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Farmer perceptions, policy and reforestation in Santa Catarina, Brazil

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ABSTRACT

Extensive reforestation may be required to avert dramatic loss of biodiversity, system resilience and ecosystem services from Brazil's Atlantic Forest, and is legally required by Brazil's Forest Code. Restoration on farmland however threatens agricultural output and the livelihoods of small family farmers, leading to weak enforcement of the law and a national debate over the Code which resulted in revisions in 2012 that significantly reduced legally mandated restoration. To inform the design of effective environmental policies, we interviewed 60 typical dairy family farmers utilizing pasture-based agroecological grazing practices to assess their perceptions and knowledge of the pre-2012 Forest Code, its impacts and their willingness to comply. Multiple correspondence analysis (MCA) identified three distinct clusters: farmers who understood the forest code and its ecological impacts and were willing to comply; farmers who understood the ecological benefits of restoration, but were unwilling to comply; and those with little knowledge of benefits or interest in compliance. We evaluate three policy options for promoting restoration, paying particular attention to their impacts on farmer livelihoods and on their intrinsic willingness to restore and preserve forest cover. We conclude that payments for ecosystem services in the form of subsidies for agroecology practices are promising.

1. Introduction

Brazil offers a complex and unique showcase of the principal tropical landscapes; it is one of the two biologically richest nations (Mittermeier et al., 2005; Visentim, 2011) and harbors the planet's most biodiverse primary forests (Myers et al., 2000; Silvano et al., 2005; Sparovek et al., 2012), which cover 35% of Brazil's territory (FAO, 2010; SBF, 2010). These forest ecosystems generate a variety of services – including the capacity of the forests to reproduce themselves – that are essential to human welfare at local, regional and global scales.[1] Though Brazil has experienced dramatic declines in deforestation rates over the past decade, it still has among the highest deforestation rates in the world, and there is concern that recent changes in environmental legislation may lead these to increase once again (Arima et al., 2014; Hansen, 2013). The greatest concern is that continued deforestation can lead forest ecosystems to cross

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[1] A common definition of ecosystem services is ecosystem processes or functions of value to humans. We agree with Leopold (1993) however that "[the last word in ignorance is the man who says of an animal or plant, 'What good is it?' If the land mechanism as a whole is good, then every part is good, whether we understand it or not." (p. 145–146) Our definition of ecosystem services therefore follows Georgescu-Roegen's (1971) distinction between stock-flows and fund-services. Natural resource stock-flows are productive inputs into the economic process that are physically transformed into what is produced and can be used up at any given rate; for example, trees converted into charcoal or timber. Natural resource funds are a particular configuration of natural resource stocks, sustained by solar energy, that generate a flux of ecosystem services at given rate, and are not physically transformed in the process; for example, a forest regulating and purifying water (Farley and Costanza, 2010).

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critical ecological thresholds beyond which positive feedback loops such as drought, fire, and additional forest loss flip the ecosystem into another state that is substantially different (Cardoso da Silva and Tabarelli, 2000; Lima et al., 2014; Tabarelli et al., 2010).

Brazil's Atlantic Forest is exceptionally rich in biodiversity and endemic species; it is also the most threatened biome in Brazil and the third most threatened in the world (Mittermeier et al., 2005; Morellato and Haddad, 2000). Home to two-thirds of Brazil's population (Jacobsen, 2003), forest cover in the biome has been reduced to 11%-16% of its original extent, largely as a result of conversion to conventional agriculture. The remaining forest is highly fragmented, mostly with plots smaller than 50ha, which reduces its ecological functions and the supply of ecosystem services (Ribeiro et al., 2009). Extensive restoration of the Atlantic Forest in the near future may be required to restore ecological resilience and avert dramatic biodiversity loss and potential collapse (Banks-Leite et al., 2014; Ribeiro et al., 2009; Santos et al., 2008).

Land use decisions made by private landowners will largely determine the future of the Atlantic Forest, with decisions to remove, conserve or restore forest heavily influenced by economic factors and government policy (Rodrigues et al., 2009). Economic factors and most government policies explicitly target the self-interest of landowners. However, land use decisions can also be based on the altruistic desire to provide benefits for society, what Adam Smith referred to as moral sentiments (Bowles, 2008), and these too must be considered. As the dominant use of former forestland, farmland offers the greatest opportunities for forest conservation and restoration, so it is particularly important to understand the farmer's decision processes.

1.1. Economic Factors Affecting Land Use Decisions

Among the most important economic factors for farmers is monetary income. Forests can be physically transformed into timber and farmland, both of which generate market returns for the landowner. Alternatively, forests can be conserved or restored in order to generate ecosystem services. However, many ecosystem services are non-marketed public goods, which means that individual beneficiaries are unlikely to voluntarily pay for their provision (Cong et al., 2014; Mayer and Tikka, 2006): in other words, markets treat the costs and benefits of degradation and restoration as externalities, and largely ignore them. Estimating monetary values of these externalities in order to compare them with market costs and benefits is both difficult and controversial, but many studies that do so find that the marginal values to society of ecosystem services generated by conservation or restoration dramatically exceed the values generated by conversion (Balmford and Whitten, 2003; Balmford, 2002; Costanza et al., 1997; De Groot et al., 2013). Unfortunately, the failure of markets to account for most ecosystem services systematically favors conversion over conservation or restoration (Farley and Costanza, 2010).

However, agriculture is itself heavily dependent on ecosystem services provided by intact forest, such as climate regulation, water regulation, pollination, nutrient cycling and biological pest control. It is possible to develop substitutes for many of these services, such as nitrogen and phosphorous inputs for nutrient cycling and pesticides for pest control, but these substitutes are based on non-renewable resources that must eventually run out, and their excessive use may further degrade the ecosystem services that they replace. This means that continued deforestation may pose an unacceptable threat to agriculture and hence to farmer livelihoods in the long-run (Martinelli et al., 2010; Bennet and Balvanera, 2007; Daily, 1997; Matson et al., 1997).

Agroecology, defined as the "application of ecological science to the study, design and management of sustainable agroecosystems" (Altieri, 1987), especially when incorporating agroforestry, is a potentially economically viable solution to the conflict between agriculture and forest conservation. Agroecology is designed to replace artificial or non-renewable off-farm inputs with ecosystem services while simultaneously maintaining or increasing output. Furthermore, agroecology is specifically designed to meet the needs of small, low-income farmers (Altieri, 1989; Gliessman, 2007). One study of nearly 300 model resource-conserving agriculture projects covering 37 million hectares in poor countries documented an average yield increase of 79%, substantial carbon sequestration, more efficient water use, reduced pesticide use and increased ecosystem services (Pretty et al., 2006). Another meta-study found that agroecology practices enhanced both species richness and abundance in a variety of agricultural landscapes (Batáry et al., 2011),while other studies have found that high biodiversity is compatible with high crop yields (Clough et al., 2011; Tscharntke et al., 2012). On the other hand, a metastudy found that organic agriculture in general provides one-third lower yields than its conventional counterparts (Seufert et al., 2012), though a more recent metastudy found only 20% lower yields on average, with less than 10% yield loss when agricultural diversification practices (a basic principle of agroecology) are used, and no yield loss for perennial crops and legumes (Ponisio et al., 2015). Lower yields can still translate into higher farmer income if input costs also decrease.

The widespread adoption of agroecological practices requires research, development (R&D) and agricultural extension agents to introduce farmers to alternative practices and help implement them. Unfortunately, market provision of R&D is inefficient because of the particular characteristics of scientific knowledge. Agricultural technologies and indeed science in general are non-rival, in that adoption of a technology by one person does not leave less available for others. Patents make it possible to charge for use, but pricing inefficiently reduces use and hence benefits. However, without patents, the private sector cannot recoup R&D costs, and hence is likely to underinvest (Callon and Bowker, 1994; Vanloqueren and Baret, 2009). A metastudy has found that public sector agricultural R&D or extension generate average monetary rates of return of 80% (Alston et al., 2000). However, economic analysis of investments in agricultural science focus primarily on monetary returns, ignoring both social and environmental impacts, and for this and other reasons government investments in agricultural R&D and extension systematically favor conventional agriculture over agroecology (Vanloqueren and Baret, 2009). Another challenge to the widespread adoption of agroecological practices is that farmers are generally risk averse, and many lack the resources to invest in new production technologies.

1.2. Government Policies Affecting Land Use Decisions

Policy options for conserving and restoring forests include prescription, payments, penalties, property rights and persuasion (Salzman, 2005). This article considers three different policies: the prescriptive Brazilian Forestry Code, which theoretically penalizes non-compliance; payments for ecosystem services; and public support for agroecology, which combines payments with persuasion.

At least on paper, the Atlantic Forest is protected by laws that prescribe conservation and restoration within specific areas of rural properties, which could alternatively be interpreted as legal restrictions on property rights. Before 2012, when the surveys reported in this article were conducted, the Brazilian Forest Code prohibited deforestation in Areas of Permanent Protection (APP) and required restoration of native vegetation in previously deforested APPs with the goal of protecting and restoring critical ecological functions and biodiversity. APPs included the margins of waterways ranging from 30 to 500 m from high water mark on each side, depending on the width of the waterway; 50 m around springs; hillsides with slopes greater than 45°; and mountain tops. In addition, the code required forest cover on a legal reserve (LR) of 20% of Atlantic Forest properties. The LR is also intended to protect and restore ecological functions and biodiversity, but allows sustainable economic use (Brasil, 2012). Full compliance with this forestry code