between characteristics intrinsic to producers and their land that affect the degree of presence of LR, APP, NV and compliance in-site. More specifically, property size was found to have an effect on the centerpieces of the framework and thesis, as well as education level, age, household per capita income, association to cooperatives, reception of financial assistance, and machinery used in the properties. The second sub question, for the description of the characteristics of the relationships showed that size has a positive relationship with the protection instruments, while age, educational level, and income delivered mixed correlations. Counterintuitively, association to cooperatives and reception of financial assistance had negative relationships as well. Finally, machinery used (on average per property by municipality) also resulted in negative relationships.

As mentioned before, when looking over the final results, some positive correlations between independent variables were observed, where it appears that some of these can enhance or influence the relationship that other factors have on the native vegetation in general. These suggest that it could be advisable to consider these relationships when planning multi-stakeholder forest and landscape restoration schemes and efforts, especially taking into account cooperatives and other farmer organizations, as well as the improvement of technical information acquisition, since these showed neutral and negative relationships with native vegetation.

5.11 Recommendations for future research

For future research, it would be advisable to include additional variables, such as time of residency of the farmer, land use (pasture, cropland, silviculture, etc.), household size and tenure security, since these factors have proven relevant in other literature. Additionally, it is advised to gather the information of farmers through more direct sources, such as interviews or surveys, so as to acquire more trustworthy data and avoid some of the limitation that were encountered.

6. Acknowledgements

I would like to thank Dr. René Verburg of the Faculty of Geosciences and the Copernicus Institute of Sustainable Development, my supervisor during this thesis, for his guidance and constant disposal to help, especially through this last, very uncertain year.

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8. Appendix

Average percentage of Legal Reserve in Property by Fiscal Module Segment

% of Legal Reserve in Property

Fiscal Module Segment	Mean	N	Std. Deviation
<1	18.8175%	4163	14.42645%
1-4	17.8815%	3665	13.88725%
4-15	18.0799%	1865	13.14767%
>15	19.5409%	955	12.02238%

Average percentage of Native Vegetation in Property by Fiscal Module

Percentage of native vegetation in property

Segment size in fiscal modules	Mean	N	Std. Deviation
<1	21.9086%	8902	85.63467%
1-4	21.8620%	5802	223.18871%
4-15	19.9217%	2293	18.97566%
>15	24.4166%	957	22.49669%

1. **Linear regressions**
    a. Independent variable: Association to cooperatives
        i) Versus percentage of legal reserve:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.361[a]	.131	.105	4.98285%

a. Predictors: (Constant), % of properties associated to cooperatives

b. Dependent Variable: Average % of LR per property

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	126.808	1	126.808	5.107	.030[b]
	Residual	844.178	34	24.829		
	Total	970.986	35			

a. Dependent Variable: Average % of LR per property

b. Predictors: (Constant), % of properties associated to cooperatives

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	21.726	2.138		10.163	.000	17.381	26.070
	% of properties associated to cooperatives	-.173	.077	-.361	-2.260	.030	-.329	-.017

a. Dependent Variable: Average % of LR per property

ii) Versus percentage of native vegetation

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.338[a]	.114	.088	13.72790%

a. Predictors: (Constant), % of properties associated to cooperatives

b. Dependent Variable: Average % of NV per property

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	827.754	1	827.754	4.392	.044[b]
	Residual	6407.476	34	188.455		
	Total	7235.230	35			

a. Dependent Variable: Average % of NV per property

b. Predictors: (Constant), % of properties associated to cooperatives

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	32.399	5.890		5.501	.000	20.430	44.368
	% of properties associated to cooperatives	-.442	.211	-.338	-2.096	.044	-.871	-.013

a. Dependent Variable: Average % of NV per property

iii) Versus compliance of LR quota in-site

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.331[a]	.110	.084	16.356%

a. Predictors: (Constant), % of properties associated to cooperatives

b. Dependent Variable: % of compliance per municipality

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1121.082	1	1121.082	4.191	.048[b]
	Residual	9095.224	34	267.507		
	Total	10216.306	35			

a. Dependent Variable: % of compliance per municipality

b. Predictors: (Constant), % of properties associated to cooperatives

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	50.097	7.017		7.140	.000	35.837	64.357
	% of properties associated to cooperatives	-.514	.251	-.331	-2.047	.048	-1.025	-.004

a. Dependent Variable: % of compliance per municipality

iv) Versus average properties with no APP per municipality

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.085[a]	.007	-.022	6.10498%

a. Predictors: (Constant), % of properties associated to cooperatives

b. Dependent Variable: % of properties with no APP

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.298	1	9.298	.249	.621[b]
	Residual	1267.207	34	37.271		
	Total	1276.505	35			

a. Dependent Variable: % of properties with no APP

b. Predictors: (Constant), % of properties associated to cooperatives

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	17.815	2.619		6.802	.000	12.493	23.138
	% of properties associated to cooperatives	.047	.094	.085	.499	.621	-.144	.237

a. Dependent Variable: % of properties with no APP

b. Independent variable: reception of financial assistance

i) Versus percentage of legal reserve:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.443[a]	.196	.172	4.79203%

a. Predictors: (Constant), % of properties receiving financing assistance

b. Dependent Variable: Average % of LR per property

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	190.226	1	190.226	8.284	.007[b]
	Residual	780.760	34	22.964		
	Total	970.986	35			

a. Dependent Variable: Average % of LR per property

b. Predictors: (Constant), % of properties receiving financing assistance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	22.491	1.981		11.355	.000	18.466	26.517
	% of properties receiving financing assistance	-.143	.050	-.443	-2.878	.007	-.244	-.042

a. Dependent Variable: Average % of LR per property

ii) Versus percentage of native vegetation:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.319[a]	.102	.076	13.82400%

a. Predictors: (Constant), % of properties receiving financing assistance

b. Dependent Variable: Average % of NV per property

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	737.727	1	737.727	3.860	.058[b]
	Residual	6497.503	34	191.103		
	Total	7235.230	35			

a. Dependent Variable: Average % of NV per property

b. Predictors: (Constant), % of properties receiving financing assistance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	31.299	5.714		5.477	.000	19.687	42.912
	% of properties receiving financing assistance	-.282	.144	-.319	-1.965	.058	-.574	.010

a. Dependent Variable: Average % of NV per property

iii) Versus percentage of compliance to LR quota:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.432[a]	.186	.162	15.637%

a. Predictors: (Constant), % of properties receiving financing assistance

b. Dependent Variable: % of compliance per municipality

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1903.015	1	1903.015	7.783	.009[b]
	Residual	8313.291	34	244.509		
	Total	10216.306	35			

a. Dependent Variable: % of compliance per municipality

b. Predictors: (Constant), % of properties receiving financing assistance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	53.362	6.463		8.256	.000	40.227	66.498
	% of properties receiving financing assistance	-.453	.162	-.432	-2.790	.009	-.783	-.123

a. Dependent Variable: % of compliance per municipality

iv) Versus percentage of properties with no APP:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.140[a]	.020	-.009	6.06659%

a. Predictors: (Constant), % of properties receiving financing assistance

b. Dependent Variable: % of properties with no APP

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25.185	1	25.185	.684	.414[b]
	Residual	1251.320	34	36.804		
	Total	1276.505	35			

a. Dependent Variable: % of properties with no APP

b. Predictors: (Constant), % of properties receiving financing assistance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	17.122	2.508		6.828	.000	12.026	22.219
	% of properties receiving financing assistance	.052	.063	.140	.827	.414	-.076	.180

a. Dependent Variable: % of properties with no APP

c. Independent variable: Land proprietors within producers

i) Versus percentage of legal reserve:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.126[a]	.016	-.013	5.30117%

a. Predictors: (Constant), % of proprietors within producers

b. Dependent Variable: Average % of LR per property

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15.503	1	15.503	.552	.463[b]
	Residual	955.483	34	28.102		
	Total	970.986	35			

a. Dependent Variable: Average % of LR per property

b. Predictors: (Constant), % of proprietors within producers

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	10.641	8.975		1.186	.244	-7.598	28.879
	% of proprietors within producers	.080	.108	.126	.743	.463	-.139	.300

a. Dependent Variable: Average % of LR per property

ii) Versus percentage of native vegetation:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.167[a]	.028	-.001	14.38296%

a. Predictors: (Constant), % of proprietors within producers

b. Dependent Variable: Average % of NV per property

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	201.662	1	201.662	.975	.330[b]
	Residual	7033.568	34	206.870		
	Total	7235.230	35			

a. Dependent Variable: Average % of NV per property

b. Predictors: (Constant), % of proprietors within producers

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-2.899	24.350		-.119	.906	-52.383	46.585
	% of proprietors within producers	.290	.293	.167	.987	.330	-.306	.886

a. Dependent Variable: Average % of NV per property

iii) Versus percentage of compliance to LR quota:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.188[a]	.035	.007	17.026%

a. Predictors: (Constant), % of proprietors within producers

b. Dependent Variable: % of compliance per municipality

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	360.802	1	360.802	1.245	.272[b]
	Residual	9855.504	34	289.868		
	Total	10216.306	35			

a. Dependent Variable: % of compliance per municipality

b. Predictors: (Constant), % of proprietors within producers

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	4.860	28.823		.169	.867	-53.715	63.436
	% of proprietors within producers	.387	.347	.188	1.116	.272	-.318	1.093

a. Dependent Variable: % of compliance per municipality

iv) Versus percentage of properties with no APP:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.116[a]	.013	-.016	6.08623%

a. Predictors: (Constant), % of proprietors within producers

b. Dependent Variable: % of properties with no APP

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.072	1	17.072	.461	.502[b]
	Residual	1259.433	34	37.042		
	Total	1276.505	35			

a. Dependent Variable: % of properties with no APP

b. Predictors: (Constant), % of proprietors within producers

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	12.060	10.304		1.170	.250	-8.880	32.999
	% of proprietors within producers	.084	.124	.116	.679	.502	-.168	.337

a. Dependent Variable: % of properties with no APP

d. Independent variable: reception of technical information

i) Versus percentage of legal reserve:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.056[a]	.003	-.026	5.33563%

a. Predictors: (Constant), % of proprietors receiving technical information

b. Dependent Variable: Average % of LR per property

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.043	1	3.043	.107	.746[b]
	Residual	967.943	34	28.469		
	Total	970.986	35			

a. Dependent Variable: Average % of LR per property

b. Predictors: (Constant), % of proprietors receiving technical information

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	19.688	7.435		2.648	.012	4.578	34.797
	% of proprietors receiving technical information	-.028	.085	-.056	-.327	.746	-.200	.144

a. Dependent Variable: Average % of LR per property

ii) Versus percentage of native vegetation:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.031[a]	.001	-.028	14.58080%

a. Predictors: (Constant), % of proprietors receiving technical information

b. Dependent Variable: Average % of NV per property

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.839	1	6.839	.032	.859[b]
	Residual	7228.391	34	212.600		
	Total	7235.230	35			

a. Dependent Variable: Average % of NV per property

b. Predictors: (Constant), % of proprietors receiving technical information

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	24.643	20.318		1.213	.234	-16.647	65.933
	% of proprietors receiving technical information	-.041	.231	-.031	-.179	.859	-.512	.429

a. Dependent Variable: Average % of NV per property

iii) Versus percentage of compliance to LR quota:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.065[a]	.004	-.025	17.298%

a. Predictors: (Constant), % of proprietors receiving technical information

b. Dependent Variable: % of compliance per municipality

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	43.042	1	43.042	.144	.707[b]
	Residual	10173.264	34	299.214		
	Total	10216.306	35			

a. Dependent Variable: % of compliance per municipality

b. Predictors: (Constant), % of proprietors receiving technical information

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	45.937	24.104		1.906	.065	-3.047	94.922
	% of proprietors receiving technical information	-.104	.274	-.065	-.379	.707	-.662	.454

a. Dependent Variable: % of compliance per municipality

iv) Versus percentage of properties with no APP:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.087[a]	.007	-.022	6.10436%

a. Predictors: (Constant), % of proprietors receiving technical information

b. Dependent Variable: % of properties with no APP

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.555	1	9.555	.256	.616[b]
	Residual	1266.950	34	37.263		
	Total	1276.505	35			

a. Dependent Variable: % of properties with no APP

b. Predictors: (Constant), % of proprietors receiving technical information

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	23.297	8.506		2.739	.010	6.011	40.584
	% of proprietors receiving technical information	-.049	.097	-.087	-.506	.616	-.246	.148

a. Dependent Variable: % of properties with no APP

e. Independent variable: Average machines per property

i) Versus percentage of legal reserve:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.379[a]	.144	.118	4.94536%

a. Predictors: (Constant), Average machines per property

b. Dependent Variable: Average % of LR per property

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	139.463	1	139.463	5.702	.023[b]
	Residual	831.523	34	24.457		
	Total	970.986	35			

a. Dependent Variable: Average % of LR per property

b. Predictors: (Constant), Average machines per property

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	21.927	2.116		10.364	.000	17.628	26.226
	Average machines per property	-3.140	1.315	-.379	-2.388	.023	-5.812	-.468

a. Dependent Variable: Average % of LR per property

ii) Versus percentage of native vegetation:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.401[a]	.161	.136	13.36287%

a. Predictors: (Constant), Average machines per property

b. Dependent Variable: Average % of NV per property

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1163.972	1	1163.972	6.518	.015[b]
	Residual	6071.258	34	178.566		
	Total	7235.230	35			

a. Dependent Variable: Average % of NV per property

b. Predictors: (Constant), Average machines per property

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	34.467	5.717		6.029	.000	22.850	46.084
	Average machines per property	-9.071	3.553	-.401	-2.553	.015	-16.291	-1.851

a. Dependent Variable: Average % of NV per property

iii) Versus percentage of compliance to LR quota:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.337[a]	.114	.088	16.319%

a. Predictors: (Constant), Average machines per property

b. Dependent Variable: % of compliance per municipality

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1161.926	1	1161.926	4.363	.044[b]
	Residual	9054.379	34	266.305		
	Total	10216.306	35			

a. Dependent Variable: % of compliance per municipality

b. Predictors: (Constant), Average machines per property

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	50.291	6.981		7.204	.000	36.104	64.478
	Average machines per property	-9.063	4.339	-.337	-2.089	.044	-17.881	-.245

a. Dependent Variable: % of compliance per municipality

iv) Versus percentage of properties with no APP:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.130[a]	.017	-.012	6.07531%

a. Predictors: (Constant), Average machines per property

b. Dependent Variable: % of properties with no APP

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21.584	1	21.584	.585	.450[b]
	Residual	1254.920	34	36.909		
	Total	1276.505	35			

a. Dependent Variable: % of properties with no APP

b. Predictors: (Constant), Average machines per property

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	95.0% Confidence Interval for B Lower Bound	95.0% Confidence Interval for B Upper Bound
1	(Constant)	17.190	2.599		6.614	.000	11.909	22.472
	Average machines per property	1.235	1.615	.130	.765	.450	-2.047	4.518

a. Dependent Variable: % of properties with no APP

f. Independent variable: Average workers hired per property

i) Versus percentage of legal reserve:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.039[a]	.002	-.028	5.33989%

a. Predictors: (Constant), Average workers hired per property

b. Dependent Variable: Average % of LR per property

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.497	1	1.497	.053	.820[b]
	Residual	969.489	34	28.514		
	Total	970.986	35			

a. Dependent Variable: Average % of LR per property

b. Predictors: (Constant), Average workers hired per property

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	17.870	2.746		6.507	.000	12.288	23.451
	Average workers hired per property	-.160	.698	-.039	-.229	.820	-1.579	1.259

a. Dependent Variable: Average % of LR per property

ii) Versus percentage of native vegetation:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.091[a]	.008	-.021	14.52755%

a. Predictors: (Constant), Average workers hired per property

b. Dependent Variable: Average % of NV per property

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	59.544	1	59.544	.282	.599[b]
	Residual	7175.685	34	211.050		
	Total	7235.230	35			

a. Dependent Variable: Average % of NV per property

b. Predictors: (Constant), Average workers hired per property

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	24.780	7.471		3.317	.002	9.596	39.963
	Average workers hired per property	-1.009	1.899	-.091	-.531	.599	-4.869	2.851

a. Dependent Variable: Average % of NV per property

iii) Versus percentage of compliance to LR quota:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.039[a]	.002	-.028	17.321%

a. Predictors: (Constant), Average workers hired per property

b. Dependent Variable: % of compliance per municipality

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15.860	1	15.860	.053	.820[b]
	Residual	10200.446	34	300.013		
	Total	10216.306	35			

a. Dependent Variable: % of compliance per municipality

b. Predictors: (Constant), Average workers hired per property

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	38.799	8.908		4.355	.000	20.695	56.902
	Average workers hired per property	-.521	2.265	-.039	-.230	.820	-5.123	4.082

a. Dependent Variable: % of compliance per municipality

iv) Versus percentage of properties with no APP:

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.110[a]	.012	-.017	6.09035%

a. Predictors: (Constant), Average workers hired per property

b. Dependent Variable: % of properties with no APP

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15.366	1	15.366	.414	.524[b]
	Residual	1261.139	34	37.092		
	Total	1276.505	35			

a. Dependent Variable: % of properties with no APP

b. Predictors: (Constant), Average workers hired per property

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	17.114	3.132		5.464	.000	10.748	23.479
	Average workers hired per property	.513	.796	.110	.644	.524	-1.106	2.131

a. Dependent Variable: % of properties with no APP

2. Correlation between independent variables

a. Age segments vs education levels

Correlations

			% of producers up to 25	% of producers from 25 to 45	% of producers from 45 to 65	% of producers of more that 65
Spearman's rho	% of producers up to 25	Correlation Coefficient	1.000	.455**	-.113	-.503**
		Sig. (2-tailed)	.	.005	.513	.002
		N	36	36	36	36
	% of producers from 25 to 45	Correlation Coefficient	.455**	1.000	-.340*	-.860**
		Sig. (2-tailed)	.005	.	.042	.000
		N	36	36	36	36
	% of producers from 45 to 65	Correlation Coefficient	-.113	-.340*	1.000	.058
		Sig. (2-tailed)	.513	.042	.	.735
		N	36	36	36	36
	% of producers of more that 65	Correlation Coefficient	-.503**	-.860**	.058	1.000
		Sig. (2-tailed)	.002	.000	.735	.
		N	36	36	36	36
	% of producers that never attended school	Correlation Coefficient	-.027	.219	-.180	-.085
		Sig. (2-tailed)	.877	.199	.293	.620
		N	36	36	36	36
	% of producers with primary education	Correlation Coefficient	.311	.264	.214	-.306
		Sig. (2-tailed)	.065	.120	.210	.069
		N	36	36	36	36
	% producers with secondary education	Correlation Coefficient	.232	.214	-.004	-.250
		Sig. (2-tailed)	.173	.210	.982	.142
		N	36	36	36	36
	% of producers with superior education	Correlation Coefficient	-.483**	-.507**	-.058	.621**
		Sig. (2-tailed)	.003	.002	.738	.000
		N	36	36	36	36
	% of producers with master and/orPhD	Correlation Coefficient	-.262	-.020	-.140	.149
		Sig. (2-tailed)	.123	.908	.415	.386
		N	36	36	36	36

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

B) Correlation between linear regressions independent variables.

Correlations

			% of properties associated to cooperatives	% of properties receiving financing assistance	% of proprietors within producers	% of proprietors receiving technical information	Average machines per property	Average workers hired per property
Spearman's rho	% of properties associated to cooperatives	Correlation Coefficient	1.000	.610**	.062	.050	.457**	.244
		Sig. (2-tailed)	.	.000	.719	.774	.005	.152
		N	36	36	36	36	36	36
	% of properties receiving financing assistance	Correlation Coefficient	.610**	1.000	-.145	.173	.498**	.373*
		Sig. (2-tailed)	.000	.	.400	.312	.002	.025
		N	36	36	36	36	36	36
	% of proprietors within producers	Correlation Coefficient	.062	-.145	1.000	.122	-.088	-.009
		Sig. (2-tailed)	.719	.400	.	.479	.609	.957
		N	36	36	36	36	36	36
	% of proprietors receiving technical information	Correlation Coefficient	.050	.173	.122	1.000	.180	.152
		Sig. (2-tailed)	.774	.312	.479	.	.294	.377
		N	36	36	36	36	36	36
	Average machines per property	Correlation Coefficient	.457**	.498**	-.088	.180	1.000	.668**
		Sig. (2-tailed)	.005	.002	.609	.294	.	.000
		N	36	36	36	36	36	36
	Average workers hired per property	Correlation Coefficient	.244	.373*	-.009	.152	.668**	1.000
		Sig. (2-tailed)	.152	.025	.957	.377	.000	.
		N	36	36	36	36	36	36

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

c) Correlation between household per capita income and property size

Correlations

			Property_Area (ha)	% of home with no income	% of homes with <25% minimum income per capita	% of homes with 25% -50% minimum income per capita	% of homes with 50% to 1 minimum income per capita	% of home with 1-2 minimum incomes per capita	% of home with 2-3 minimum incomes per capita	% of home with 3-5 minimum incomes per capita	% of home with >5 minimum incomes per capita
Spearman's rho	Property_Area (ha)	Correlation Coefficient	1.000	.281	.044	-.053	-.428**	.027	.199	.364*	.440**
		Sig. (2-tailed)	.	.097	.798	.758	.009	.877	.243	.029	.007
		N	37	36	36	36	36	36	36	36	36

3. Pre-Change Section of Intro and Research Questions

It has been mentioned that it is key to consider the values of people when making policies addressed for FTT. The interactions between forest transitions, ecosystem services and social values and perceptions are important to understand and play a major role in the success of policies intended for promoting natural conservation and sustainable management (Garcia et al, 2020). Therefore, recognizing the role that these values, perceptions or motivations have in relation towards nature can prove to be crucial when developing FTT strategies.

It is also important to gain knowledge of the effects of the interactions between values and perceptions, and different dimensions of influence, since it can be relevant when studying behavior of farmers (Muhar et al, 2017). Multi-level views that include larger contexts and interactions when analyzing individual-scale socio-cultural concepts, such as values and perceptions, can improve the understanding of attitudes and behaviors that can lead to support conservation (Dietsch et al, 2016). For this reason, it is necessary to understand the behavior of these crucial actors towards achieving policy goals, forest transitions and ultimately widescale forest restoration. Depending on the individual, different types of associations with responses related to conservation measures have been observed, where they are largely conditioned by the intrinsic value of nature that the individuals attribute it (values clustered in descriptive, experiential and normative structures). Normative reasons answer the question: "How do we value nature?", relating to more holistic, eco-centric interpretations (Buijs & Elands, 2013).

In this thesis, the aim was to perform an exploratory effort to identify normative reasons that influence forest and landscape restoration and the relation that they have to different intrinsic and extrinsic factors and characteristics. This is conducted in the Alto Paranapanema water basin in the Sao Paulo state, Brazil. Normative reasons can provide a glimpse into understanding why despite high economic costs product of the undertaking of restoration efforts, there is still widespread, but still not sufficient, growth in native vegetation cover in the BAF (passive or actively performed). As a foundation for understanding why this happens, it is important to understand the underlying normative reasons behind these behaviors. To achieve this, the following research question attempted to be answered in this thesis was:

- ➔ *What are the normative reasons (NR) of farmers/landowners that affect forest restoration?*
  - *a) Are farmer/landowner characteristics related to these normative reasons towards engaging in restoration efforts?*
    - *If so, how are they related?*

4. Pre-Change of Theoretical Framework

In contrast with the original model by Schoonhoven & Runhaar (2018), the different conditions that are analyzed (Motivation, ability, demand and legitimation) are substituted by the central concept of the study, normative reasons that affect forest restoration by landowners. To address the aforementioned research questions, it is important to first define what are considered as normative reasons. These can be defined as "facts that guide responses, in one's emotions, beliefs, actions, etc., to how things are" (Raz, 2012), in other words, reasons that are more internal and intrinsic to the individual in question. Socio-cultural concepts are linked and in fact interact with individual environmental concepts, where beliefs, values and norms have an effect on environmental perceptions such as human-nature relationships, environmental worldviews and connection with nature (Mohar, 2017). These socio-cultural concepts (beliefs, values, norms) are therefore considered in this study as the normative reasons that ultimately affect restoration.

With this as the centerpiece of the research, the "onion model" is tailored to attempt to visualize relations between different characteristics of the agents concerned, their direct context, their distal context, and the NR that are detected (fig. 2). With regard to the outer layers, these are separated into three: (1) the innermost is comprised by the individual characteristics of the subjects and their properties; (2) the middle layer considers the direct context with which the subjects interact, including relationships between farmers/landowners, their social network, cultural components, societal pressures; (3) the outermost layer contemplates a more distal context, with factors that the subjects have little influence on and that shape the landscape in which they operate (e.g. Economic and legal characteristics).

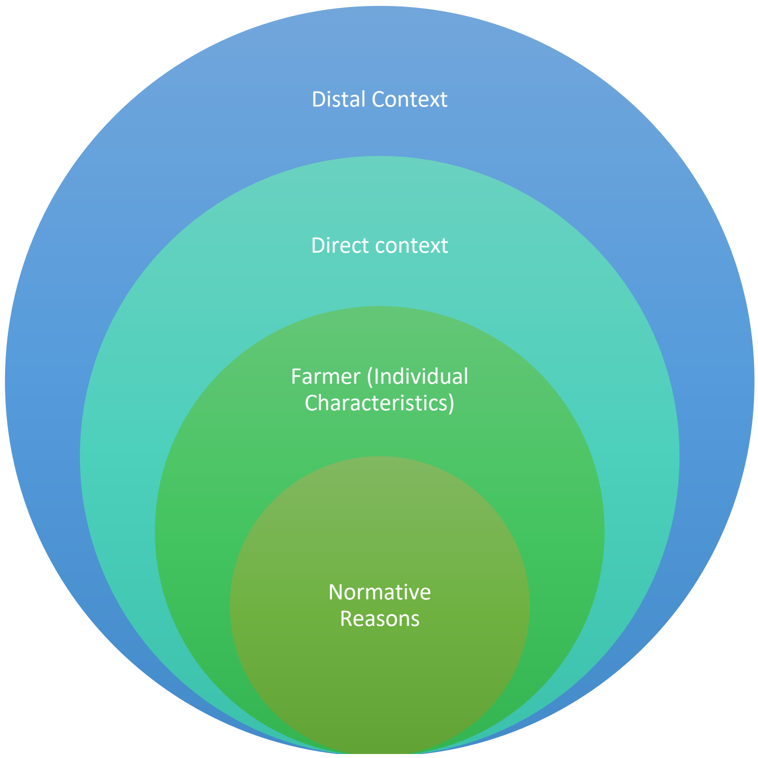

Figure 8.4.1. Conceptual framework of the adapted onion model to be used in the thesis.

Regarding the contexts that end up influencing normative reasons, factors must be addressed to determine the effects that these layers have on the beliefs, values and motivations that farmers have towards restoration of native vegetation. To achieve this, an array of properties for each layer are specified:

4) Individual characteristics:
   a) Intensity of practices: Intensification of farming is directly associated with loss in farmland-proximate biodiversity, in turn reducing habitat heterogeneity in those areas (Benton et al. 2003). It is hypothesized that this also negatively affects farmers' predisposition to engage in restoration efforts.
   b) Size of properties: The relationship between property size and deforestation within the property has been explored. Largeholders show an increase of deforestation, but a decline in percentage of the property that is deforested when compared with smallholders (Godar et al, 2012). Because it is more feasible for largeholders to destine land for restoration, it is hypothesized that NR towards restoration will not show many differences between different property sizes.
   c) Land use type: Type of use for farmland (crop, pasture, forestry) has shown differences in the willingness to participate in previous efforts for restoration, since a variation in type of farm brings different tradeoffs when engaging in restoration (Zhu et al. 2016). The

hypothesis for this factor is that landowners that work with cropland and forestry will show a negative relation towards the willingness to restore native vegetation.

d) Knowledge and capabilities: In terms of sociodemographic factors, knowledge of the farmers has been identified as one of the most important influencers in the adoption of environmental measures (Sanchez et al. 2016). The way this knowledge is handled is also relevant since it can bring improvements in developing further knowledge and in turn enhance capabilities for implementation (Padel et al. 2010). A positive relation between knowledge and capabilities, and NR for restoration actions is expected.

5) Direct context:
   a) Farmer organizations: These organizations can play crucial roles in the willingness of farmers to adopt beneficial ecological initiatives. Not only do they tend to vouch for better socio-economic conditions for small-scale farmers, they have also been seen influential in environmental management of agronomical activities at local and even international scales (Hart et al, 2016). It is hypothesized that being part of farmer organizations has a positive influence on NR for environmentally friendlier practices.
   b) Peer-to-peer influence: Interactions, cooperation and influence between peers can be important for functions in knowledge exchange that in turn can prove to help drive perceptions from aversion to inclination towards new farming practices and techniques (Bell, 2010). These interactions are hypothesized to have a positive relation with NR for restoration.
   c) Consumer demand: The public demand for sustainable practices in agriculture and environmental management measures has been observed in both developed and undeveloped countries (Alcón et al, 2019; Cerda et al, 2013). Incorporation of social demands is expected to have a positive relation with NR.
   d) Social groups and customs: It is hypothesized that there will be a difference between social groups, where some positive relation with NR will be observed in lands managed by traditional community-managed groups. A study conducted in the Sao Paulo state analyzing the amount of native vegetation present in rural lands demonstrated empirical data that depending on social groups there are differences in native vegetation coverage on their properties (Leite et al, 2020).
6) Distal context:
   a) Demand from policies: As previously mentioned, the 2012 revision of the Forest Act enforces restrictions on land use for both private and public land. While the mechanisms available to meet compliance do not necessarily bring environmental improvements, they do make it economically more viable to achieve. Therefore, it is hypothesized that relations with NR are neutral.
   b) Subsidies and incentives: Incentives and subsidies have been shown to increase the commitment that farmers have towards conservation (Lockhorst et al, 2011). While incentives such as payment for ecosystem services can be observed in Brazil, and while they can be effective, they have shown slow increase in restoration (Ruggiero et al. 2019). Since other factors, such as identity, responsibility and altruism have also been observed to affect restoration commitment by farmers (Chapman et al. 2020), it is hypothesized that incentives have a slight positive relation with NR.

Achieving an overview of these factors and assessing the type of influence (positive, neutral, negative) that they have on normative reasons for restoration can therefore provide the foundations for understanding focalized local socio-cultural concepts belonging to different agents. This in turn can help understand the attitudes and behaviors that they have towards restoration of native vegetation in the BAF.

5. Pre-Change of Thesis Methods

This thesis is centered in the identification and understanding of normative reasons that landowners have towards the restoration of native vegetation in the Brazilian Atlantic Forest. To achieve this, a methodology where normative reasons are identified and characterized is needed, as well as the characterization of the relationships that the factors that are specified in the surrounding concepts have with each other and with the NR. This research focuses on the data obtained regarding the farmers and landowners in the Alto Paranapanema water basin, located in the state of Sao Paulo, Brazil. The following section is centered on the design and operationalization of the framework proposed to attend to these questions, the contingency plans considered, and the latter data analysis.

Research Design

This research takes an exploratory qualitative approach to attempt to answer the research questions. The explorative property of the approach is due to the fact there is not an extensive literature regarding the famers' normative reasons that affect restoration in the BAF, and what influences them. The methodological framework used to attend to the research questions is divided into two parts. First the identification of normative reasons and the latter the relationships that the characteristics of farmers have with each other and with the normative reasons identified. To identify the NR, an inductive approach will be used. An inductive approach is used to establish a link between the objectives of the research and the findings obtained from the raw data, where the research findings emerge from the frequent, dominant themes inherent in the data (Thomas, 2006). Regarding the second research question and its sub question, a deductive approach will be used, since literature on different characteristics of landowners affecting vegetation cover, conservation measures, or agroecological schemes has been covered (i.e. Runhaar et al, 2018; Leite et al, 2020). The intention is to test these previous results observed in literature and link them to the normative reasons identified in the specific context of the landowners in the geographical scope (Alto Paranapanema) of the study.

Operationalization

Operationalization in inductive research occurs with and/or after the data collection (Newman, 2012). Theories are not being directly used in this case, hence the explorative characteristic of this part of the study. With the intention of reaching findings by interviewing, the normative reasons will be identified when the interviews are transcribed, coded and clustered into different nodes that are later classified during the analysis. For the deductive part, literature is used to determine the variables used for each distinct factor mentioned for the outer layers of the framework.

Individual:

- Farm size: Small (up to 5 ha), medium (between 5 and 500 ha), large (over 500 ha).
- Intensity of practices: Intensive or extensive.
- Type of land use: Crop, pasture, silviculture.
- Knowledge and capabilities: Autoperception: Low, intermediate, high.

Direct context:

- Farmer organizations: Participation: none, low, intermediate, high.
- Peer-to-peer influence: Interactions with other farmers: none, low intermediate, high.
- Consumer demand for sustainable agriculture and conservation: Perception: None, low, intermediate, high.
- Social groups or customs: Traditional-community farming, family farming, conventional farming.

Distal Context:

- Demand from policies:
    - (1) Do they meet necessary quota of protected land in their property? Why?
    - Which is viewed more favorable, APP or LR? Why?
- Subsidies and Incentives: Are there incentives or subsidies available to them? Do they receive any of them?

Data collection:

In an initial stage, on-site field research was stipulated, where a 2-month trip to the Alto Paranapanema region in Brazil was planned. The idea was to work with Dr. Alex Camargo Martensen, the on-site liaison to contact the farmers that were going to be interviewed. Since circumstances changed, the plan now is to conduct these interviews by phone, skype or any other contact form that can allow a direct conversation. Farmers remain to be contacted by the counterpart in Brazil, but it is previsioned that the sample size will not be significative enough to conduct a quantitative research. This thesis will use semi-structured interviews, (which will be recorded if granted permission) with open questions to give space for the inductive part of the study, looking for nominal answers to use in the analysis. The interviews also include ordinal-oriented questions, to address the deductive section of the research, where relationships regarding characteristics and factors are meant to be categorized. These interviews will be conducted in the language agreed by the interviewee and interviewer (the most convenient choice), with English, Portuguese and Spanish as the possibilities.

Data saturation is also considered, which can be explained as the degree in which new data becomes redundant and repetitive with respect to data previously collected. This degree is rather obscure and is generally up to the researcher to determine it. It is always possible for something new to emerge though data collection, so the question to address is: "how much saturation is enough?". The proposed solution is by searching for the point in which new information does not change the outcome of the analysis (Saunders et al, 2017).

Contingency plan

In the case that it is not possible to conduct the interviews, a contingency plan is considered to collect data. In first instance, if encountering difficulties to interact directly with farmers, contact with farmer organizations will be procured, given that they may be easier to contact and that they in turn are comprised of individuals that are the target unit to interview, providing useful general information. The liaisons present in the field that will be aiding our research can also help in contacting these organizations. In the case that farmer organizations become inaccessible as well, or that the information is not considered sufficient, data extracted from newspapers and other secondary data will be used to collect information.

Data analysis

Transcription of data can be very time and energy-consuming, nevertheless it is necessary for the interpretation of recorded interviews. After the transcription of interviews, the process with NVivo will be performed with the aim of categorizing data, as well as detecting and clustering patterns of data into different NR categories. This will be done by coding, generating codes that later cluster into nodes. These nodes can either group codes in terms of themes, the connection that different codes may have, and the negative or positive relationships between some codes (www.qsrinternational.com), helping to answer the subquestion in the RQ, showing how the farmer characteristics are related to NR. This process is iterative, meaning that as more and more information is being coded, changes in these nodes can happen (modifications, adding, deleting) until sufficient information is available so that they are not changing anymore. This would be considered data saturation. Using the research questions as an orientation for the coding, these will be categorized and distributed into different clusters to help illustrate and answer main questions of this thesis. The results collected will serve to understand the normative reasons, comprised of values, beliefs, and visions for nature that in turn affect forest restoration of BAF in the Alto Paranapanema water basin in Brazil.

6. Survey guide

Pesquisa Agricola

1.Que tipo de agricultura é feita em sua propriedade principalmente?
Agricultura de pastagem
Agricultura arável
Agrossilvicultura

Agricultura mixta

2.Como você avaliaria a produtividade da terra em sua propriedade?

muito pouca produtividade ☐ ☐ ☐ ☐ ☐ muito produtiva

3.Há quantos anos sua fazenda está funcionando?

4.Como você avalia a disponibilidade de água para a agricultura em sua propriedade?

Muito pobre ☐ ☐ ☐ ☐ ☐ Muito abundante

5.Este fazenda mudou no que era usado recentemente? Por quê?

6.Como você classificaria a localização geográfica de sua fazenda para produtividade?

O pior ☐ ☐ ☐ ☐ ☐ ótima

7.Com que frequência você usa maquinário pesado em sua fazenda?

Nunca ☐ ☐ ☐ ☐ ☐ Sempre

8.Quantos trabalhadores você emprega em sua fazenda?

- Eu não emprego trabalhadores
- 1-5
- 5-20
- 20-40
- 40+

9.Quão benéfico é para você fazer parte de organizações ou cooperativas de agricultores?

Não benéfico ☐ ☐ ☐ ☐ ☐ Muito benéfico

10.Você compartilha informações com seus vizinhos?

Como você adquire essas informações?

11.Como você avaliaria a cooperação entre você e seus vizinhos?

Muito mal ☐ ☐ ☐ ☐ ☐ Muito bom

12.Quanta pressão você sente para cumprir o APP?

Sem pressão ⍰ ⍰ ⍰ ⍰ ⍰ Alta pressão

13. Quem exerce essa pressão?
- você mesmo
- vizinhos
- associação de fazendeiros
- família
- governo
- otro:

14. Como você acha que isso afeta você?

15. Em termos de justiça, como você vê as APPs?

Muito injusta ⍰ ⍰ ⍰ ⍰ ⍰ Muito justa

16. Com relação à questão 15: Por quê?

17. Quão desafiador é atingir a cota necessária de APP?

Muito fácil ⍰ ⍰ ⍰ ⍰ ⍰ Muito desafiante

18. Com relação à questão 16: Por quê?

19. Como você caracterizaria os incentivos para a restauração da vegetação nativa em seu terreno?

Muito mal ⍰ ⍰ ⍰ ⍰ ⍰ Excelente

20. Quantos anos você tem?
- 18-25
- 26-40
- 41-55
- 56-65
- 66+

21. Gênero?

22. Quantas pessoas constituem sua família imediata?
- Você mesmo
- 1-4
- 5-10

- 10+

23. Como você se caracterizaria em termos de renda?
    - A
    - B
    - C
    - D
    - E