AGROFORESTRY AS AN ALTERNATIVE TO LEGAL RESERVES[1]

TATIANA PARREIRAS MARTINS[2]
VICTOR EDUARDO LIMA RANIERI[3]

Introduction

The debate surrounding the changes to Brazilian environmental legislation, particularly to the Forestry Code, has awakened many sectors of society to the agricultural production model that Brazil has adopted and to the responsibilities of rural landowners as regards conservation and restoration of forests and other forms of native vegetation, soil and water.

On the one hand, sectors led by large landowners have called for fewer responsibilities, stating that the Code, which has been in force since 1965 and updated over four and a half decades, severely hampers the development of the agricultural sector (CNA, 2011).

In opposition to this view, scientists have joined together in highlighting the possible damage that could arise from the proposed changes and the existence of sufficient area to marry preservation of biological patrimony and increased agricultural production for internal consumption and export (BACHA, 2004; MARTINELLI *et al.*, 2010; METZGER, 2010; SBPC; ABC, 2011a; SPAROVEK *et al.*, 2010, 2011, 2012; VIANA *et al.*, 2002).

Despite the scientific efforts and evidence, Law No 12.651 was adopted on 25 May 2012, albeit still replete with controversial points, such as the functions of Legal Reserves (LR) and how this instrument will be implemented.

Whereas the 1965 Forestry Code gave these protected areas a clear conservation role (BACHA, 2005; METZGER, 2002, 2010; RANIERI; MORETTO, 2012), in Law No 12.651/2012 this is a secondary objective compared to the priority of LRs for production and economic use. The very existence of LRs has gone from being mandatory in all rural properties to being dependent on factors such as prior ground use and occupation. In cases where the mandatory nature of LRs is upheld, Law No 12.651/2012 provides for clusters of native and exotic species in agroforestry systems as an alternative to the re-composition and use of these areas (BRASIL, 2012).

1. Este trabalho apresenta parte dos resultados da dissertação de mestrado desenvolvida na EESC/USP (MARTINS, 2013). Agradeço ao CNPq (Processo **131600/2011-7) e** à Capes pelo auxílio financeiro.

2. Bióloga, Mestre em Ciências da Engenharia Ambiental. E-mail: tatiana.martins1@gmail.com (Universidade de São Paulo, Escola de Engenharia de São Carlos. São Carlos, SP – Brasil)

3. Professor Doutor da Escola de Engenharia de São Carlos. E-mail: vranieri@sc.usp.br (Universidade de São Paulo, Escola de Engenharia de São Carlos. São Carlos, SP – Brasil)

However, the label "Agroforestry Systems" (AFS) covers a wide range of systems from the very simple, consisting of two or a handful of species, to the most complex and biodiverse. Given this, the following questions arise: are Agroforestry Systems an adequate alternative for the constitution of Legal Reserves? Which AFS enable the functions of these protected areas to be performed?

The objective of this article is to put forward relevant aspects and considerations for discussion of these questions based on peer-reviewed literature. To do this, we shall first present the concepts and necessary background to Legal Reserves, Agroforestry Systems and sustainability in order to furnish approaches to and discussion of the key questions that follow.

Legal Reserves

Protected areas are recognised globally as being essential to the preservation of a range of fundamental goods and services for life on Earth. Given the coverage and severity of the anthropomorphic impacts and pressures on the planet, the importance and need for efforts to maintain and extend these areas are even greater (CHAPE *et al.*, 2008; ELI, 2003; HOCKINGS; PHILLIPS, 1999). These being the case, protected areas are at the very heart of global commitments, with 168 countries signing the Convention on Biological Diversity, building *in situ* conservation strategies. The situation in Brazil is no different. Federal Law No 6.938 of 31 August 1981 (National Environment Policy) instituted as one of its instruments especially protected territorial areas, which can be public or private, with full protection or for sustainable use, in accordance with laws No 9.985/2000 and No 12.651/2012 (BRASIL, 1981, 2000, 2012).

As it is considered that there are not enough public areas under protection in terms of their number and distribution (GOTTFRIED *et al.*, 1996), conservation in private areas, in fragments of forest and other types of vegetation is fundamental in protecting nature and is an important component of the national strategy for sustainable use of natural resources (ELI, 2003; HAUFLER; KERNOHAN, 2009; METZGER, 2002). In Brazil, roughly 70% of the remaining natural vegetation is located on private land (SPAROVEK *et al.*, 2012), to which Law No 12.651/2012 applies. This brought in two instruments – Permanent Preservation Areas (APPs) and Legal Reserves – which are deemed to be the main means of promoting protection of nature on private property (RANIERI; MORETTO, 2012).

While the APPs are basically areas designed to contain erosion processes and to protect water courses or bodies, LRs are, in accordance with Law No 12.651/2012, areas within a property or rural holding (the percentage varies in accordance with the region of the country). Their function is to ensure the sustainable economic use of the natural resources of the land asset, to aid conservation and regeneration of ecological processes and to promote conservation of biodiversity, as well as to shelter and protect forest fauna and native flora (Article 3, Paragraph III). To this end, they should be conserved with native vegetation coverage and exploited through sustainable management plans previously approved by the competent body of the National Environment System.

Properties with legal reserves smaller in size than that stipulated by the law and which need to regularise their situation have, as one option, re-composition through interspersed planting of native and exotic planting in an Agroforestry System. In this case, the area recomposed with exotic species must not exceed 50% of the total area to be recovered. In the case of a small rural property or rural family holding[i], Law No 12.651/2012 stipulates that a LR area can be retained with fruit, ornamental or industrial trees consisting of exotic species grown in an intercropping system or in a group with native species. In the case of small-scale landowners, agroforestry use that does not impinge on the existing plant coverage and which does not harm the environmental function of the area is also considered an activity of social interest. The law also provides for different treatment for these landowners in terms of simplifying legal procedures and providing technical, legal and financial support (BRASIL, 2012).

Moreover, the Ministry of the Environment published Normative Instructions No 4 and No 5 on 8 September 2009: the former regulates the methodological procedures for the restoration and recovery of Permanent Preservation Areas and Legal Reserves; meanwhile, the latter sets out the technical procedures for the sustainable use of existing vegetation in LR areas through sustainable forest management (BRAZIL, 2009a, 2009b).

The federal legislation establishes a number of general guidelines for the re--composition and exploitation of LR areas through Agroforestry Systems and others. However, there is no distinction or mention of which types of AFS are suitable for fulfilling the functions of the LRs. In this way, it is left up to the competent environmental body to determine the criteria and acceptable standards for the restoration, exploitation and management of these protected areas. More knowledge of these systems is required to understand better the implications of this shortcoming of the legislation.

Agroforestry Systems

Agroforestry systems (AFS) are in essence land use systems that include perennial woody species with agricultural crops and/or livestock within given spaces and over a given period of time (BATISH *et al.*, 2008; MAY; TROVATTO, 2008; SCHROTH; FONSECA; *et al.*, 2004; UMRANI; JAIN, 2010). In order for a given cluster to be deemed agroforestry, all that is required is that at least one of the species making up the cluster be typically a forestry species, regardless of whether it is a native species or acclimatised, tree-like or bushy in size, or temporary or permanent in the system. Accordingly, there is a broad variety of combinations and possibilities that fall under the term "Agroforestry Systems", differing in their structural components (space and time), physiognomy, forestry composition, functional role of the components and ecological aspects, system management, production objectives and prevailing socioeconomic characteristics (BATISH *et al.*, 2008; ENGEL, 1999; MAY; TROVATTO, 2008; TORQUEBIAU, 2000; UMRANI; JAIN, 2010). There are AFS that basically consist of simple clusters, where the paradigm is the same as that of a monoculture, of competition, where you have the combination of certain species employed to make better use of production factors, inputs and manpower; whereas other more complex AFS are based on another paradigm, which, with their

ecological principles, look to the forest for their essence (PENEIREIRO, 2003). These systems can therefore be classified on a scale of sustainability and conservation potential (BHAGWAT *et al.*, 2008; PENEIREIRO, 2003; SCALES; MARSDEN, 2008).

The biodiversity of AFS, consisting of planned and unplanned components, is continually interacting, optimising ecological processes that generate environmental and socioeconomic benefits (ALTIERI; NICHOLLS, 2011; SCHROTH; FONSECA; *et al.*, 2004). Among the environmental benefits are those related to conservation, which is especially important in highly fragmented landscapes: (a) they provide habitats for species that tolerate a certain level of disturbance; (b) they help reduce the conversion rates of natural habit through less pressure from land use for agricultural production; (c) they provide a more productive and sustainable alternative to conventional systems exploiting natural resources; (d) they offer support to remaining forest areas – they act as green corridors, stepping stones or buffer zones – encouraging conservation of sensitive species of flora and fauna and (e) they provide ecosystem services such as carbon sequestration, better air, water and soil quality, together with conservation of biodiversity (BHAGWAT *et al.*, 2008; JOSE, 2012; NAIR, 2007, 2011; SCHROTH; FONSECA; *et al.*, 2004; UDAWATTA; GODSEY, 2010; UMRANI; JAIN, 2010).

The widely recognised socioeconomic benefits (AS-PTA; ILEIA, 2011; NAIR, 2007; SANTOS, 2010; SOUZA *et al.*, 2011; VIVAN, 2010; YAMADA; GHOLZ, 2002) stem mainly from alternating and diversifying production, from use and reuse of the resources intrinsic to the system and more involvement of farmers in the production system (MACEDO, R. L. G., 2000; MAY; TROVATTO, 2008).

By optimising land use and by providing benefits that are both biological and socioeconomic at the same time, AFS are often highlighted as sustainable systems that are promising in terms of solving problems related to the use of natural resources and deemed suitable for the use of this resource base (ENGEL, 1999; JOSE, 2009; MACEDO, R. L. G., 2000; NAIR, 2007; SCHROTH; FONSECA; *et al.*, 2004). Yet in order to discuss the sustainability of these systems, it is important to understand this concept and its practical implications.

Sustainability

The term "sustainable development" was clearly disseminated from the beginning of the 1970s against a backdrop of controversy as regards the relationships between economic growth and the environment (MAY *et al.*, 2003). In 1987, the report "Our Common Future" (or the Brundtland Report) officialised the term "sustainable development" as being development that could meet the needs of the present generation without compromising those of future generations (WCED, 1987).

Since then, many converging and diverging definitions have been put forward. A certain consensus can be seen in the gradual recognition that the search for sustainability and sustainable development requires integrating different dimensions[ii], simultaneous consideration of multiple scales (from the local to the global) and a broadening of the timeframe so as to take into account intra-generational needs and inter-generational

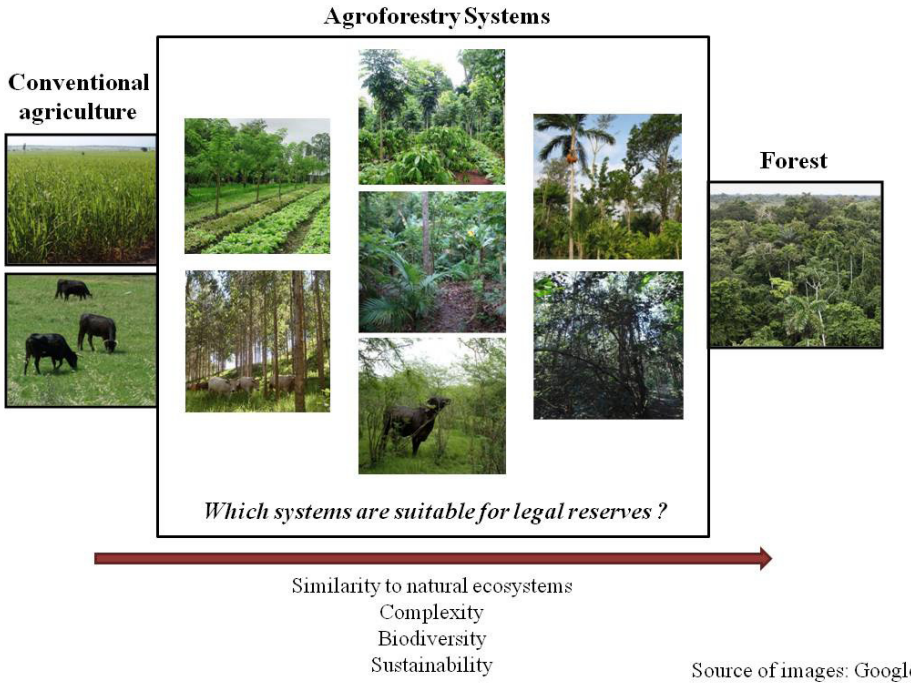
equity (SACHS, 2002; VEIGA, 2010). Nevertheless, differing objectives, priorities and perspectives still give rise to divergences that place the terms "sustainability" and "sustainable development" among the most ambiguous and controversial in literature (GALLOPÍN, 2003; VEIGA, 2010).

Nevertheless, the idea of sustainability has become very popular and has been incorporated in the programmes and rhetoric of most governments and institutions (VIANA, 1999). Brazilian environmental legislation is no different: sustainability is a clear guiding principle and a leading objective, including in approaches on sustainable use that are part of strategies for conservation in protected areas, such as the National Strategic Plan for Protected Areas and the National System of Nature Conservation Units (BRAZIL, 2000, 2006). However, the results that have effectively been achieved come up severely short of what is needed. There is an enormous gap to be bridged between words and deeds; many attempts to transpose the concept into coherent practical actions have failed and, depending on the definition adopted for "sustainability" (and derived terms), the same practice can be deemed sustainable or not (VEIGA, 2010; VIANA, 1999).

From whatever angle of sustainability taken, in the ecological and/or environmental dimensions the essential ecological processes and the systems that support life should be retained as a bare minimum, so that meeting present needs does not compromise answering the needs of future generations (MORSE, 2010; ROGERS *et al.*, 2008). However, the adjective "sustainable" is conditioned by the ability to be perpetuated in the future (MORSE, 2010). This potential can only be determined through monitoring in the long term systems components, particularly those of biological populations. In this way, in the majority of actions labelled or deemed "sustainable", sustainability has always been assumed, and has not been tested or demonstrated (FERNANDEZ, 2005; FERNANDEZ *et al.*, 2012; MORSE, 2010; PERES *et al.*, 2003). Ways of exploiting resources are labelled "sustainable" on a recurring basis that may have a lesser ecological impact than other more destructive means of exploitation. However, a less damaging form of use does not necessarily imply sustainability (FERNANDEZ, 2005; FERNANDEZ *et al.*, 2012).

Discussion

Based on the concepts and justification presented, the initial questions can be revisited and are shown in the figure below as a means of broaching the elements that are relevant to discussion of these questions.



Agroforestry: diversity and conservation potential – Between both ends of the scale - conventional agricultural systems (on the left) and forestry ecosystems (on the right) - a wide and heterogeneous range of systems that are classed as Agroforestry Systems (AFS) can be seen. They form a gradient in terms of their complexity, biodiversity, sustainability and similarity to natural ecosystems. Hence the question is whether and which AFS are suitable for conservation and for constituting Legal Reserves.

As mentioned, Agroforestry Systems cover many differing practices. Such great variety means it is possible to maximise the benefits from ecologically interdependent groups and provide flexibility in adapting systems to the site, to the environmental characteristics and to the needs, objectives and restrictions of producers and the market (GLIESSMAN, 2009; JOSE; GORDON, 2008). However, many of the combinations labelled "Agroforestry Systems" do not offer the benefits one would normally expect that are associated with AFS (SBPC; ABC, 2011b; SCHROTH; FONSECA; *et al.*, 2004; UMRANI; JAIN, 2010).

The sustainability and degree to which an AFS contributes to conservation efforts depend on a variety of factors, such as the design of the system in terms of its diversity and structure, the landscape it is part of, the location of the AFS in relation to the remaining natural habitats as well as management of the system (pruning, use of inputs, removal of products etc.). Studies suggest that the Agroforestry Systems with the greatest potential for conservation are those that are closest to intact habitats, more diversified, more

similar structurally and functionally to natural ecosystems and managed less intensively (BHAGWAT *et al.*, 2008; JOSE, 2009, 2011, 2012; UMRANI; JAIN, 2010).

According to Schroth; Fonseca *et al.* (2004), only Complex Agroforestry Systems, which are similar in their structure and diversity to forests, present a great degree of potential for conservation in tropical regions. Yet even these AFS, with their exceptionally high level of biodiversity for agricultural systems, are poor replacements for natural forests due to the lack or low quantity of many species that depend on the forest (SCHROTH; HARVEY; *et al.*, 2004).

Scales e Marsden (2008), in reviewing 43 studies that compare the richness or the species diversity among agroforestry systems and adjacent forests, concluded that 34 studies indicated lower species richness in agroforestry than in natural habitats.

The fact of the matter is that even today the effectiveness of strategies that marry production and conservation is controversial and called into question. From the prospective of protecting biodiversity, Phalan *et al.* (2011) stress that designating areas for production that are high in productivity and yields, different to areas for the protection of natural habitats, is more promising than strategies trying to reconcile these two objectives. From the perspective of production, Clough *et al.* (2011) conclude that it is possible to optimise both in the same area as the presence of a high level of biodiversity does not negatively impact on the agricultural productivity of AFS.

Despite the undeniable need to reshape the relationship between humankind and the environment both inside and outside protected areas, and recognising the contribution that the use of agro-ecological principles in conventional productive systems can make to conservation efforts, there is scientific research that shows the importance of and need to maintain specific areas with as little human alteration possible, as fundamental habitats so that species can reproduce and grow in safe conditions. However, there is also scientific data that suggests the opposite; if the precautionary principle is adopted, the search for and improvement of sustainable practices for direct use of natural resources should predominantly take place outside protected areas. In this way, these spaces can prioritize the protection of biodiversity above the needs and social and economic interests of humans (DUDLEY *et al.*, 2010; LOCKE; DEARDEN, 2005; SILVEIRA, 2001).

In general, knowledge of Agroforestry Systems and their ecological-environmental, social and economic aspects is limited. There are more questions than answers, especially as regards the long-term viability of populations of flora and fauna that make up the AFS. The majority of studies have taken stock and monitored biodiversity in little-changed landscapes, focussing on a few *taxa* and over short periods of time and small areas. Studies of biological aspects of communities (that examine multiple *taxa*) and socioeconomic aspects on different scales and in the long term are needed to find out the true level of sustainability (or unsustainability) and the value of AFS to conservation; in addition to making the development of appropriate Agroforestry Systems possible for the various objectives (JOSE; GORDON, 2008; JOSE, 2012; SCHROTH; FONSECA; *et al.*, 2004; UDAWATTA; GODSEY, 2010; UMRANI; JAIN, 2010).

Regardless of their type, Agroforestry Systems normally feature biodiversity levels, both planned and unplanned, above those of conventional agricultural systems

(SCHROTH; FONSECA; *et al.*, 2004). In this way, they tend to be environmentally advantageous as compared to modern agriculture and forestry production methods (ALTIERI; NICHOLLS, 2011; UMRANI; JAIN, 2010). However, as AFS cannot provide the same niches and habitats as the original habitats, they should not be promoted to the detriment of the remaining native vegetation but rather as an important complementary tool in conservation efforts for large areas (JOSE, 2009, 2012; MAY; TROVATTO, 2008; UMRANI; JAIN, 2010). Schroth, Harvey and Vincent (2004) stress that in areas where large tracts of forest remain, the AFS mainly contribute to protecting these fragments; where the remnants are already scarce, the AFS, which usually constitute the last available habitats for fauna and flora, increase the available area for refuge and/or displacement.

Another way for Agroforestry Systems to contribute towards conservation efforts is to use them to recover degraded areas and to restore ecosystems (JOSE, 2012; MAY; TROVATTO, 2008; SCHROTH; FONSECA; *et al.*, 2004; VIEIRA *et al.*, 2009). Viera *et al.* (2009) highlight the benefits of agro-successional restoration[iii]: this extends the restoration management period (making it possible to introduce species at the best possible time), reduces/offsets the process costs, offers food security to small landowners and involves them in the restoration process.

There is one point worth stressing in the context of restoration and/or sustainable use by means of an AFS, that being the different characteristics and objectives of small producers and rural entrepreneurs, which require different types of AFS for each group. Small producers are able and, generally, are interested in managing more diversified crops. Meanwhile large producers, or rural entrepreneurs, have a major interest in reducing their workforce who are employed in planting and maintaining systems as much as possible (VAZ DA SILVA, 2002). Nevertheless, the existing models and experience closest to meeting the conservation and sustainability objectives are biodiverse and complex AFS, which are currently best suited to, and put into practice by, small producers (AS-PTA; ILEIA, 2011; CALDEIRA; CHAVES, 2010; MAY; TROVATTO, 2008; SANTOS, 2010; VIVAN, 1998).

For the Brazilian context, where rural properties that have a registered Legal Reserve are few and far between (BACHA, 2005; DÉSTRO; CAMPOS, 2010; SPAROVEK *et al.*, 2010), AFS stand as a promising alternative in providing the economic stimulus to restore these areas (ABDO *et al.*, 2008; CARDOSO, 2009; MAY; TROVATTO, 2008; RODRIGUES, E. R. *et al.*, 2008). However, permission and use of these systems in these protected areas must carefully observe the factors (type of AFS and landscape context) that determine appropriate compliance with the functions of legal reserves (SBPC; ABC, 2011b), mainly by taking into account the fact that Law No 12.651/2012 provides the interpretation of the permanent character of the exploitation of exotic species in LR areas (Art. 66, Para 4). This differs from the previous Code, which specified that exotic species were planted as pioneers with the objective of restoring the original ecosystem. In this way, it also important that these AFS have a solid ecological basis, following the principles of ecological succession and agro-ecological management practices (ALTIERI; NICHOLLS, 2011; MAY; TROVATTO, 2008; PENEIREIRO *et al.*, 2002).

In a seminar held in 2004 - as part of an initiative of the Brazilian Agroforestry

Network (REBRAF), in partnership with the Ministry of the Environment's Amazon Coordination Secretariat, the International Education Institute of Brazil and the World Agroforestry Centre (ICRAF) -, participants concluded that the majority of AFS in place do not feature enough internal biodiversity to enable this option to be authorised for the objectives of environmental recovery and sustainable use of LRs (MMA; REBRAF, 2005).

The historic failure to comply with environmental legislation has been attributed to the presumed inadequacies and limitations of the legislation in terms of the country's agricultural reality (CNA, 2011). With the recent change to the law, it is expected that the regularisation process for land in Brazil will begin to comply with the new legislation in force. However, the legislation suggests different functions for the LRs as an instrument, without clarifying at the same time how to discharge these functions in practice (IPEF *et al.*, 2012). On the subject of restoration, exploitation and management of legal reserves, the federal legislation features only general guidelines. It is the responsibility of the competent environmental body to specify and apply acceptable criteria and standards for activities in LRs (BRAZIL, 2012). It is essential that precise objectives and goals be defined for the management and effective reconciliation of protecting nature and socioeconomic development. This is all the more so because, in general, the precarious nature of the environmental bodies' institutional structure is a serious problem when it comes to managing native vegetation, and managing and inspecting rural properties in the country. This makes it more difficult to effectively comply with the law so these areas can perform their functions satisfactorily (BACHA, 2005; BERNARDO, 2010; MARQUES; RANIERI, 2012; VIANA *et al.*, 2002). The environmental bodies still have little experience and knowledge of the possibility of applying and using AFS in legal reserves (RAMOS FILHO, 2007). Even outside these protected areas, the practical experiences of AFS are relatively few and far between and are recent. They frequently consist of simplified, low density combinations that are mainly instituted by non-governmental organisations (NGOs) and social movements, and are not significantly monitored by scientific research (AS-PTA; ILEIA, 2011; MAY; TROVATTO, 2008; PENEIREIRO *et al.*, 2002). In the absence of spirited efforts to increase knowledge of the environmental benefits of the different types of AFS on the one hand and, on the other, to equip the State's management structure in such a way that it can guide the setting up, management, inspection and monitoring of AFS that make up Legal Reserves, it is likely that these protected areas will not fulfil their roles appropriately and that the sustainability sought by environmental legislation will not be achieved.

Final Considerations

In such a large and diverse country, the LR instrument should be tailored to Brazil's specificities, not just by taking into account the percentages of LRs required in each region of Brazil, but also in the permitted uses of these areas based on the level of conservation and dimensions of the LRs.

In regions and areas where there is remaining vegetation that is surviving and evolving autonomously, intervention should be kept to the minimum level possible, while, in other areas, humans can sustainably interact with nature by means of AFS or other

practices. In regions and sites that have already been altered and degraded to a great extent, AFS should be promoted in order to restore ecosystems, because the possibility of obtaining economic benefits stimulates interest in promoting the recovery of these areas and the necessary human interaction to manage the system can result in swifter and more effective restoration.

Matching the type of AFS to the size of the LR should not forgo the constant progression towards systems that are increasingly alike natural ecosystems. Nevertheless, the current state of knowledge indicates the potential of systems with a high degree of biodiversity and complexity in both structural and functional terms for small properties; whereas for larger areas, simplified systems still dominate, although efforts are already underway to improve these AFS. The literature shows that the potential of simple AFS for conservation is rather limited and does not guarantee full compliance with the functions of the LR, especially as regards biodiversity. In order to achieve this objective, we recommend a thorough observation of AFS composition, especially in terms of the richness and relative abundance of native species and their population dynamics over the long term.

Notes

[i] Small property or rural family smallholding: "those farmed or worked by the family farmer and rural family entrepreneur in person, including settlements and agrarian reform projects, and which respect the provisions of Art. 3 of Law No 11.326 of 24 July 2006" (Art. 3, paragraph V of Law 12.651/2012).

[ii] Three (environmental, social and economic) suggested by John Elkington in 1990, eight (social, cultural, ecological, environmental, territorial, economic, national policy and international policy) suggested by Sachs (2002), or other proposals (GLAVIČ; LUKMAN, 2007; PAWŁOWSKI, 2008; VUCETICH; NELSON, 2010).

[iii] Agro-successional – incorporates a range of agro-ecology techniques and agro-forestry systems as a transitional phase at the beginning of forest restoration (VIEIRA et al., 2009).

References

ABDO, M. T. V. N.; VALERI, S. V.; MARTINS, A. L. M. Sistemas agroflorestais e agricultura familiar: uma parceria interessante. **Revista Tecnologia & Inovação Agropecuária**, v. Dezembro, p. 50-59, 2008.

ALTIERI, M.; NICHOLLS, C. I. O potencial agroecológico dos sistemas agroflorestais na América Latina. **Revista Agriculturas:** experiências em agroecologia, v. 8, n. 2, 2011.

AS-PTA; ILEIA. **Revista Agriculturas:** experiências em agroecologia, v. 8, n. 2, 2011. ISSN: 1807-491X

BACHA, C. J. C. O uso de recursos florestais e as políticas econômicas brasileiras: uma visão histórica e parcial de um processo de desenvolvimento. **Estudos Econômicos**, v. 34, n. 2, p. 393-426, 2004.

BACHA, C. J. C. Eficácia da política de reserva legal no Brasil. **Revista de Teoria e Evidência Econômica**, v. 13, n. 25, p. 9-27, 2005.

BATISH, D. R.; KOHLI, R. K.; JOSE, S.; SINGH, H. P. **Ecological basis of agroforestry**. Boca Raton: CRC Press, 2008.

BERNARDO, K. T. **Análise do êxito dos sistemas estaduais de gestão de reservas legais com foco no mecanismo de compensação**. 2010. Dissertação (Mestrado). Programa de Pós Graduação em Ciências da Engenharia Ambiental. Universidade de São Paulo, São Carlos. 2010.

BHAGWAT, S. A.; WILLIS, K. J.; BIRKS, H. J. B.; WHITTAKER, R. J. Agroforestry: a refuge for tropical biodiversity? **Trends in Ecology & Evolution**, v. 23, n. 5, p. 261-7, maio 2008.

BRASIL. Lei nº 6.938 de 31 de agosto de 1981. Dispõe sobre a Política Nacional do Meio Ambiente, seus fins e mecanismos de formulação e aplicação, e dá outras providências. **Diário Oficial da República Federativa do Brasil**. Poder Legislativo, Brasília, DF: 02 de Set. Seção 1, 1981. p. 16509.

BRASIL. Lei nº 9.985 de 18 de julho de 2000. Regulamenta o art. 225, parágrafo 1º, incisos I, II, III, VII da Constituição Federal, institui o Sistema Nacional de Unidades de Conservação da Natureza. **Diário Oficial da República Federativa do Brasil**. Poder Legislativo, Brasília, DF: 19 de Jul. Seção 1, 2000. p. 01-06.

BRASIL. Decreto nº 5.758, de 13 de abril de 2006. Institui o Plano Estratégico Nacional de Áreas Protegidas - PNAP, seus princípios, diretrizes, objetivos e estratégias, e dá outras providências. **Diário Oficial da República Federativa do Brasil**. Poder Executivo, Brasília, DF: 17 de Abr. Seção 1, 2006.

BRASIL. Instrução Normativa Ministério do Meio Ambiente n° 04 de 08 de Setembro de 2009. Dos procedimentos técnicos para a utilização da vegetação da RL sob regime de manejo florestal sustentável. **Diário Oficial da República Federativa do Brasil**. Poder Executivo, Brasília, DF: 09 de Set. Seção I. n. 172, 2009a. p. 64-65.

BRASIL. Instrução Normativa Ministério do Meio Ambiente n° 05 de 08 de Setembro de 2009. Dos procedimentos metodológicos para restauração e recuperação das Áreas de Preservação Permanentes e da reserva legal. **Diário Oficial da República Federativa do Brasil**. Poder Executivo, Brasília, DF: 09 de Set. Seção I. n. 172, 2009b. p. 65-66.

BRASIL. LEI Nº 12.651, DE 25 DE MAIO DE 2012. Dispõe sobre a proteção da vegetação nativa; altera as Leis nos 6.938, de 31 de agosto de 1981, 9.393, de 19 de dezembro de 1996, e 11.428, de 22 de dezembro de 2006; revoga as Leis nos 4.771, de 15 de setembro de 196. **Diário Oficial da República Federativa do Brasil**. Poder Legislativo, Brasília, DF: 28 de Mai., 2012.

CALDEIRA, P. Y. C.; CHAVES, R. B. **Sistemas agroflorestais em espaços protegidos**. São Paulo: Secretaria de Estado do Meio Ambiente, Coordenadoria de Biodiversidade e Recursos Naturais, 2010.

CARDOSO, J. H. Ensaio de Sistema Agroflorestal com Espécies Nativas para a Restauração de Áreas de Reserva Legal. **Revista Brasileira de Agroecologia**, v. 4, n. 2, p. 2616-2619, 2009.

CHAPE, S.; SPALDING, M.; JENKINS, M. D. **The World's Protected Areas**. Berkeley: University of California Press, 2008.

CLOUGH, Y.; BARKMANN, J.; JUHRBANDT, J. *et al.* Combining high biodiversity with high yields in tropical agroforests. **Proceedings of the National Academy of Sciences of the United States of America**, v. 108, n. 20, p. 8311-6, 17 maio 2011.

CNA. **Produzir e preservar:** por que precisamos de um novo código florestal? Brasília, DF: Confederação da Agricultura e Pecuária (CNA), 2011.

DÉSTRO, G. F. G.; CAMPOS, S. Implantação de Reservas Legais: Uma nova perspectiva na conservação dos recursos naturais em paisagem rural. **Revista Brasileira Agrícola e Ambiental**, v. 14, n. 8, p. 887-895, 2010.

DUDLEY, N.; PARRISH, J. D.; REDFORD, K. H.; STOLTON, S. The revised IUCN protected area management categories: the debate and ways forward. **Oryx**, v. 44, n. 04, p. 485-490, 2010.

ELI. **Legal tools and incentives for private lands conservation in Latin America:** building models for success. Washington: Environmental Law Institute (ELI), 2003.

ENGEL, V. L. **Introdução aos Sistemas Agroflorestais**. Botucatu: FEPAF, 1999.

FERNANDEZ, F. A. S. Aprendendo a lição de Chaco Canyon: do "Desenvolvimento Sustentável" a uma Vida Sustentável. **Reflexão**, v. Ano 6, n. 15, 2005.

FERNANDEZ, F. A. S.; ANTUNES, P. C.; MACEDO, L.; ZUCCO, C. A. How Sustainable Is The Use of Natural Resources in Brazil? **Natureza & Conservação**, v. 10, n. 1, p. 77-82, 2012.

GALLOPÍN, G. **A systems approach to sustainability and sustainable development**. Santiago: Sustainable Development and Humam Settlements Division, Naciones Unidas, 2003.

GLAVIČ, P.; LUKMAN, R. Review of sustainability terms and their definitions. **Journal of Cleaner Production**, v. 15, n. 18, p. 1875-1885, 2007.

GLIESSMAN, S. R. **Agroecologia:** processos ecológicos em agricultura sustentável. 4. ed. Porto Alegre: Ed. Universidade/UFRGS, 2009.

GOTTFRIED, R.; WEAR, D.; LEE, R. Institutional solutions to market failure on the landscape scale. **Ecological Economics**, v. 18, n. 2, p. 133-140, 1996.

HAUFLER, J. B.; KERNOHAN, B. J. Landscape Considerations for Conservation Planning on Private Lands. In: MILLSPAUGH, J.; THOMPSON, F. R. (Eds.). **Models for planning wildlife conservation in large landscapes**. San Diego: Academic Press, 2009. p. 153-176.

HOCKINGS, M.; PHILLIPS, A. How well are we doing? – some thoughts on the effectiveness of protected areas. **PARKS**, v. 9, n. 2, 1999.

IPEF; PACTO; SMA. **Workshop sobre florestas nativas** - Propostas para subsidiar um plano de implantação de florestas nativas com viabilidade econômica e ecológica.

Piracicaba: Secretaria de Estado de Meio Ambiente; Instituto de Pesquisas e Estudos Florestais; Pacto pela Restauração da Mata Atlântica , 2012

JOSE, S. Agroforestry for ecosystem services and environmental benefits: an overview. **Agroforestry Systems**, v. 76, n. 1, p. 1-10, 2009.

JOSE, S. Managing native and non-native plants in agroforestry systems. **Agroforestry Systems**, v. 83, n. 2, p. 101-105, 2011.

JOSE, S. Agroforestry for conserving and enhancing biodiversity. **Agroforestry Systems**, v. 85, n. 1, p. 1-8, 2012.

JOSE, S.; GORDON, A. M. **Toward Agroforestry Design:** An Ecological Approach - Advances in Agroforestry 4. Dordrecht: Springer, 2008.

LOCKE, H.; DEARDEN, P. Rethinking protected area categories and the new paradigm. **Environmental Conservation**, v. 32, n. 1, p. 1-10, 2005.

MACEDO, R. L. G. **Princípios básicos para o manejo sustentável de sistemas agroflorestais**. Lavras: UFLA / FAEPE, 2000.

MARQUES, E. M.; RANIERI, V. E. L. Determinantes da decisão de manter áreas protegidas em terras privadas: o caso das reservas legais do Estado de São Paulo. **Ambiente & Sociedade**, v. XV, n. 1, p. 131-145, 2012.

MARTINELLI, L. A.; JOLY, C. A.; NOBRE, C. A.; SPAROVEK, G. A falsa dicotomia entre a preservação da vegetação natural e a produção agropecuária. **Biota Neotropica**, v. 10, n. 4, 2010.

MARTINS, T. P. **Sistemas agroflorestais como alternativa para recomposição e uso sustentável das reservas legais**. 2013. Dissertação (Mestrado). Programa de Pós Graduação em Ciências da Engenharia Ambiental. Universidade de São Paulo, São Carlos. 2013.

MAY, P. H.; LUSTOSA, M. C.; VINHA, V. **Economia do meio ambiente:** teoria e prática. Rio de Janeiro: Elsevier, 2003.

MAY, P. H.; TROVATTO, C. M. M. **Manual agroflorestal para a Mata Atlântica**. Brasília: Ministério do Desenvolvimento Agrário, Secretaria de Agricultura Familiar, 2008.

METZGER, J. P. Bases biológicas para a "reserva legal". **Ciência Hoje**, v. 3, n. 183, p. 48-49, 2002.

METZGER, J. P. O Código Florestal tem base científica? **Natureza & Conservação**, v. 8, n. 1, 2010.

MMA; REBRAF. **Políticas Públicas e Financiamento para o Desenvolvimento Agroflorestal no Brasil**. Brasília, DF: Ministério do Meio Ambiente e Instituto Rede Brasileira Agroflorestal, 2005.

MORSE, S. **Sustainability:** A Biological Perspective. Cambridge: Cambridge University Press, 2010.

NAIR, P. K. R. The coming of age of agroforestry. **Journal of the Science of Food and Agriculture**, v. 87, p. 1613-1619, 2007.

NAIR, P. K. R. Agroforestry Systems and Environmental Quality: Introduction. **Journal of Environmental Quality**, v. 40, n. 3, p. 784-90, 2011.

PAWŁOWSKI, A. How many Dimensions Does Sustainable Development Have? **Sustainable Development**, v. 16, p. 81-90, 2008.

PENEIREIRO, F. M. **Fundamentos da agrofloresta sucessional**. Artigo apresentado no II Simpósio sobre Agrofloresta Sucessionais, em Sergipe. 2003. Disponível em: <http://www.agrofloresta.net/2010/07/fundamentos-da-agrofloresta-sucessional/>. Acesso em mar. 2012.

PENEIREIRO, M.; RODRIGUES, Q. F.; BRILHANTE, M. O.; LUDEWIGS, T. **Apostila do educador agroflorestal** - Introdução aos sistemas agroflorestais: um guia técnico. Rio Branco: Editora da Universidade / UFAC, 2002.

PERES, C. A.; BAIDER, C.; ZUIDEMA, P. *et al.* Demographic threats to the sustainability of Brazil nut exploitation. **Science**, v. 302, n. 5653, p. 2112-4, 2003.

PHALAN, B.; ONIAL, M.; BALMFORD, A.; GREEN, R. E. Reconciling food production and biodiversity conservation: land sharing and land sparing compared. **Science**, v. 333, p. 1289-91, 2011.

RAMOS FILHO, L. O. **Uso de sistemas agroflorestais para recuperação de APP e Reserva Legal na agricultura familiar**. 2007. Sumário de palestra apresentada em 21 de novembro de 2007, no I Fórum sobre Área de Preservação Permanente e Reserva Legal na Paisagem e Propriedade Rural, ESALQ/USP - Piracicaba. Disponível em: < http://www.sigam.ambiente.sp.gov.br/sigam2/Repositorio/222/Documentos/forum%20app/20071_Uso2_Luiz_EMBRAPA.pdf>. Acesso em: 2011.

RANIERI, V. E. L.; MORETTO, E. M. Áreas protegidas: por que precisamos delas? **Engenharia Ambiental:** conceitos, tecnologia e gestão. São Paulo: Elsevier, 2012. p. 717-740.

RODRIGUES, E. R.; CULLEN JÚNIOR, L.; MOSCOGLIATO, A. V.; BELTRAME, T. P. O uso do sistema agroflorestal Taungya na restauração de reservas legais: indicadores econômicos. **FLORESTA**, v. 38, n. 3, p. 517-525, 2008.

ROGERS, P. P.; JALAL, K. F.; BOYD, J. A. **An introduction to sustainable development**. London: Earthscan, 2008.

SACHS, I. **Caminhos para o desenvolvimento sustentável**. Rio de Janeiro: Garamond, 2002.

SANTOS, A. C. **O papel dos sistemas agroflorestais para usos sustentáveis da terra e políticas públicas relacionadas** - Indicadores de Funcionalidade Econômica e Ecológica de SAFs em Redes Sociais da Amazônia e Mata Atlântica. Brasília: Ministério do Meio Ambiente, Subprograma Projetos Demonstrativos (PDA), 2010.

SBPC; ABC. **O Código Florestal e a Ciência:** Contribuições para o Diálogo. São Paulo: Sociedade Brasileira para o Progresso da Ciência, SBPC; Academia Brasileira de Ciências, ABC, 2011a.

SBPC; ABC. **Propostas e considerações da Sociedade Brasileira para o Progresso da Ciência (SBPC) e Academia Brasileira de Ciências (ABC) acerca da reforma do Código Florestal (PLC 30/2011)**. Sociedade Brasileira para o Progresso da Ciência, SBPC; Academia Brasileira de Ciências, ABC. , 2011b. Disponível em: < http://www.socioambiental.org/banco_imagens/pdfs/Propostas_Mudanca_Pontos_Codigo_Florestal_Out_2011.pdf>. Acesso em: 2011.

SCALES, B. R.; MARSDEN, S. J. Biodiversity in small-scale tropical agroforests: a review of species richness and abundance shifts and the factors influencing them. **Environmental Conservation**, v. 35, n. 2, p. 160-172, 2008.

SCHROTH, G.; FONSECA, G. A. B.; HARVEY, C. A. *et al.* Introduction: The Role of Agroforestry in Biodiversity Conservation in Tropical Landscapes. In: SCHROTH, G.; FONSECA, G. DA; HARVEY, C. *et al.* (Eds.). **Agroforestry and Biodiversity Conservation in Tropical Landscapes**. Washington: Island Press, 2004. p. 1-12.

SCHROTH, G.; HARVEY, C. A.; VINCENT, G. Complex Agroforests: Their Structure, Diversity, and Potential Role in Landscape Conservation. In: SCHROTH, G.; FONSECA, G; HARVEY, C. *et al.* (Eds.). **Agroforestry and Biodiversity Conservation in Tropical Landscapes**. Washington: Island Press, 2004. p. 227-260.

SILVEIRA, P. C. B. Parks in Peril: People, Politics and Protected Areas. **Ambiente & Sociedade**, v. IV, n. 9, p. 157-162, 2001.

SOUZA, H. N.; GRAAFF, J.; PULLEMAN, M. M. Strategies and economics of farming systems with coffee in the Atlantic Rainforest Biome. **Agroforestry Systems**, v. 84, p. 227-242, 2011.

SPAROVEK, G.; BARRETO, A.; KLUG, I. L. F.; PAPP, L.; LINO, J. A revisão do Código Florestal brasileiro. **Novos Estudos**, v. 89, p. 111-135, 2011.

SPAROVEK, G.; BERNDES, G.; BARRETTO, A. G. D. O. P.; KLUG, I. L. F. The revision of the Brazilian Forest Act: increased deforestation or a historic step towards balancing agricultural development and nature conservation? **Environmental Science & Policy**, v. 16, p. 65-72, 2012.

SPAROVEK, G.; BERNDES, G.; KLUG, I. L. F.; BARRETTO, A. G. O. P. Brazilian agriculture and environmental legislation: status and future challenges. **Environmental Science & Technology**, v. 44, n. 16, p. 6046-53, 2010.

TORQUEBIAU, E. F. A renewed perspective on agroforestry concepts. **C.R. Acad. Sci. Paris, Sciences de la vie / Life Science**, v. 323, p. 1009-1017, 2000.

UDAWATTA, R. P.; GODSEY, L. D. Agroforestry comes of age: putting science into practice. **Agroforestry Systems**, v. 79, n. 1, p. 1-4, 2010.

UMRANI, R.; JAIN, C. K. **Agroforestry Systems and Practices**. Jaipur: Oxford Book Company, 2010.

VAZ DA SILVA, P. P. **Sistemas agroflorestais para recuperação de matas ciliares em Piracicaba, SP**. 2002. Dissertação (Mestrado). Programa de Pós Graduação em Ciências Florestais. Universidade de São Paulo, Piracicaba. 2002.

VEIGA, J. E. **Desenvolvimento sustentável:** o desafio do século XXI. 3. ed. Rio de Janeiro: Garamond, 2010.

VIANA, V. M. Envolvimento sustentável e conservação das florestas brasileiras. **Ambiente & Sociedade**, p. 241-244, 1999.

VIANA, V. M.; MAY, P. H.; LAGO, L.; DUBOIS, O.; GRIEG-GRAN, M. **Instrumentos para o manejo sustentável do setor florestal privado no Brasil.** Uma análise das necessidades, desafios e oportunidades para o manejo de florestas naturais e plantações florestais de pequena escala. Londres: International Institute for Environment and Development, 2002.

VIEIRA, D. L. M.; HOLL, K. D.; PENEIREIRO, F. M. Agro-Successional Restoration as a Strategy to Facilitate Tropical Forest Recovery. **Restoration Ecology**, v. 17, n. 4, p. 451-459, 2009.

VIVAN, J. L. **Agricultura e Florestas:** princípios de uma interação vital. Guaíba: Livraria e Editora Agropecuária, 1998.

VIVAN, J. L. **O papel dos sistemas agroflorestais para usos sustentáveis da terra e políticas públicas relacionadas** - Relatório Síntese e Estudos de Caso. Brasília: Ministério do Meio Ambiente, Subprograma Projetos Demonstrativos (PDA), 2010.

VUCETICH, J. A.; NELSON, M. P. Sustainability: Virtuous or Vulgar? **BioScience**, v. 60, n. 7, p. 539-544, 2010.

WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT (WCED). **Our common future**. Oxford: Oxford University Press, 1987.

YAMADA, M.; GHOLZ, H. L. An evaluation of agroforestry systems as a rural development option for the Brazilian Amazon. **Agroforestry Systems**, p. 81-87, 2002.

Submitted on: 15/12/2012
Accepted on: 14/05/2014

AGROFORESTRY AS AN ALTERNATIVE TO LEGAL RESERVES

Abstract: According to Brazilian environmental law, agroforestry systems (AFS) are an alternative to restoration and use of legal reserves (RL). However, since AFS comprises very heterogeneous practices, it is pertinent to discuss whether and which systems are adequate to fulfill de functions of these protected areas. This paper presents relevant elements and considerations to these questions, based on literature review. The literature indicates that the value and potential of AFS for conservation are limited and controversial; AFS's sustainability and benefits depend on their structure, diversity, management and the surrounding landscape. Therefore, it is essential to establish criteria and limits to use AFS in environmental restoration and exploitation of RL that consider the degree of conservation and the extent of RL and be based on studies about the ecological/environmental feasibility of these systems in a long term.
Keywords: Legal Reserve; Agroforestry; Sustainability.

Resumo: De acordo com a legislação ambiental brasileira, os Sistemas Agroflorestais (SAF) constituem uma alternativa para recomposição e uso das Reservas Legais (RL). Todavia, uma vez que SAF compreendem práticas muito heterogêneas, é pertinente discutir se, e quais Sistemas são adequados para cumprir as funções dessas áreas protegidas. O presente artigo visa apresentar elementos e considerações pertinentes a essas questões, com base em ampla revisão bibliográfica. A bibliografia aponta que o valor e potencial dos SAF para a conservação são limitados e controversos; a sustentabilidade e os benefícios proporcionados por esses Sistemas dependem de sua tipologia (estrutura e diversidade), da paisagem do entorno e da condução do manejo. Portanto, é imprescindível estabelecer critérios e limites para o uso dos SAF na restauração e exploração das RL, que considerem o grau de conservação e a extensão das RL e baseiem-se em estudos sobre a viabilidade ecológica e/ou ambiental desses Sistemas a longo prazo.

Palavras-chave: Reserva Legal; Sistemas Agroflorestais; Sustentabilidade.

Resumen: De acuerdo con la legislación ambiental brasileña, los Sistemas Agroforestales (SAF) son una alternativa para la restauración y el uso de las Reservas Legales (RL). Sin embargo, como los SAF comprenden prácticas heterogéneas, es pertinente discutir si, y qué Sistemas son los adecuados para cumplir las funciones de estas áreas protegidas. Este artículo presenta los elementos y las consideraciones pertinentes a estas cuestiones, basados en una extensa revisión de la literatura. La literatura indica que el valor y el potencial de los SAF para la conservación son limitados y polémicos; la sostenibilidad y los beneficios que proporcionan estos Sistemas dependen de su estructura y diversidad, del manejo y del

paisaje su entorno. Por tanto, es imprescindible establecer criterios y límites para el uso de los SAF en la restauración y exploración de las RL, que consideren el grado de conservación y extensión de las RL y estén basados en estudios sobre la viabilidad ecológica/ambiental de estos Sistemas en el largo plazo.

Palabra clave: Reservas Legales; Agroforestería; Sostenibilidad.