

1 **Agroforestry Systems on Brazilian Legal Protected Lands:**
2 **Permanent Preservation Areas (PPA) and Legal Reservation Areas (LRA)**



3
4 **ABSTRACT**

5 Forests preservation and restoration are crucial, to sustain ecological and social benefits.
6 However, forest lands have been reducing around the world. In the context of forest
7 restoration, agroforestry systems are important land use instruments, because they allow
8 food production combined with sustainable forest management. There are different kinds
9 of agroforestry systems, and they can occur in degraded areas and also in forested areas
10 which are legally protected or not. In Brazil, where forests cover 46.5% of land area,
11 deforestation continues and there are several challenges to protect and restore forests. In
12 this case, it is necessary to advance sustainable forest management to protect the
13 remaining forests, to restore forest lands and to permit uses which contribute to Brazilian
14 society, especially to the campesinos. *Permanent Preservation Areas (PPA)* and *Legal*
15 *Reservation Areas (LRA)*, which have been institutionalized in Brazilian Environmental
16 Legislation require the maintenance of areas with native vegetation within rural properties
17 restricting certain activities, accordingly with this understanding, the legislation limits the
18 possibility of obtaining income from agricultural activities. Historically, they have not
19 been duly respected by most landowners where riverbanks, springs, slopes and other areas
20 that should be preserved have been occupied suppressing natural vegetation. Thus, there
21 are possibilities for ecological management and use of protected areas, specifically *PPA*
22 and mainly *LRA*, which seek to both preserve environmental resources and contribute to
23 food production and income, especially in the campesino smallholders. This paper
24 discusses possibilities and limitations of using agroforestry systems in *PPA* and *LRA*,
25 pointing out that agroforestry systems are also feasible for restoring degraded areas and
26 for expanding enriched areas and uses of their natural resources. Despite legal
27 possibilities, a historical problem in Brazil is related to the lack of compliance with
28 environmental legislation. Moreover, in actuality the scenario of deforestation and several
29 difficulties to advance in environmental management in Brazil have been harming this
30 conservationist possibilities. There is much to be done to facilitate the expansion of
31 agroforestry systems, such as investments in research, extension and public policies that
32 provide grants and loans for this kind of management.

33
34 **Keywords:** Forest Legislation. Deforestation. Agroforestry for Environmental
35 Objectives. Biodiversity.

36

37

38

39

40 **1 Introduction**

41 Certain human activities such as wood extraction, agriculture, forestry and
42 intensive livestock raising, in addition to urban sprawl and industrialization, have been
43 responsible for reducing natural forest cover around the world. These processes lead to
44 harmful consequences for the dynamics of ecosystems, including the loss of biodiversity
45 (plant and animal), erosion and loss of soil fertility, silting of watercourses, etc.

46 To decrease these problems, Environmental Legislation aims to regulate the land
47 use and occupation, especially regarding the institution of rights and duties/obligations
48 related to natural resources. In Brazil, the natural environment is considered a good of
49 common use (Milaré, 2007).

50 The Brazilian Environmental Legislation, specifically from 1965 through Law
51 4,771/65, requires the maintenance of areas with native vegetation within rural properties,
52 by the following legal mechanisms: the *Permanent Preservation Areas (PPA)* and the
53 *Legal Reservation Areas (LRA)*. These two legal figures restrict certain activities to favor
54 environmental preservation and conservation. History tells us, these areas have not been
55 properly respected by some rural property owners, as well as by the government in the
56 process of rural and urban engagement. Thus, riverbanks, springs, slopes and other areas
57 that should be preserved have been absorbed, suppressing natural vegetation in all
58 Brazilian biomes and ecosystems.

59 To the present date, many lands that should be destined for PPA and LRA continue
60 to be cleared, because farmers consider the legislation useless or unnecessary.
61 Understanding that these areas limit the possibility of obtaining income, most Brazilian
62 farmers oppose the requirements of forest legislation. Although, there are legal
63 possibilities for the management and use of PPA and mainly of LRA, which can
64 contribute to farmers' food and income, especially those that have smallholdings, called
65 "small property" or "family rural tenure" in Brazilian legislation (Law 12,651/2012).
66 Among these alternatives agroforestry systems stand out.

67 Agroforestry is a collective name for land-use systems in which woody
68 perennials (trees, shrubs, etc.) are grown in association with herbaceous
69 plants (crops, pastures) or livestock, in a spatial arrangement a rotation,
70 or both; there are usually both ecological and economic interactions
71 between the trees and other components of the system. (Lundgren,
72 1982: 3).

73
74 In a global context where agriculture demands much of natural resources, such as
75 water and soil, environmental impacts (deforestation, biodiversity loss, etc.) occur and

76 contribute to environmental contamination (with wide pesticides and fertilizers use) it is
77 necessary to create and implement sustainable land use strategies. In this perspective,
78 agroforestry systems, mainly agroecological and diversified are an important example.

79 Food and Agriculture Organization (FAO) of the United Nations (UN) points out
80 that agroforestry is crucial to smallholder farmers and other rural people because it can
81 enhance their food supply income and health.¹

82 Despite the different agroforestry systems, from the simplest (for economic
83 purposes) to the most complex (which in addition to production, aim to conserve the forest
84 with native species) (Miller, 2009), they are, generally, understood in Brazilian law as
85 agroforestry systems (SAF) (Brazil, 2009 and 2012) or agroforestry and
86 *agrossilvipastoril*² systems (Brazil, 2012).

87 Considering a historic process of inadequate land settlement in Brazil where
88 forests and other natural vegetation have been suppressed for agriculture, pastural, and
89 other uses, discuss and present actions which combine food production and biodiversity
90 restoration, like agroecological agroforestry systems is very important.

91 By the provisions of Law 12,651/2012, which instituted the “new” Brazilian
92 Forest Code, in Resolutions 369/2006, 425/2010 and 429/2011 of the National Council
93 of the Environment (CONAMA) and in Normative Instruction 5/2009 of the Ministry of
94 the Environment, we sought to analyze in what sense agroforestry systems have been
95 covered in Brazilian legislation to discuss how agroforestry systems can be implemented
96 in areas of LRA and PPA.

97 The methods of this article utilized literature about land and forestry management
98 systems (concept, basic principles, kinds), highlighting the difference between simple and
99 diversified/agroecological systems; an analysis of the legislative tools that govern forest
100 protection in Brazil, especially Law 12,651/2012; data of forest cover and deforestation
101 in Brazil (supplementary file); and results and conclusions from similar literature which
102 analyzed questions related to agroforestry systems in the country. With this information,
103 we have discussed possibilities of agroforestry management in PPA and LRA, reflecting
104 about difficulties and challenges for expansion of agroforestry systems in Brazil.

¹ Available at <<http://www.fao.org/forestry/agroforestry/80338/en/>>.

² The word *agrossilvipastoril* means a combination of agriculture, planted trees and pasture land use.

105 The article is structured in four sections and a supplementary file beyond
106 introduction and conclusion. The supplementary file provides data about world forest
107 configuration and deforestation, to highlight the importance of Brazilian forests.

108 Section 1: provides an overview of the topics of the article. Section 2: discusses
109 briefly agroforestry systems basic principles in the context of sustainable forest
110 management. Section 3: presents elements of Brazilian forest legislation foremost PPA
111 and LRA. Section 4: argues the possibilities of agroforestry use in PPA and LRA
112 considering Brazilian legislation. Section 5: discusses the feasibility and difficulties for
113 applying agroforestry in PPA and LRA, considering actual challenges to advance in the
114 accomplishments of environmental and forest legislation in Brazil. Section 6: provides a
115 conclusion.

116

117 **2 Agroforestry for Sustainable Forest Management**

118 In the context of forest restoration, agroforestry systems are important land use
119 tools because they allow food production (plants and animals) combined with forest
120 rehabilitation and sustainable management. The goals, principles, history and kinds of
121 agroforestry systems are discussed by international (Lundgren, 1982; De Jong et al.,
122 2001; Mead, 2004; Roshetko et al., 2008; Smith, 2010; Umrani and Jain, 2010) and
123 Brazilian authors (May and Trovatto, 2008; Deitenbach, 2008; Porro, 2009; Miller, 2009;
124 Ewert et al., 2016).

125 The term agroforestry is an “umbrella” term for those land-use practices
126 and technologies where trees or other woody perennials are deliberately
127 grown with crops, pastures or animals on farms. [...] agroforestry as a
128 dynamic, ecologically based, natural resource management system that,
129 through the integration of trees on farms and in the agricultural
130 landscape, diversifies and sustains production for increased social,
131 economic and environmental benefits for land users at all levels. [...] it
132 is seen by many as a means of poverty alleviation, particularly for rural
133 peoples. The scientific application is relatively new, although many of
134 the practices are ancient. (Mead, 2004: 8).

135

136 Agroforest consists of land use that combines ‘planted trees’ with forest flora and
137 fauna, either retained or naturally regenerated vegetation (De Jong et al., 2001), creating
138 environmental, economic, and social benefits (USDA, 2019³).

³ Available <https://www.usda.gov/topics/forestry/agroforestry>

139 Agroforestry is a productive and sustainable alternative for socioenvironmental
140 contexts. They allow a dynamic and ecological management of natural resources,
141 contributing to the maintenance of biodiversity and to the food and income of farming
142 families (Porro, 2009).

143 There is potential for an agroforestry ecosystem to move from a
144 relatively simple one to one of greater complexity, which is akin to
145 natural succession in forests. [...] The three basic components of an
146 agroforestry land-use system are the tree or woody perennial, the
147 herbaceous component, and animals. Agroforestry systems must have
148 trees and at least one of the other components. This is the basis of the
149 classification into trees plus crops (agrosilvicultural), trees plus pastures
150 and/or animals (silvopastoral), and trees plus crops and animals
151 (agrosilvopastoral). (Mead, 2004: 11).
152

153 Agroforestry can contribute to reducing agriculture's vulnerability to climate
154 change, improve water quality and availability among other services. It also can increase
155 and diversify farmers' incomes, allow them to have access to more nutritious food and
156 impel other social benefits. Because agroforestry integrates multiple natural components,
157 it necessarily brings together people from diverse fields of knowledge. (FAO, 2015⁴).

158 "Tree planting in agroforests can occur in an open field stage, often in between
159 food crops, or in small gaps or clearings in existing forest." (Roshetko et al., 2008: 466).
160 Agroforestry can occur in degraded areas and in forested areas legally protected or not.
161 For each area there are different kinds of agroforestry systems that can be applied
162 according to farmer opposition and interest.

163 Roshetko et al. (2008) present four kinds of tree-based land use systems: 1)
164 *Natural forests*; 2) *Sustainably Managed Forests*; 3) *Forest and Tree Plantations*, with a
165 commercial goal and one or two planted species; and 4) *Smallholder Tree-Based Systems*.
166 For the discussion in this paper, we will focus on *smallholder agroforestry systems* (4),
167 understanding that this kind of land use is possible and viable in Brazilian protected areas,
168 i.e., PPA and LRA, especially in "campesino"⁵ properties.

169 Considering that smallholder tree-based systems play significant roles in the
170 livelihoods of local communities it is important to 1) recognize the contribution and
171 importance of smallholder agroforestry systems; 2) provide technical support; 3) adopt

⁴ Available <http://www.fao.org/forestry/agroforestry/80338/en/>

⁵ The term "campesino" refers to farmers who live and work in smallholders. It is a word from Spanish language which has been used in academic literature around the world. In Brazil, Law 11,326/2006 use the terms "family farmer" and "family agriculture".

172 holistic and sustainable strategies to support and strengthen the market orientation; 4)
173 develop supportive institutions and policies (rules and organizations); 5) utilize enabling
174 conditions that support the success of these systems (Roshetko et al., 2008).

175 According to Mead (2004: 10), “in both the developing and industrialized world,
176 agroforestry is now accepted as an important land-use system, driven by the need to create
177 sustainable and robust agroforestry ecosystems.”

178 In Brazil, despite forest covering 46.5% of land area (Mapbiomas, 2021),
179 deforestation continues and there are several challenges to forest protection and
180 conservation. In this sense, it is necessary to advance sustainable strategies for forest
181 management, to protect the forests and to permit uses which could contribute to Brazilian
182 society, especially campesinos. In this context, complex agroforestry systems can play an
183 important role to improve campesino lives.

184 Miller (2009) differentiates two major groups of agroforestry in Brazil: 1) based
185 on an agroecological perspective, that seek to combine food production and restore forests
186 with diverse native species and 2) agronomic and conventional systems, which are based
187 on few species and seek to produce wood. The first works with dense planting, diversified
188 species, rapid accumulation of organic matter, ecological and economic stability
189 contributing to biodiversity. The second promotes lower density and diversification of
190 species, few species and interactions, offering fewer products. In this sense, our focus is
191 to discuss the possibilities of agroforest land use in PPA an LRA in smallholder are based
192 on agroecological agroforestry systems.

193 The sequences in addressing this thesis are, the main Brazilian laws of forest
194 protection, the definitions of PPA and LRA and the possibilities of management in these
195 areas with agroecological agroforestry systems.

196

197 **3 Brazilian Forest Legislation and Agroforestry in the Context**

198 **3.1 Background and Overview of Forest Protection**

199 The legal instruments that direct the Legislation have different segments. No legal
200 device can be above or contradictory to the content of the Federal Constitution. The
201 Legislative Power is responsible for creating Laws, whether at the Federal (Chamber of

202 Deputies and Federal Senate), interstate (Legislative Assemblies) or Municipal (City
203 Councils) levels⁶.

204 To make some Law acceptable it is necessary to regulate it by Decrees, which are
205 prepared by law-related agencies. The elaboration of a Decree by the Ministry of the
206 Environment (ME), which is sanctioned by the President of the Republic, is essential to
207 regulate a Law on the environment. Another legal tool is normative instructions (NIs),
208 which details contents, administrative procedures and permitted and prohibited practices.

209 Other bodies with attributions in the environmental area are the Environmental
210 Councils. The main Council at the Federal level is the National Council of the
211 Environment (CONAMA). The states of the federation and municipalities must also have
212 their Councils. The councils aim at expanding the participation of sectors involved with
213 the environmental issue (public, private or social organizations).

214 Regarding forest protection standards, the first to be published in Brazil was in
215 1934, through Decree 23,793/34, which institutionalized the first Brazilian Forest Code.
216 The main objective of the Decree was to order the exploitation of forest resources (Zakia
217 and Derani, 2006).

218 In the 1960s, with the emergence of the ecological movement, new legislative
219 texts were institutionalized to the prevention and control of environmental degradation⁷,
220 Forest Code (Law 4,771/65).

221 In 1965, through the enactment of Law 4,771, a new Forest Code was established
222 in Brazil. Unlike the 1934 Code, which dealt with the protection of forests against the
223 dilapidation of the country's forest cover, limiting individuals to the unrestricted power
224 over rural properties the new text of 1965 had an interventionist state policy on private
225 property. Forests came to be considered goods of common interest of the country
226 (Laureano and Magellan, 2011).

227 The Forest Code of 1965 also established the *Permanent Preservation Area (PPA)*
228 and the *Legal Reservation Area (LRA)*, which, although not properly delimited and
229 maintained by most of landowners, constitute legal requirements to date. This Law could

⁶ There are 27 states and 5,570 municipalities in Brazil.

⁷ Other Laws in this context are the Land Statute (Law 4,504/64); the Wildlife Protection Act (Law 5,197/67); the Fishing Code (Decree 221/67); the Mining Code (Decree 227/67); and the National Basic Sanitation Policy (Decree 248/67) (Milaré, 2007).

230 have been a milestone for the effective protection of forests throughout Brazilian territory
231 whether in rural or in urban areas.

232 If it had been fulfilled since 1965, the process of land use in Brazil would have
233 taken place with more caution, protecting areas with greater environmental fragility
234 (wetlands, areas with high slopes, refuges for plant and animal biodiversity). Though, the
235 Law has not properly applied, generating problems that continue. The lack of adequate
236 environmental management with guidance, inspection and enforcement of infractions has
237 made this law ineffective.

238 Recently, Law 4,471/65 and other legislative tools⁸, were repealed or amended
239 with the new Forest Code, institutionalized through Law 12,651/2012. Considering the
240 relevance of this Law, called “new Brazilian Forest Code” either as an incentive for
241 conservation and forest preservation, or as a limiting factor in the expansion of
242 agribusiness, it is worth mentioning that it was developed and approved after various
243 debates between the “ruralist bench” (composed by politicians linked to agribusiness) and
244 environmental groups in the country⁹.

245 It indicates different intentions and territorialities, and despite the enactment of
246 the Law, continue to exist. Although, the debates on Law 12,651/2012 lasted for months
247 involving meetings, consultation with specialists and public hearings, environmentalists
248 and many environmental and forestry researchers concluded that the agribusiness sector
249 managed to press their interests on this law.

250 On the other hand, many argue that Law 12,651/2012 allowed the legal
251 regularization of thousands of rural establishments, which were not in compliance with
252 Law 4,471/65. Through the creation of “consolidated rural areas”, Law 12,651/2012
253 made it possible to regularize construction and occupation of areas that should have been
254 preserved. Still, it is necessary to consider why these establishments did not follow the
255 provisions of the 1965 Law?

256 The Forest Code requires the maintenance/preservation of a portion of the rural
257 property with existing native or secondary vegetation and if there is no such vegetation,
258 forest regeneration within rural properties is necessary. The two legal figures of forest

⁸ Laws 4,471/65, 7,754/89 and Provisional Measure 2,166-67/2001 have been repealed and Laws 6,938/81, 9,393/96, and 11,428/2006 have been amended.

⁹ The debate about the construction process and the changes that occurred in the Forest Code promulgated in 2012 will not be addressed here. The documentary “The Law of Water”, available in <https://www.youtube.com/watch?v=jgq_SXU1qzc> presents the main points that generated controversy in this context.

259 preservation/conservation are the so-called *Permanent Preservation Areas (PPA)* and
260 the *Legal Reservation Areas (LRA)*. In them, especially in PPA activities are restricted.
261 Even so, there are possibilities of conservation use in these areas.

262 These areas are similar, but have different usage and restrictions. They play
263 important roles such as maintaining and/or restoring forest areas. Even though, PPA and
264 LRA are the target of criticism from the agribusiness sector because they are seen as
265 useless from an economic perspective.

266 Many farmers revolt against environmental laws without realizing that they fight
267 against ecosystems, which have an immeasurable wealth and if properly managed, can
268 bring environmental and economic benefits. In the midst of existing environmental
269 conflicts related to compliance with environmental legislation, types of conservation use,
270 such as agroforestry systems appear as a strategy for the environmental regularization of
271 protected areas in rural properties, i.e., PPA and LRA (Meirelles, 2003).

272

273 **3.2 Permanent Preservation Areas (PPA) and Legal Reservation Areas (LRA)**

274 The concept of PPA was established in Law 4,771/65 and was not changed in the
275 new Forest Code (Law 12,651/2012). It legally corresponds to a:

276 protected area covered or not by native vegetation, with the
277 environmental function of preserving water resources, landscape,
278 geological stability, and biodiversity, facilitating the gene flow of fauna
279 and flora, protecting the soil, and ensuring the well-being of human
280 populations (Brazil, 2012, Article 3rd, III).

281

282 Unlike the LRA, which can be instituted in any portion of the rural property, PPA
283 are delimited according to the relief and hydrography of the rural property.

284 PPA¹⁰ are the marginal strips of any natural watercourse, from the edge of the
285 regular watercourse bed, areas around the lakes and natural lagoons, the areas surrounding
286 artificial water reservoirs resulting from impoundment or damming of natural
287 watercourses [...]; the areas around the springs [...]; the slopes [...] greater than 45°; the
288 *restingas*¹¹; the mangroves; the edges of the plateaus; on top of hills; and areas at an
289 altitude greater than 1,800 meters (Brazil, 2012, Article 4h).

¹⁰ Article 4th of Law 12,651/2012 provides in detail the delimitations corresponding to PPA (BRASIL, 2012).

¹¹ *Restinga* is a sandy deposit parallel to the coastline, generally elongated, produced by sedimentation processes, where different communities that receive marine influence are found, with mosaic vegetation cover, found on beaches, sandy ridges, dunes and depressions, presenting, according to the successional stage, herbaceous, shrubby and arboreal strata. (BRASIL, 2012, Article 3rd, XVI).

290 Considering that diverse ecosystems encompass PPA, agroforestry systems could
 291 be recommended for marginal strips of natural watercourses (Chart 1) and natural
 292 lagoons, areas surrounding artificial water reservoirs and slopes greater than 45°, only if
 293 these areas have been without natural vegetation.

294 **Chart 1: Width of the Marginal Watercourse Range of the PPA**

Width of Regular Watercourse (meters)	Marginal Band (meters)
Less than 10	30
10 to 50	50
50 to 200	100
200 to 600	200
Higher than 600	500

295 Source: Law 12,651/2012 Chapter II, Article 4th.

296

297 Yet, in the case of proof of the existence of “consolidated rural areas” in “small”
 298 properties (smaller than 4 fiscal modules¹²), the requirements in terms of the size of the
 299 marginal areas to the watercourses were reduced. Article 61-A of Law 12,651/2012
 300 details this flexibilization.

301 As in the case of PPA, LRA was practically not changed in the current Forest
 302 Code (Law 12,651/2012). The LRA corresponds to an:

303 area located within a property or rural property, delimited in accordance
 304 with art. 12, with the function of ensuring the sustainable economic use
 305 of the natural resources of the rural property, assisting the conservation
 306 and rehabilitation of ecological processes, and promoting the
 307 conservation of biodiversity, as well as the shelter and protection of
 308 wild fauna and native flora (Brazil, 2012, Article 3rd).

309

310 The LRA is a percentage of the rural property according to the total area of the
 311 property. Article 12 defines the percentage that each region needs to maintain in rural
 312 properties and this area can be delimited by the owner. This law establishes that “every
 313 rural property must maintain an area with native vegetation cover as a LRA, without
 314 prejudice to the application of the rules on PPA” (Brazil, 2012, Article 12).

315 Article 12 of Law 12,651/2012 provides the percentage that each region needs to
 316 maintain in rural properties with native vegetation as a LRA which are: I - located in the

¹² In Brazil, the size of a fiscal module in an agricultural establishment (farm) varies between municipalities, with the smallest being 50,000 m² and the largest being 1,100,000 m². Thus, the area of an establishment with up to 4 fiscal modules can reach 4,400,000 m².

317 Legal Amazon: a) 80% in the property located in forest area, b) 35% in the property
318 located in Cerrado¹³ area, c) 20% in the property located in general field area, II - located
319 in the other regions of the country: 20% (Brazil, 2012, Article 12). Therefore, except for
320 the Amazon Biome in the other Brazilian biomes, including the Atlantic Forest, it is
321 required that 20% of each rural property be destined as LRA.

322 LRA is a portion of the rural property that must be destined to forest conservation
323 (Delduque, 2008). If the area were preserved it can be maintained. If LRA were without
324 natural vegetation or with some land use, legislation allows sustainable management, like
325 agroforestry. Despite the priorities for the delimitation of LRA it is necessary to question
326 if the criteria and studies to define the location of legal reservation areas, present in Article
327 14 of Law 12,651/2012, will be properly followed, and conducted.

328 LRA could be in strategic areas to contribute to ecological functions. It could
329 improve ecological corridors for animals, linking PPA areas and rivers, establish tree
330 barriers to reduce pesticide contamination, etc. Although the concept and dimensions of
331 PPA and LRA have been maintained, Law 12,651/2012 relaxed some requirements for
332 smallholders, as will be discussed in the next section.

333

334 **3.3 PPA and LRA in Smallholders**

335 In Brazil, the recognition of the need to decipher smallholders and large rural
336 properties as well as campesinos and farmers with a capitalist and commercial profile,
337 including big landowners, is recent. This kind of debate is wide and involve Brazilian
338 agrarian problems.

339 Historically, benefits such as agricultural public policies and financing were
340 restricted to large-scale farmers. A National Policy for campesino smallholders was
341 created only in 2006 (Candiotto, 2011). According to Law 11,326/2006, which broaches
342 the “National Policy on Family Agriculture and Rural Family Enterprises”, to be
343 considered a family farmer the following requirements should be met: 1) must not hold
344 an area greater than 4 fiscal modules; 2) predominantly use his family’s labor force in the
345 economic activities of his establishment or enterprise; 3) have part of family income
346 originated from economic activities of smallholder.

¹³ Cerrado is one of the five major biomes in Brazil, which covered about 25% of Brazilian territory. It is similar to Savannah. More information is available at <<https://www.icmbio.gov.br/cbc/conservacao-da-biodiversidade/biodiversidade.html>>.

347 Law 12,651/2012 lessened some requirements for forest restoring for
 348 smallholders. In spite of that, according to Law 11,326/2006, any rural property that has
 349 a land area smaller than 4 fiscal modules can be a smallholder. But in Brazil, the area of
 350 a property with less than 4 fiscal modules can reach 4,400,000 m², i.e., 440 hectares. In
 351 this sense, in Brazil big areas can be legally accepted in the context of smallholder. For
 352 many experts it is a problem because large land areas can benefit from this loophole.

353 Firstly, Law 12,651/2012 allows that a Brazilian “smallholder” which can have
 354 440 hectares, include the area of LRA in the same area of PPA in the cases when more
 355 than 25% of the rural property is covered by PPA and in other situations (Article 16).

356 With the creation of “consolidated rural area” in Law 12,651/2012, other
 357 advantages have been institutionalized for who occupied legal forests land. Any portion
 358 of PPA with some construction, crop or stockbreeding implemented before June 2008 can
 359 be pronounced a consolidated rural area by the owner, in the *Cadastro Ambiental Rural*
 360 (Rural Environmental Registry – CAR). Chart 2 presents the possibilities of PPA
 361 reduction in consolidated rural areas, according to the size of rural establishment or
 362 property.

363 **Chart 2: Width of the Marginal Watercourse Range of the PPA with Consolidated**
 364 **Rural Areas**

Establishment or Property Size (fiscal module)	Minimum Marginal Band (meters)
Less than 1	5
1 to 2	8
2 to 4	15
4 to 10	20
Higher than 10	30

365 Source: Law 12,651/2012, Article 61-A.

366

367 Moreover, the exigence of PPA around springs in consolidated rural areas has
 368 been reduced by 50 meters to 15 meters, beyond other facilities allowed in these
 369 situations¹⁴.

370 Section 4 discusses the main legislation which allow agroforestry management in
 371 PPA and LRA and the limits of those uses in protected areas.

372

¹⁴ Candiotta and Vargas (2018) provide additional information about Law 12,651/2012.

373 **4 Agroforestry in Protected Areas**

374 Despite PPA and LRA have been generally considered untouchable lands by many
375 landowners, it is possible to use them in a conservation manner. Considering the
376 importance of regulating these areas and restoring lands in properties that have
377 environmental liabilities, it is necessary to advance the debate on forest management and
378 other forms of conservationist use especially regarding agroforestry. Since 2006, Brazil
379 institutionalized legislative tools which allow agroforestry systems in PPA and LRA.

380

381 **4.1 Brazilian Normality Linked to Agroforestry in PPA and LRA**

382 Through a review of the provisions of Law 11,428/2006, Law 12,651/2012,
383 Decree 6,660/2008, Resolutions 369/2006, 425/2010 and 429/2011 of CONAMA and
384 Normative Instruction (NI) 05/2009 of the Ministry of the Environment, we sought to
385 analyze in what sense agroforestry systems can be implemented in LRA and PPA.

386 With Law 12,651/2012, some exigences of the other cited legislation have been
387 changed or invalidated. But the presentation of some parts of these legislative tools show
388 the possibilities to use agroforestry systems in PPA and LRA have been considered in
389 Brazil.

390 Law 11,428/2006 established the use and protection of Atlantic Forest Biome.
391 *Primary vegetation* (Art. 20) and *Secondary vegetation in an advanced stage of*
392 *regeneration* (Art. 21) can only be suppressed for activities of public utility, scientific
393 research, and preservationist practices with authorization. Nevertheless, cutting part of
394 *Secondary vegetation in an advanced stage of regeneration* is authorized when necessary
395 for small rural producers and traditional populations for the exercise of activities or
396 agricultural, livestock or silvicultural activities essential to their subsistence and that of
397 their family, except for PPA (Article 23).

398 In 2008, Decree 6,660 was launched, which identifies what can be done in the
399 remnants of Native Atlantic Forest vegetation in terms of sustainable use. We highlight
400 here the following aspects:

- 401 - Possible exploration, with no direct or indirect commercial purpose,
402 of native flora species originating from natural formations, for
403 consumption on rural properties, possessions of traditional populations
404 or small rural producers, with respect to primary vegetation and
405 endangered species is free (Cap. II);
- 406 - Ecological enrichment with native species is encouraged to restore
407 biodiversity in the remaining secondary vegetation (Cap. III);

- 408 - Planting and reforestation with native species can be done without the
409 need for authorization from environmental agencies (it is also included,
410 in a single paragraph in this provision of Art. 12, sustainable
411 agroforestry management activities) (Cap. IV);
412 - Cutting and exploitation of native species that are proven to be planted
413 is permitted, provided they are registered and have authorization from
414 the environmental agency (Cap. III);
415 - Free collection of leaves, fruits and seeds is allowed during the periods
416 of collection and maturation, if there is no risk to the survival of
417 individuals and species collected (Cap. IV).
418

419 Items listed above are just some regulations for the use of the Atlantic Forest,
420 which may be directly related to agroforestry management, given the restrictions and
421 permissions of use. On the use of agroforestry systems in PPA, CONAMA Resolutions
422 369/2006, 425/2010 and 429/2011 complemented and strengthened the points made in
423 the Forest Code of 1965 (Law 4,771/65).

424 CONAMA Resolution 369/2006 allows the existence of:

- 425 exceptional cases in which the competent environmental agency may
426 authorize the intervention or removal of vegetation in PPA for the
427 implementation of works, plans, activities or projects of public utility
428 or social interest, [...] and of low environmental impact (BRASIL,
429 2006b, Article 1st).
430

431 Since agroforestry is considered an activity of social interest for smallholders and
432 has a low environmental impact, it can also occur in PPA of small family rural
433 establishments, if there is authorization from the competent Environmental Agency. The
434 implementation of agroforestry is permitted both in PPA and LRA of family farms if there
435 is no degradation or damage to the ecological function of the area. Though, CONAMA
436 Resolution 369/2006 does not describe specific procedures.

437 CONAMA Resolution 425/2010 also defines exceptional cases of social interest
438 in which the competent Environmental Agency can regularize intervention in vegetation
439 in PPA with agroforestry management being one of those cases. It is set out in Section III
440 of Article 2nd that social interests include “the activities of sustainable agroforestry
441 management, as long as they do not degrade the vegetation cover and do not undermine
442 the environmental function of the area”.

443 In CONAMA Resolutions 369/2006 and 425/2010, there are possibilities for
444 agroforestry management in PPA by campesinos when the chance of enhancing the use
445 of these areas has become greater.

446 In 2009, the NI 05 was the first legislative tool that defined methodological
447 procedures for the restoration of PPA and LRA. In Chapter VII of this NI, the use of
448 agroforestry is instituted as inducers to restore PPA in the property or possession of the
449 family farmer, the campesino entrepreneur or traditional peoples and communities.

450 Based on subparagraph “b”, item II of Article 2nd of CONAMA Resolution
451 369/2006 (which provides that agroforestry management practiced on small family farms
452 or rural tenure cannot deprive the native vegetation cover or obstruct its restoration
453 besides not harming the ecological function of the area), Article 9th of NI 05/2009
454 presents the requirements and procedures for the implementation of agroforestry in PPA,
455 being:

- 456 I - soil tillage and erosion control when necessary;
457 II- the restoration and maintenance of the native vegetation,
458 permanently maintaining the soil cover;
459 III - establishment of at least 500 (five hundred) individuals per hectare
460 of at least 15 perennial species native to local phytophysiology;
461 IV - limitation of the use of agrochemical inputs, giving priority to the
462 use of green manure;
463 V - restriction of the use of the area for grazing domestic animals,
464 except as provided in art. 11 of CONAMA Resolution 369, of 2006¹⁵
465 VI - in the use of agricultural species of annual crops, the maintenance
466 of the environmental function of the APP must be guaranteed and the
467 provisions of Art. 10 of this Normative Instruction;
468 VII - intercropping of perennial, native or non-invasive alien species,
469 intended for the production and collection of non-wood products, such
470 as fibers, leaves, fruits or seeds; and
471 VIII - maintenance of established, planted and/or germinated seedlings,
472 by crowning, control of disturbance factors such as competing species,
473 insects, fire, or others and fencing or isolation of the area, when
474 necessary and technically justified.
475

476 In addition to these two Resolutions, in 2011, CONAMA created Resolution 429,
477 which presents the methodology for restoring PPA through sustainable agroforestry
478 management practiced on small family farms (Article 6th of Chapter IV). In this standard,
479 authorization from the competent Environmental Agency for the agroforestry of PPA is
480 not required; still, similar aspects of NI 05 of 2009 must be considered. Both NI 05/2009
481 and CONAMA Resolution 429/2011 provide for procedures and requirements for
482 developing agroforestry activity in PPA in a similar way. In general, the possibility of

¹⁵ CONAMA Resolution 369/2006, Article 11, deals with what it considers of intervention or suppression of vegetation, eventual and of low environmental impact, in a PPA. Thus, in NI 05/2009 and in CONAMA Resolution 429/2011, the use restriction is for obtaining water by domestic animals, which is considered of low impact.

483 productive use is clear, limiting the activity mainly to non-wood products. These two
484 standards also restrict the use of alien species in these areas, but while the NI 05/2009
485 obligated a minimum of native species composition (15 per hectare), CONAMA
486 Resolution 429/2011 excluded this requirement. In whatever manner, with Law 12,651
487 published in 2012, alien species have been approved to be planted in consortium with
488 regional native species through agroforestry systems.

489

490 **4.2 Agroforestry Systems in PPA and LRA According to Law 12,651/2012**

491 The Forest Code (Law 12,651/2012) is an important instrument that outlines how
492 PPA and LRA should be applied to avoid degradation of remnant forests and permit forest
493 regeneration of degraded areas. It provides possibilities for utilizing agroforestry systems
494 in these areas especially in smallholder. This represents an advance in the sense that
495 campesinos may be conducting agroforestry activity and at the same time, complying
496 with the legislation (Dubois, 2008).

497 Agroforestry systems, mainly complex and agroecological, have been indicated
498 and boosted in smallholders by Law 12,651/2012, in the context of “Social Interest”
499 (Article 3rd, Section IX).

500 The sustainable agroforestry exploitation practiced in the small family
501 property or rural possession or by traditional peoples and communities,
502 as long as it does not degrade the existing vegetation cover and does not
503 undermine the environmental function of the area (Brazil, 2012, Article
504 3rd, Section IX, Line B).
505

506 Depending on the type of agroforestry management developed, agroforestry has
507 the function of protecting the area, not degrading the forest cover, thus making it an
508 acceptable and viable activity. In this sense, agroecological agroforestry are widely
509 recommended for smallholders.

510 Another important instrument given by Law 12,651/2012 is the concept of
511 Eventual Activities or of Low Environmental Impact, in which agroforestry activity is
512 also included. Among the low-impact activities that may be related to diversified
513 agroforestry systems, the following stand out:

514 h) collection of non-wood products for subsistence purposes and
515 production of seedlings, such as seeds, nuts and fruits, in compliance
516 with specific legislation on access to genetic resources;
517 i) planting of native species that produce fruits, seeds, nuts and other
518 plant products, provided that it does not imply the suppression of
519 existing vegetation or impair the environmental function of the area;

520 j) agroforestry exploitation and sustainable, community and family
521 forest management, including the extraction of non-timber forest
522 products, if they do not disfigure the existing native vegetation cover or
523 harm the environmental function of the area; (Brazil, 2012, Article 3rd,
524 Section X).
525

526 Hence, extractive activities (collection of forest products, such as seeds, nuts, and
527 fruits), the planting of native species, agroforestry and sustainable forest management are
528 permitted in areas of LRA that are classified as small properties or family rural tenure,
529 i.e., which have less than 4 fiscal modules. Nevertheless, if the LRA area is in a
530 “consolidated rural area”, it is stated that the LRA can be restored through the interspersed
531 planting of native and exotic or fruit-bearing species, in an agroforestry system provided
532 that the area recomposed with exotic species does not exceed 50% of the total area to be
533 recovered (Article 66, Paragraph 3rd).

534 Chapter XII, Article 54 provides that:

535 to comply with the maintenance of the legal reserve area in the
536 properties referred in item V¹⁶ of Art. 3, fruit tree plantations, either
537 ornamental or industrial composed of alien species cultivated in interim
538 system or in consortium with species native to the region in agroforestry
539 systems (Brazil, 2012, Article 54).
540

541 In this case, the restoration of LRA with native species should be prioritized, so
542 as not to degrade the natural biodiversity of each ecosystem. Knowing that it is necessary
543 to expand technical assistance on agroforestry management for farmers, Sole paragraph
544 of Article 54 set governmental institutions to provide technical support. In this matter, the
545 governmental role for the expansion of diversified and agroecological agroforestry
546 systems is fundamental.

547 In the same way, if rural tenure is classified as owned by a family farmer or rural
548 family entrepreneur and part of the PPA is in a consolidated rural area¹⁷, the owner will
549 be able to recompose up to 50% of the degraded PPA with alien species. As the main
550 function of PPA is to optimize the gene flow of animals and plants, we believe that the

¹⁶ Item V of Article 3rd of Law No. 12,651/2012 defines small family property or rural tenure according to Article 3rd of Law 11,326/2006.

¹⁷ To be considered a consolidated rural area, a given area must have been occupied until 22th July of 2008 and pronounced in the *Cadastro Ambiental Rural* (Rural Environmental Registry – CAR). However, as the CAR is still in the implementation phase and as the Environmental Regularization Program (ERP), instituted in Article 59 of Law 12,651/2012, has not yet been implemented, thus agroforestry use in PPA depends on the interpretation of environmental agencies state. Despite the delay in complying with the legislation and implementing its legal mechanisms, the most important thing here is to emphasize that there is the possibility of expanding the areas of agroforestry, both in LRA and in PPA that are to be restored.

551 authorization to plant alien species in these areas implies an unnecessary risk as it can
552 generate competition between native and exotic species as well as invasion of the latter
553 in areas that are ecologically important.

554 Article 41 says that the Federal Executive Government may institute programs to
555 support and encourage environmental conservation, such as payment for environmental
556 services or compensation for environmental conservation measures. Among the forms of
557 compensation there should be lines of financing for sustainable forestry and agroforestry
558 management. In Article 58, possibilities of governmental incentives for the handling of
559 agroforestry and agrosilvopastoral systems are also mentioned.

560

561 **5 Impressions About the Feasibility and Difficulties for Implementing Agroforestry** 562 **in PPA and LRA**

563 In spite of, the possibilities of agroforestry in PPA and LRA that are important
564 protected areas in Brazil, there are situations where agroforestry land use may be a
565 problem and not a solution. Ecologically, an agroforestry composition based on alien
566 species can reduce biodiversity, mostly in cases where some alien (invasive) species
567 suppress or outcompete native species.

568 While in LRA areas some exotic individuals could be used to generate biomass
569 for the agroforestry system or supply the family's demand for firewood and wood, we
570 understand that PPA should be managed primarily only with native species as they are
571 important corridors of biodiversity.

572 Considering the flexibility of forestry legislation in Brazil is linked to the
573 predominance of interests of landowners with large extension of land, it is necessary to
574 be cautious when interpreting the legal provisions that allow the use of protected areas.

575 We believe that agroecological agroforestry systems fully recommended in
576 degraded and protected areas as simple systems are not suitable for PPA and LRA.
577 According to Santos, Crouzeilles and Sansevero (2019: 140), “[...] biodiverse
578 agroforestry system is the best option to enhance biodiversity and ecosystem services
579 (ES) in degraded areas where production systems based on sustainable management of
580 natural resources are allowed by law”. Likewise, it is necessary to analyse the experiences
581 of management and commission of agroforestry in PPA and LRA, to verify the practices
582 that have been carried out and their ecological, social, and economic results.

583 Analysing Brazilian reality, Ewert et al. (2016: 103) alert that “the absence or
584 inadequacy of protocols and registration systems stipulated in legal instruments, but
585 incipiently established by environmental agencies has made the regulation of agroforestry
586 practices practically impracticable.”

587 Martins and Raniere (2014) have identified some limits of agroforestry use in
588 Brazilian LRA. They argue that agroforestry systems in LRA areas need to be
589 implemented “[...] on solid ecological bases, on the principles of ecological succession
590 and on agroecological management practices.” (p. 86). Considering that many kinds of
591 agroforestry systems in Brazil have been established with limited species diversity
592 (simple systems with alien species), the goals of environmental restoration and
593 sustainable use of LRA need to be carefully analysed. In addition, there are problems with
594 the institutional structure of Environmental Agencies for the management of native
595 vegetation.

596 The literature points out that the potential of simple agroforestry
597 systems for conservation is quite limited and not guaranteeing the
598 fulfilment of the LRA functions, especially regarding the protection of
599 biodiversity. To achieve this objective, careful observation of the
600 composition of the agroforestry system is recommended, especially
601 regarding the richness and abundance of native species and their
602 population dynamics over time. (Martins and Raniere, 2014: 88).
603

604 According to Deitenbach (2008) with the possibility of using agroforestry in PPA,
605 farmers can adapt to the Legislation and take advantage of the resources available in these
606 areas. However, there are some reservations regarding use.

607 The important thing is that the agroforestry system to be installed must
608 guarantee the protection function of the PPA in question. [...]
609 Therefore, it will not be any agroforestry system that can be authorized
610 in PPA. [...] Environmental authorities have little experience with this
611 type of licensing, and it is therefore up to family farming organizations
612 to make proposals for agroforestry systems (Deitenbach, 2008: 131).
613

614 Silva and Steenbock (2011) indicate that different productive practices or
615 production and reproduction systems of distinct social groups do not correspond in laws,
616 decrees or other legal instruments in the environmental area. This may erroneously
617 assume that such practices are illegal and are often prohibited by the environmental
618 agencies themselves. If agroforestry encounters barriers and/or difficulties to be regulated
619 this is mainly due to the lack of knowledge about them.

620 Considering that diversified and agroecological agroforestry systems provides an
621 ecologically balanced environment for present and future generations and restores
622 ecological processes, they need to have protection and recognition from the government.
623 In whatever way, to have legal support according to the provisions of Forest Code and
624 other mentioned legislative tools, the question of the type of agroforestry needs to be
625 raised as not all of them can be used.

626 Agroforestry plays an important role in the regeneration of vegetation, as well as
627 in effecting the process of conservation and expansion of forest remnants. The use of this
628 alternative in PPA and LRA is potentially favorable and is a strategy to regularize rural
629 establishments.

630 The actual scenario of deforestation and environmental public policies regression
631 in Brazil, in the context of Bolsonaro's government, started in 2019 have been harming
632 preservation and conservation possibilities. Regardless of the legal possibilities discussed
633 in this paper, the Environmental Regularization Program (ERP) provided in Law 12,651
634 of 2012, as well as agroforestry management practices within the scope of the
635 agroecological perspective, have not been advancing in Brazil. Thus, it is necessary to
636 consider the weakness of Brazilian environmental agencies (Deitenbach, 2008; Martins
637 and Raniere, 2014; Ewert et al., 2016).

638 Regarding legal means presented here, that could disseminate and support the use
639 of agroforestry, Deitenbach (2008) comments that the Federal Government should
640 consider the social interest, in most of cases, providing financing for family farmers, in
641 addition to the environmental interest in the use of natural resources. Although the law
642 provides for technical support for agroforestry management, it is necessary to move
643 forward in this direction, prioritizing campesino smallholders.

644 More work is needed on the qualitative improvement and quantitative expansion
645 of agroforestry systems in Brazil especially in smallholders. Therefore, it is necessary to
646 advance public policies, funding, training of technicians and campesinos and other
647 aspects, considering the importance of agroforestry in food security (Neves, 2013) and
648 food sovereignty; to reduce the effects of climate change (Schembergue et al., 2017),
649 expand carbon storage (Torres et al., 2014); and the advance of agroecology practices
650 (Candiotto, 2020; Gregio, 2020).

651 According to Meirelles (2003), despite the offer of credit for the implementation
652 of agroforestry, technical assistance has neither prioritized nor promoted strategies. Even
653 NGOs working with agroforestry have not been able to expand them.

654 With such problems remaining, the tendency is to maintain insecurity
655 as farmers reject the introduction of trees on their properties. The
656 damage falls on the entire society due to the difficulty of advancing
657 feasible proposals that reconcile conservation and environmental
658 restoration and production of food, wood, fibers, fuels, medicinal
659 plants, and of environmental services (Méier et al., 2011: 14).
660

661 Méier et al. (2011: 14) states that, “when the management of agroforestry in PPA
662 is configured, the posture of environmental agencies has been punitive and restrictive
663 when it should be more instructive and informative”. This punitive bias can result in
664 farmers’ rejection of implementing this form of land use.

665 According to Russo (2002: 77), agroforestry systems “should not be presented as
666 a magic solution that will solve all environmental and social problems”, but be promoted
667 as a “correction of conduct in relation to PPA and LRA”.

668 Certainly, agroforestry should not be seen as the only “solution” in discussions
669 about the restoration of environments, but as a viable and promising mechanism.
670 Depending on the ecological relevance of the area, as the case of PPA, the forest must be
671 regenerated with only native species. Nonetheless, agroforestry can contribute to
672 overcoming the idea that PPA and LRA are unproductive and unnecessary areas.

673 In addition, to being important alternatives for forest regeneration, the
674 accomplishment of agroforestry systems in PPA and LRA allows to reconcile the
675 restoration of degraded areas with the diversified production of food and other products,
676 and may contribute to the expansion of agroecology, food sovereignty, improvement of
677 smallholder livelihoods (Dawson et al., 2014) and the income of rural family.

678 In this manner, only to illustrate some examples of diversified agroforestry
679 systems in Brazilian smallholders, it is interesting to mention experiences in different
680 ecosystems.

681 1) The work of *Cooperafloresta*, located in Ribeira River Valley, in the east
682 frontier between São Paulo State (Southeastern Region) and Paraná State
683 (Southern Region). This experience has been analyzed in a book with 15 chapters
684 organized by Steenbock et al. (2013), and in Ewert et al. (2016) paper;

685 2) The Ernst Götsch Syntropic Agriculture, created in Olhos D'Água Farm, in the
686 South of Bahia State (Northeastern Region). It was analyzed in Götsch (1997);
687 Gregio (2018; 2020) and on the website “agendagotsch.com”;

688 3) Agroforestry systems in the Tomé-Açu municipality, Pará State (Northern
689 Region / Amazon Region), which involve commercial farmers through Tomé-Açu
690 Mixed Agricultural Cooperative (CAMTA) and campesinos linked to Association
691 of Rural Family Farmers of the Municipality of Tomé-Açu (APPRAFAMTA).
692 Pompeu, Kato and Almeida (2017) and Yamada (2009) analyzed elements of this
693 experiences.

694

695 **6 Conclusions**

696 Agroforestry corresponds to new possibilities for ecological management,
697 characterized by integrated cultivation, (whether of annual, perennial, forest, wood,
698 ornamental, medicinal, native and/or alien plant species). They can restore deforested and
699 degraded environments and conserve ecosystems and their biodiversity.

700 Important role in the restoration of native vegetation can be played by
701 Agroforestry, as well as in effecting the process of conservation and expansion of forest
702 remnants (Lundgren, 1982; Russo, 2002; Mead, 2004; Deitenbach, 2008; Paludo and
703 Costabeber, 2012; Gregio, 2018). In this situation, some kinds of agroforestry have the
704 potential to restore degraded lands, to improve conservation practices and to contribute
705 to forest preservation (Santos, Crouzeilles and Sansevero, 2019). The use of this
706 alternative in PPA and LRA is potentially favorable, being a viable and promising
707 strategy to regulate rural context, mainly smallholders (Roshetko et al., 2008; Dawson et
708 al., 2013; Dawson et al., 2014), which are mainly managed by campesinos.

709 Charging, punishing and demanding compliance from farmers and campesinos is
710 not enough, it is necessary to create conditions that enable farmers to produce quality
711 food, conserve natural resources, and restore the existent environment on their rural land
712 (water, soil, forests).

713 Depending on the ecological relevance of the area, the most important aspect of
714 PPA is to regenerate the forest with only native species. But exotic and alien species can
715 be planted in LRA, either to serve as support for native species in the initial stages of
716 implantation or to be used as products to support farm livelihoods or organic matter to
717 cover and regenerate the soil.

718 Considering Law 12,651 of 2012, there are several opportunities to use
719 agroforestry systems in the process of forest restoration and legal regularization of
720 smallholders and in greater rural establishment. For example: 1) agroforestry systems can
721 improve to mitigate emissions of greenhouse gases (GHGs) through capturing and storing
722 atmospheric carbon (Torres et al., 2014); 2) campesinos and farmers can be benefited by
723 Payment for Environmental Services (PES); 3) agroforestry can optimize the creation of
724 ecological corridors, linking forest remnants, which are generally located in PPA and
725 LRA; 4) farmers that administer and have profit with agroforestry systems can expand
726 this kind of land usage beyond PPA and LRA; 5) agroforestry can contribute for river
727 basin planning and management, at various spatial scales, optimizing environmental and
728 territorial management.

729 Finally, this paper shows that Brazil has a forest legislation that allows combining
730 preservation, restoration and productive use, through agroecological and diversified
731 agroforestry systems. It can be used as an example in other countries and compared with
732 other initiatives and experiences around the world.

733 In the Brazilian context, the article highlights the importance of prioritizing
734 agroecological and diversified agroforestry systems (with native species and diverse
735 biodiversity) in LRA and PPA restoration, mainly in campesinos smallholders, to
736 contribute to environmental and social sustainability. If simple agroforestry systems (with
737 the introduction of alien species and a few diversity) expand in LRA and PPA, it can
738 hasten the problem of native biodiversity loss. So, simple agroforestry systems should be
739 used in degraded lands or to substitute other agriculture or pastureland use, but not in PPA
740 and LRA. Thus, institutions linked to environmental conservation and to campesinos need
741 to focus on agroecological and diversified agroforestry systems to reconcile food
742 production and forest restoration.

743 Agroforestry can contribute to expand sustainable land use strategies, along with
744 overcoming the idea that PPA and LRA are unproductive and unnecessary areas.
745 Nevertheless, for this alternative be actualized, there are many challenges, which may
746 require the proper application of forest legislation; the training of technicians and farmers
747 regarding the institution and management of agroforestry systems; the strengthening of
748 research and rural extension actions based on a conservation and integrated perspectives
749 between society and nature; the creation and implementation of public policies that
provide subsidies, credits or funds for the expansion of agroecological agroforestry
systems in Brazil.

HIGHLIGHTS

Forests preservation and restoration are crucial to sustain ecological and social benefits.

In the context of forest restoration, agroforestry systems are important land use instrument because they allow sustainable forest management combined with food production.

Brazil's forest legislation permits to combine preservation, restoration, and productive uses in Legal Reservation Areas (LRA) and Permanent Preservation Areas (PPA), which are protected lands of rural properties.

This paper discusses possibilities and limitations to introduce agroforestry systems in Brazil through LRA and PPA, highlighting the importance of agroecological and diversified agroforestry systems.

Agroforestry systems are also viable for the restoration of degraded areas and for expanding forested areas and uses of their natural resources, especially in campesino properties.

753 **7 References**

754

755 Brasil. 1934. *Decreto nº 23.793*, de 1934. Aprova o código florestal. Available
756 www.planalto.gov.br/ccivil_03 (last accessed 17 September 2016).

757

758 _____. 1965. *Lei nº 4.771*, de 15 de setembro de 1965. Available
759 http://www.planalto.gov.br/ccivil_03/LEIS/L4771.htm (last accessed 26 October 2016).

760

761 _____. 1988. *Constituição da República Federativa do Brasil*. Brasília. Available
762 http://www.planalto.gov.br/ccivil_03/Constituicao/Constituicao.htm (last accessed 05
763 December 2019).

764

765 _____. 2006. *Lei nº 11.326*, de 24 de julho de 2006. Estabelece as diretrizes para a
766 formulação da Política Nacional de Agricultura Familiar e Empreendimentos Familiares
767 Rurais. Brasília, 2006a. Available [http://www.planalto.gov.br/ccivil_03/_ato2004-
768 2006/2006/lei/11132](http://www.planalto.gov.br/ccivil_03/_ato2004-2006/2006/lei/11132) (last accessed 11 March 2020).

769

770 _____. 2006. *Lei nº 11.428*, de 22 de dezembro de 2006. Dispõe sobre a utilização e
771 proteção da vegetação nativa do bioma Mata Atlântica. Brasília, 2006b. Available
772 http://www.planalto.gov.br/ccivil_03/_ato2004-2006/2006/lei/111428 (last accessed 14
773 August 2019).

774

775 _____. 2006. *Resolução do CONAMA nº 369*, de 28 de março de 2006. Dispõe sobre os
776 casos excepcionais, de utilidade pública, interesse social ou baixo impacto ambiental, que
777 possibilitam a intervenção ou supressão de vegetação em Área de Preservação
778 Permanente- APP. Brasília, 2006c. Available <http://www.cetesb.sp.gov.br> (last accessed
779 10 May 2018).

780

781 _____. 2008. *Decreto nº 6.660*, de 21 de novembro de 2008. Regulamenta dispositivos

782 da Lei nº 11.428, de 22 de dezembro de 2006, que dispõe sobre a utilização e proteção da

783 vegetação nativa do Bioma Mata Atlântica. Available www.planalto.gov.br/ccivil (last
784 accessed 07 November 2019).

785

786 _____. 2009. Ministério do Meio Ambiente. *Instrução Normativa nº 5*, de 2009. Dispõe
787 sobre os procedimentos metodológicos para restauração e recuperação das Áreas de
788 Preservação Permanentes e da Reserva Legal. Brasília. Available
789 <http://www.mma.gov.br> (last accessed 19 May 2019).

790

791 _____. 2010. *Resolução do CONAMA nº 425*. Dispõe sobre critérios para a
792 caracterização de atividades e empreendimentos agropecuários sustentáveis para fins de
793 produção, intervenção e recuperação de Áreas de Preservação Permanente e outras de uso
794 limitado. Brasília. Available <http://www.mma.gov.br/port/conama/res> (last accessed 24
795 April 2019).

796

797 _____. 2011. *Resolução do CONAMA nº 429*. Metodologia de recuperação das Áreas de
798 Preservação Permanente - APPs. Brasília, DF. Available
799 <http://www.dialogoflorestal.org.br/download> (last accessed 27 October 2018).

800

801 _____. 2012. *Lei nº 12.651*, de 25 de maio de 2012. Dispõe sobre a proteção da
802 vegetação nativa e dá outras providências. Brasília. Available
803 http://www.planalto.gov.br/ccivil_03/_Ato2011-2014/2012/Lei/L12651.htm (last
804 accessed 06 May 2018).

805

806 Candiotto, L.Z.P. 2011. A agricultura familiar no contexto do rural contemporâneo. In:
807 Saquet, M.; Suzuki, J.; Marafon, G. (Ed.). *Territorialidades e diversidade nos campos e*
808 *nas cidades latino-americanas e francesas*. São Paulo: Outras Expressões, pp. 275-298.

809

810 Candiotto, L.Z.P.; Vargas, F.A. 2018. Principais alterações no novo Código Florestal
811 brasileiro e os potenciais impactos ao meio ambiente. *Observatorium: Revista Eletrônica*
812 *de Geografia*, 9, pp. 181-208.

813

- 814 Candiotto, L.Z.P. 2020. Agroecologia: Conceitos, princípios e sua
815 multidimensionalidade. *AMBIENTES: Revista de Geografia e Ecologia Política*, 2(2), pp.
816 25-75. Doi: [10.48075/amb.v1i2.23619](https://doi.org/10.48075/amb.v1i2.23619) (last accessed 06 September 2021).
817
- 818 Dawson, I.K.; Guariguata, M.R.; Loo, J. et al. 2013. What is the relevance of
819 smallholders' agroforestry systems for conserving tropical tree species and genetic
820 diversity in circa situm, in situ and ex situ settings? A review. *Biodivers Conserv*, 22, pp.
821 301–324. Doi: [10.1007/s10531-012-0429-5](https://doi.org/10.1007/s10531-012-0429-5) (last accessed 19 January 2022).
822
- 823 Dawson, I.K.; Leakey, R.; Clement, C.R. et al. 2014. The management of tree genetic
824 resources and the livelihoods of rural communities in the tropics: Non-timber forest
825 products, smallholder agroforestry practices and tree commodity crops. *Forest Ecology
826 and Management*, 333, pp. 9-21. Doi: [10.1016/j.foreco.2014.01.021](https://doi.org/10.1016/j.foreco.2014.01.021) (last accessed 19
827 January 2022).
828
- 829 Deitenbach, A. 2008. Políticas públicas para sistemas agroflorestais na mata Atlântica.
830 In: May, P; Trovatto, C. *Manual agroflorestal para a Mata Atlântica. Ministério do
831 Desenvolvimento Agrário*. Brasília. Secretaria da Agricultura Familiar. Available
832 www.mda.gov.br/portal/saf/arquivos/...Manual_Agroflorestal.pdf (last accessed 11
833 August 2019).
834
- 835 De Jong, W.; Van Noordwijk, M.; Sirait, M. Liswanti, N.; Suyanto. S. 2001. Farming
836 secondary forests in Indonesia. *Journal of Tropical Forest Science*, 13, pp. 705–726.
837
- 838 Delduque, M. 2008. *Propriedades rurais na mata atlântica: Conservação ambiental e
839 Produção florestal*. Instituto Refloresta. Available <https://www.setepontes.com.br/blank>
840 (last accessed 15 December 2019).
841
- 842 Dubois, J. 2008. Classificação e breve caracterização de SAFs e práticas Agroflorestais.
843 In: May, P; Trovatto, C. *Manual agroflorestal para a Mata Atlântica*. Ministério do
844 Desenvolvimento Agrário. Brasília. Secretaria da Agricultura Familiar. pp. 17-62.
845 Available www.mda.gov.br/portal/saf/arquivos/...Manual_Agroflorestal.pdf (last
846 accessed 10 September 2018).

847

848 Ewert, M.; Venturieri, G.A.; Steenbock, W.; Seoane, C.E.S. 2016. Sistemas agroflorestais
849 multiestrata e a legislação ambiental brasileira: desafios e soluções. *Desenvolvimento e*
850 *meio ambiente*, 36, pp. 95-114. Doi: [10.5380/dma.v36i0.39944](https://doi.org/10.5380/dma.v36i0.39944) (last accessed 10 October
851 2021).

852

853 FAO (Food and Agriculture Organization). 2015. *Agroforestry*. Available
854 <http://www.fao.org/forestry/agroforestry/80338/en/> (last accessed 29 September 2021).

855

856 Götsch, E. 1997. *Homem e natureza: cultura na agricultura*. Centro de Desenvolvimento
857 Agroecológico Sabiá. Recife-PE. Available <http://www.agendagotsch.com> (last accessed
858 27 September 2021).

859

860 Gregio, Josué V. *Agricultura Sintrópica: Produzindo alimentos na floresta, das raízes do*
861 *aipim ao dossel das castanheiras*. Dissertação (Mestrado em Geografia). Universidade
862 Estadual Do Oeste Do Paraná, Campus Francisco Beltrão. Francisco Beltrão, 2018.

863

864 Gregio, J.V. 2020. Da degradação à floresta: A Agricultura Sintrópica de Ernst Götsch e
865 sua aplicação nas Fazendas Olhos D'Água e Santa Teresinha, Pirai do Norte/BA.
866 *AMBIENTES: Revista de Geografia e Ecologia Política*, 2(2), pp. 106-143. Doi:
867 [10.48075/amb.v2i2.26585](https://doi.org/10.48075/amb.v2i2.26585)

868

869 Laureano, D; Magalhães, J. *Código Florestal e catástrofes climáticas*. Available
870 <http://www.correiocidadania.com.br> (last accessed 20 March 2019).

871

872 Leite, M.C. 2015. *Agroflorestas: do potencial conservacionista à análise de experiências*
873 *no Sudoeste do Paraná*. Dissertação de Mestrado em Geografia. UNIOESTE, Francisco
874 Beltrão.

875

876 Lundgren, B. 1982. Introduction [Editorial]. *Agroforestry Systems*, 1, pp. 3-6.

877

- 878 Mapbiomas. 2021. *Vegetação nativa perde espaço para a agropecuária nas últimas três*
879 *décadas*. Available [https://mapbiomas.org/vegetacao-nativa-perde-espaco-para-a-](https://mapbiomas.org/vegetacao-nativa-perde-espaco-para-a-agropecuaria-nas-ultimas-tres-decadas)
880 [agropecuaria-nas-ultimas-tres-decadas](https://mapbiomas.org/vegetacao-nativa-perde-espaco-para-a-agropecuaria-nas-ultimas-tres-decadas) (last accessed 04 October 2021).
881
- 882 Martins, T.P.; Raniere, V.E.L. 2014. Sistemas agroflorestais como alternativa para as
883 Reservas Legais. *Ambiente & Sociedade*, 17(3), pp. 79-96.
884
- 885 May, P; Trovatto, C. 2008. *Manual agroflorestal para a Mata Atlântica*. Ministério do
886 Desenvolvimento Agrário. Brasília. Secretaria da Agricultura Familiar Manual
887 agroflorestal para a Mata Atlântica. Ministério do Desenvolvimento Agrário. Brasília.
888 Secretaria da Agricultura Familiar.
889
- 890 Mead, D. J. 2004. What is Agroforestry? *Agroforestry Systems*, 1, pp. 7-12.
891
- 892 Méier, M, et al. 2011. Sistemas agroflorestais em áreas de preservação permanente. In:
893 Schmitt C, et al. *Agriculturas - experiências em agroecologia - Árvores na agricultura*.
894 *Revista Agriculturas: experiências em agroecologia*, 8(2), pp. 12-17. Available
895 <http://www.agriculturesnetwork.org/magazines/brazil> (last accessed 26 August 2018).
896
- 897 Meirelles, L. 2003. *Revista dos sistemas agroflorestais*. Centro Ecológico Litoral Norte-
898 PDA/PPG7/MMA. Available
899 http://www.mda.gov.br/portal/saf/arquivos/livros/Manual_Agroflorestal (last accessed 13
900 July 2017).
901
- 902 Milaré, É. 2007. *Direito do ambiente: A gestão ambiental em foco - doutrina,*
903 *jurisprudência, glossário*. São Paulo: Editora Revista dos tribunais.
904
- 905 Miller, R.P. 2009. Construindo a complexidade: o encontro de paradigmas agroflorestais.
906 In: PORRO, R. *Alternativa agroflorestal na Amazônia em transformação*. Brasília-DF:
907 Embrapa Informação Tecnológica, pp. 537-557.
908
- 909 Neves, P. 2013. Sistemas agroflorestais como fomento para a segurança alimentar e
910 nutricional. *Revista Verde*, 8(5), pp. 199-207.

911

912 Paludo, R.; Costabeber, J.A. 2012. Sistemas agroflorestais como estratégia de
913 desenvolvimento rural em diferentes biomas brasileiros. *Revista Brasileira de*
914 *Agroecologia*. Porto Alegre, 7(2), pp. 63-76.

915

916 Pompeu, Kato and Almeida, 2017. Percepção de agricultores familiares e empresariais de
917 Tomé-Açu, Pará, Brasil sobre os Sistemas de Agrofloresta. *Sustentabilidade em Debate*,
918 8(3), pp. 152-166. Doi:[10.18472/SustDeb.v8n3.2017.24197](https://doi.org/10.18472/SustDeb.v8n3.2017.24197). (last accessed 19 January
919 2022).

920

921 Porro, R. 2009. Expectativas e desafios para a adoção da alternativa agroflorestal na
922 Amazônia em transformação. Porro, R. *Alternativa agroflorestal na Amazônia em*
923 *transformação*. Brasília-DF: Embrapa Informação Tecnológica, pp. 33- 51.

924

925 Roshetko, J.M.; Snelder, D.J.; Lasco, R.D.; Van Noordwijk, M. 2008. Future Challenge:
926 A paradigm shift in the forestry sector. In: Snelder, D.J.; Lasco, R.D. (eds.). *Smallholder*
927 *tree growing for rural Development and environmental services*. Springer Science +
928 Business Media B.V., pp. 453-485.

929

930 Russo, R. 2002. Sistemas agroflorestais. In: Prochnow, M. Shaffer, W. (eds). *A mata*
931 *atlântica e você: Como preservar, recuperar e se beneficiar da mais ameaçada floresta*
932 *brasileira*. Brasília: APREMAVI, pp. 75-77.

933

934 Santos, P.Z.F.; Crouzeilles, R.; Sansevero, J.B.B. 2019. Can agroforestry systems
935 enhance biodiversity and ecosystem service provision in agricultural landscapes? A meta-
936 analysis for the Brazilian Atlantic Forest. *Forest Ecology and Management*, 433, pp. 140-
937 145. Doi:[10.1016/j.foreco.2018.10.064](https://doi.org/10.1016/j.foreco.2018.10.064). (last accessed 19 October 2022).

938

939 Schembergue, A.; Cunha, D. A.; Carlos, S.M.; Pires, M.V.; Faria, R.M. 2017. Sistemas
940 agroflorestais como estratégia de adaptação aos desafios das mudanças climáticas no
941 Brasil. *RESR*, 55(1), pp. 9-30. Doi: [10.1590/1234-56781806-94790550101](https://doi.org/10.1590/1234-56781806-94790550101)

942

- 943 Silva, R.O.; Steenbock, W. 2011. *Análise da Legislação referente a Sistemas*
944 *Agroflorestais (SAFs) no Sul do Brasil: Marco pedagógico em agrofloresta*. Barra do
945 Turvo: Cooperafloresta/PDA.
- 946
- 947 Smith, J. (2010). *Agroforestry: reconciling production with protection of the*
948 *environment: A synopsis of research literature*. The Organic Research Centre, Elm Farm,
949 UK.
- 950
- 951 Steenbock, W. et al. 2013. *Agrofloresta, ecologia e sociedade*. Curitiba: kairós. Available
952 <https://www.icmbio.gov.br/educacaoambiental/images/stories/biblioteca/permacultura/li>
953 [viro_AGROFLORESTA_ECOLOGIA_E_SOCIEDADE.pdf](https://www.icmbio.gov.br/educacaoambiental/images/stories/biblioteca/permacultura/li) (last accessed 22
954 September 2021).
- 955
- 956 Torres, C.M.M.E.; Jacovine, L.A.G.; Oliveira Neto, S.N.; Brianezi, D.; Alves, E.B.B.M.
957 2014. *Sistemas agroflorestais no Brasil: uma abordagem sobre a estocagem de carbono*.
958 *Brazilian Journal of Forestry Research*, 34(79), pp. 235-244. Doi:
959 [10.4336/2014.pfb.34.79.633](https://doi.org/10.4336/2014.pfb.34.79.633)
- 960
- 961 Torres, M.M.; Jacovine, L.A.G.; Neto, S.N.O.; Brianezi, D.; Alves, E.B.B.M. 2014.
962 *Sistemas agroflorestais no Brasil: uma abordagem sobre a estocagem de carbono*. *Pesq.*
963 *flor. bras.*, 34(79), pp. 235-244. doi: [10.4336/2014.pfb.34.79.633](https://doi.org/10.4336/2014.pfb.34.79.633)
- 964
- 965 Umrani, R.; Jain, C. K. 2010. *Agroforestry Systems and Practices*. Jaipur: Oxford Book
966 Company.
- 967
- 968 USDA (United States Department of Agriculture). 2019. *Agroforestry*. Available
969 <https://www.usda.gov/topics/forestry/agroforestry> (last accessed 26 September 2021).
- 970
- 971 Yamada, M. 2009. Uma breve história de desenvolvimento agroflorestal Nikkei na
972 Amazônia: o caso da colônia de Tomé-Açu, PA. In: Porro, R (Ed.). *Alternativa*
973 *agroflorestal na Amazônia em transformação*. Brasília: Embrapa Informação
974 Tecnológica, pp. 691-704.
- 975

976 Zakia, M.; Derani, C. 2006. Situação Jurídica das Florestas Plantadas. In: Lima, W; Zakia,
977 M. *As florestas plantadas e a água: Implementando o conceito da microbacia*
978 *hidrográfica como unidade de planejamento*. São Carlos: RiMa. pp. 171-184.