iForest
Biogeosciences and Forestry

Short Communication
doi: 10.3832/ifor1901-009
vol. 10, pp. 303-308

Biodiversity inventory of trees in a neotropical secondary forest after abandonment of shaded coffee plantation

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Tree structure and diversity of a secondary Atlantic Forest resulting from the abandonment (ca. 70 years) of a shaded coffee (*Coffea arabica*) plantation was studied in southeastern Brazil. All trees with DBH ≥ 5 cm (alive and dead) were measured in 25 plots of 20 × 20 m. Out of the 1926 sampled trees, 1837 were living trees belonging to 116 species. The most important species (importance value - IV) in the community were *Euterpe edulis* (22.9% - present in all plots) and *Piptadenia gonoacantha* (16.5%). *Euterpe edulis* is a typical palm tree of high importance value in mature forests, comprising 41.2% of individuals. The results show a more mature tree community in relation to other secondary forests with the same abandonment period in the region, with high richness and diversity of species, high basal area, and low dead tree density. In addition, several endangered species were recorded with high conservation value for the regional flora. The results also showed many typical characteristics of "novel ecosystems" discussed here in order to value these environments, still neglected due to strong environmental human alterations.

Keywords: Brazilian Atlantic Forest, Forest Succession, Novel Ecosystem, Agroforestry

Introduction

The development of agriculture in Brazil has led to a high degree of fragmentation of the Atlantic Forest, with the formation of landscape mosaics between secondary and mature forests, and the subsequent extinction of several species belonging to the native flora (Fonseca 1985). The areas with the highest levels of degradation coincide with the main areas of economic development in the country (Ayres et al. 2005). Based on current cover rates of the tropical forest vegetation, it is clear that the few existing mature forests will eventually disappear. These ecosystems are being more and more replaced by a complex mosaic of small forest fragments at different successional stages, in most cases separating agricultural crops from urban areas (Ribeiro et al. 2009).

Mature forests of neotropical regions are currently subject to a great human pressure, while secondary forests have the potential to remain ecologically untapped due to their rapid growth characteristics (Guariguata & Ostertag 2001). Its vast extension in humid tropics and its predominance in biomes such as the Brazilian Atlantic Forest, calls for an increased understanding and appreciation of the environmental services provided by these forests by addressing the existing research gaps and providing the scientific basis of reforestation and restoration methods (Chazdon et al. 2009).

Phytosociological studies conducted in forest fragments in southeastern Brazil provided important advances to the knowledge of forest succession under anthropogenic influence (Valente et al. 2011, Fonseca & Carvalho 2012, Moreira & Carvalho 2013, Brito & Carvalho 2014, Carvalho et al. 2014, Moreira 2014). Such information may help planning of appropriate management practices, particularly where species with viable economic production are present in the study area. Chazdon et al. (2009) claim that the management of secondary formations is one of the greatest potential solutions to increasing biodiversity conservation of tropical forests, including Brazilian forests.

This study focused on a secondary Atlantic Forest formerly used as a shaded coffee plantation (*Coffea arabica*), that has been naturally regenerating in the last 70 years after abandonment. The main goal was to evaluate the structure and species diversity of its tree regenerating community. We tested the hypothesis that the forest would present distinct successional tree community indicators (structural and diversity parameters) in comparison with secondary forests studied to date, with the same abandonment time in the region, due to its history of regeneration from shaded plantations.

Materials and methods

The study area was located in an Atlantic Forest fragment that belongs to the Federal University of Juiz de Fora Botanical Garden (JB-UFJF) in the city of Juiz de Fora, Minas Gerais, southeastern Brazil (Fig. 1). The JB-UFJF covers about 80 ha and is contiguous to the Environmental Protection Area of "Mata do Krambeck" forest, forming an extensive urban forest remnant with a total area of approx. 370 ha. According to Köppen, the climate is humid subtropical (Cwa) with two distinct seasons: summer-spring, with higher temperatures and rainfall (October to April); and autumn-winter, which is colder and drier (May to September – Fonseca & Carvalho 2012). The annual rainfall average is close to 1500 mm, with

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Received: Oct 20, 2015 - Accepted: Sep 14, 2016

Citation: Oliveira-Neto NE, Nascimento DR, Carvalho FA (2017). Biodiversity inventory of trees in a neotropical secondary forest after abandonment of shaded coffee plantation. iForest 10: 303-308. – doi: 10.3832/ifor1901-009 [online 2017-02-23]

Communicated by: Raffaele Lafortezza

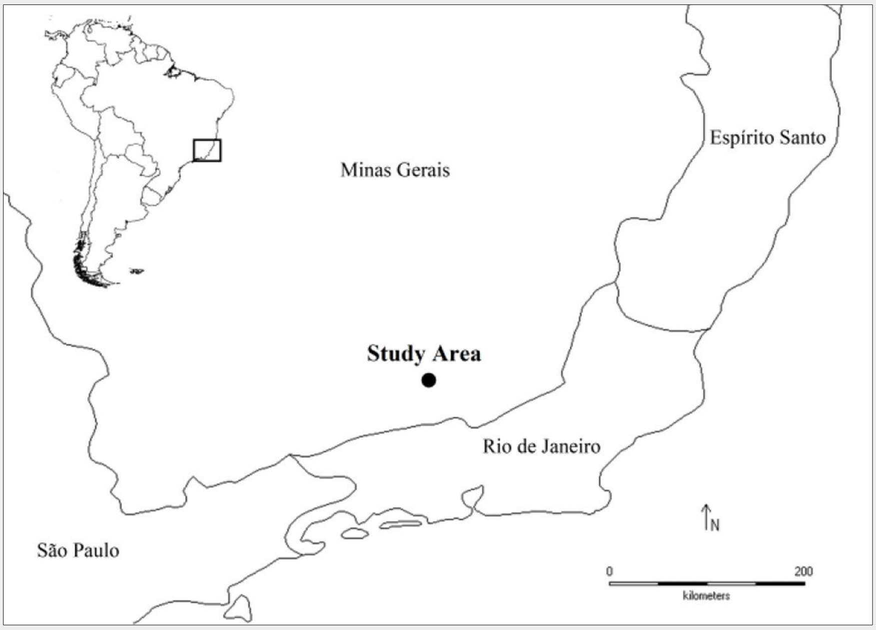

Fig. 1 - Geographical location of the study area, a secondary forest regenerating after the abandonment of a shaded coffee plantation (*Coffea arabica*) in the Botanical Garden of the Federal University of Juiz de Fora, Juiz de Fora, Minas Gerais, Southeastern Brazil.

the highest rates in January (ca. 300 mm), while the annual temperature average is around 18.9 °C (Fonseca & Carvalho 2012). The relief is formed by very old rocks, basically gneiss and granite, with predominant soils classified as Dystrophic Yellow Oxisoils (Oliveira-Neto 2014). The forest vegetation is classified as mountainous semideciduous (seasonally) forest according to the Brazilian Vegetation System (IBGE 2012).

The entire area corresponding to the JB-UFJF was formerly a coffee crop plantation (*Coffea arabica* L.) cultivated both in full sun and under the canopy of native forest species, especially *Pau-jacaré* (*Piptadenia gonoacantha* [Mart.] J.F.Macbr.), a large size, long-lived pioneer tree species native to Brazilian seasonal forests and exploited for tannins (Carvalho 2003). The current forest cover of JB-UFJF results from the abandonment of coffee crops and cattle pastures, which gave rise to a mosaic of different successional stages related to the past use of the area. Forest patches are found from early stages of succession after grazing abandonment to more mature woodlands with low anthropogenic interference, characterized by the presence of large remnant native trees.

This study was conducted in a forest patch (a section of a former coffee plantation grown under *P. gonoacantha* canopy), abandoned about 70 years ago (Oliveira-Neto 2014). The surveyed area covers approximately 15 ha (center coordinates: 21° 43′ 59.216″ S, 91° 22′ 19.359″ W), and represents an intermediate succession stage according to criteria established by the Brazilian Environmental Resolution (CONAMA 392/2007).

Twenty-five permanent plots of 20×20 m (400 m^2) were established in the surveyed area, with a total sampled area of 1 ha (Felfili et al. 2005). We measured the diameter of all living and standing dead individual trees with a DBH ≥ 5 cm (diameter at breast height at 1.3 m from the soil). The botanical material collected was identified using the CESJ herbarium collection from UFJF and the collection of Plant Ecology Laboratory (UFJF). The specific nomenclature and the abbreviations of the names of authorities follow the Species List of Brazilian Flora (http://floradobrasil.jbrj.gov.br/). The classification of botanical families followed the APG III system (APG 2009).

The characterization of the tree community was carried out by calculating following phytosociological parameters for each species: species richness (S), absolute density (*AD*), total and individual basal area (*BA*), relative frequency (*RF*), relative density (*RD*), relative dominance (*RDo*), and importance value (*IV*, Kent & Coker 1992 – eqn. 1):

$$IV = RF + RD + RDo$$

Species diversity was estimated using the Shannon's diversity index (H' – eqn. 2):

$$H' = -\sum_{i=1}^{n} p_i \log p_i$$

where p_i is the proportion of the i-th species, and n is the total number of species. This index is more influenced by species with a lower density, *i.e.*, locally rare (Magurran 2004). The Pielou's evenness index (J) was used to estimate the species uniformity of the community.

Results

We sampled a total of 1927 individual trees, of which 1837 were living trees. We found 117 species belonging to 84 genera and 33 families (Tab. 1). The five families with the highest species richness were Fabaceae (17 species; 14.6% of the total), Myrtaceae (10; 11.6%), Moraceae (9; 7.8%), Lauraceae (8; 6.9%), and Annonaceae (7; 6.0%), which together accounted for 46.2% of the total number of sampled species. Among the most abundant families in the area, five had the highest density of individuals: Arecaceae (824 individuals; 44.9% of the total), Fabaceae (234; 12.7%), Annonaceae (186; 10.1%), Rubiaceae (66; 3.6%), and Sapindaceae (65; 3.5%), which together accounted for 74.8% of the total number of sampled individuals.

We also sampled 89 standing dead trees, representing 4.6% of all sampled trees. The community had a total basal area of 43.61 m^2 ha^{-1}, and a strong dominance of few species. The five species with the highest importance value (IV) in the community were *Euterpe edulis* (22.9%), *Piptadenia gonoacantha* (16.5%), *Xylopia sericea* (5.7%), *Annona cacans* (3.5%), and *Syagrus romanzoffiana* (3.3%), which together amounted to 51.9% of the total IV. *Euterpe edulis* had the highest abundance (759 ind ha^{-1}), represented 41.2% of the total, and was present in all plots. Not surprisingly, the species with the highest basal area was *P. gonoacantha* (16.60 m^2 ha^{-1}), representing 38.2% of the total.

The value of Shannon's diversity species index for the whole community was H' = 2.92, while that of the Pielou evenness index was J = 0.61. Excluding the high-density species *E. edulis* from the analyses, the highest values were H' = 3.83 and J = 0.80.

With 117 species in a standard 1-ha sampled area, we found the highest species richness compared to secondary patches with the same vegetation type in the region, which registered 105 (Brito & Carvalho 2014), 78 (Fonseca & Carvalho 2012) and 48 species (Moreira 2014), respectively. Among the rare species in the sample, we found the climax species *Abarema cochliocarpos* and some late secondary species (such as *Andira fraxinifolia, Ceiba speciosa, Aspidosperma australe, Inga cylindrica* and *Nectandra lanceolata*), suggesting the potential of the area to conserve species with advanced succession. Based on the lists of threatened species prepared by the IUCN (2016), four species were considered "vulnerable" for the state of Minas Gerais: *Dalbergia nigra, Euterpe edulis, Ocotea odorifera,* and *Protium heptaphyllum.* The high-density species *E. edulis* is also in the "endangered" category. These same species were also found on the Brazilian official list of endangered flora species (MMA 2011). These results demonstrate the relevance of the study area in terms of high tree species richness, including endangered species.

Tab. 1 - Results of the phytosociological survey of the tree population sampled in the secondary forest regenerating after the abandonment of a shaded coffee plantation (*Coffea arabica*) in the Botanical Garden of the Federal University of Juiz de Fora, Juiz de Fora, Minas Gerais (southeastern Brazil). Species are listed in a decreasing order of importance value (*IV*). (*AD*): absolute density (ha^{-1}); (*BA*): basal area (m^2 ha^{-1}); (*FA*): absolute frequency; (*RD*): relative density; (*RDo*): relative dominance; (*RF*): relative frequency; (*IV*): importance value; (*%IV*): importance value as percentage; (*): Non-native species.

Species	AD	BA	FA	DR	RDo	RF	IV	IV(%)	Species	AD	BA	FA	RD	RDo	RF	IV	IV(%)
Euterpe edulis	759	99.518	25	41.29	22.82	4.59	68.70	22.90	*Miconia cinnamomifolia*	1	0.2037	1	0.05	0.47	0.18	0.70	0.23
Piptadenia gonoacantha	130	166.077	23	7.07	38.08	4.22	49.37	16.46	*Cordia glabrata*	2	0.0917	2	0.11	0.21	0.37	0.69	0.23
Xylopia sericea	111	31.211	22	6.04	7.16	4.04	17.23	5.74	*Myrtaceae* sp. (2)	6	0.0612	1	0.33	0.14	0.18	0.65	0.22
Annona cacans	43	25.618	13	2.34	5.87	2.39	10.60	3.53	*Casearia arborea*	3	0.0299	2	0.16	0.07	0.37	0.60	0.20
Syagrus romanzoffiana	63	10.768	21	3.43	2.47	3.85	9.75	3.25	*Cedrela fissilis*	2	0.0537	2	0.11	0.12	0.37	0.60	0.20
Machaerium nyctitans	42	12.725	11	2.29	2.92	2.02	7.22	2.41	*Ocotea odorifera*	2	0.0526	2	0.11	0.12	0.37	0.60	0.20
*Eriobotrya japônica**	45	0.3247	13	2.45	0.74	2.39	5.58	1.86	*Ficus adhatodifolia*	2	0.0515	2	0.11	0.12	0.37	0.59	0.20
Sparattosperma leucanthum	21	0.8277	11	1.14	1.90	2.02	5.06	1.69	*Brosimum guianense*	3	0.0223	2	0.16	0.05	0.37	0.58	0.19
*Coffea arabica**	33	0.1039	13	1.80	0.24	2.39	4.42	1.47	*Maytenus salicifolia*	3	0.0205	2	0.16	0.05	0.37	0.58	0.19
Coutarea hexandra	31	0.3009	10	1.69	0.69	1.83	4.21	1.40	*Ficus enormis*	2	0.0309	2	0.11	0.07	0.37	0.55	0.18
Xylopia brasiliensis	20	0.4631	11	1.09	1.06	2.02	4.17	1.39	*Ficus insipida*	2	0.0298	2	0.11	0.07	0.37	0.54	0.18
Cabralea canjerana	20	0.1247	14	1.09	0.29	2.57	3.94	1.31	*Annona neolaurifolia*	2	0.0186	2	0.11	0.04	0.37	0.52	0.17
Piper arboreum	28	0.0789	12	1.52	0.18	2.20	3.91	1.30	*Casearia* sp. (1)	2	0.0119	2	0.11	0.03	0.37	0.50	0.17
Piptocarpha macropoda	14	0.4885	11	0.76	1.12	2.02	3.90	1.30	*Ocotea villosa*	2	0.0091	2	0.11	0.02	0.37	0.50	0.17
Dalbergia nigra	24	0.2381	11	1.31	0.55	2.02	3.87	1.29	*Geonoma schottiana*	2	0.0080	2	0.11	0.02	0.37	0.49	0.16
Alchornea glandulosa	17	0.2960	12	0.92	0.68	2.20	3.81	1.27	*Campomanesia laurifolia*	2	0.0070	2	0.11	0.02	0.37	0.49	0.16
Nectandra oppositifolia	17	0.2358	12	0.92	0.54	2.20	3.67	1.22	*Stryphnodendron adstringens*	2	0.0064	2	0.11	0.01	0.37	0.49	0.16
Ocotea diospyrifolia	20	0.2212	11	1.09	0.51	2.02	3.61	1.20	*Jacaranda micrantha*	2	0.0063	2	0.11	0.01	0.37	0.49	0.16
Maprounea guianensis	17	0.1538	12	0.92	0.35	2.20	3.48	1.16	*Sloanea hirsuta*	2	0.0062	2	0.11	0.01	0.37	0.49	0.16
Cupania ludowigii	17	0.1161	12	0.92	0.27	2.20	3.39	1.13	*Citrus* sp. (1)	2	0.0048	2	0.11	0.01	0.37	0.49	0.16
*Syzygium jambos**	16	0.2592	10	0.87	0.59	1.83	3.30	1.10	*Luehea grandiflora*	1	0.0935	1	0.05	0.21	0.18	0.45	0.15
Sorocea guilleminiana	19	0.1059	11	1.03	0.24	2.02	3.29	1.10	*Solanum leucodendron*	2	0.0683	1	0.11	0.16	0.18	0.45	0.15
Allophylus sericeus	14	0.2740	8	0.76	0.63	1.47	2.86	0.95	*Schefflera morototoni*	1	0.0911	1	0.05	0.21	0.18	0.45	0.15
Guapira hirsuta	15	0.0675	9	0.82	0.15	1.65	2.62	0.87	*Solanum pseudoquina*	2	0.0522	1	0.11	0.12	0.18	0.41	0.14
Siparuna guianensis	12	0.0319	9	0.65	0.07	1.65	2.38	0.79	*Tibouchina granulosa*	1	0.0741	1	0.05	0.17	0.18	0.41	0.14
Ocotea puberula	9	0.1759	8	0.49	0.40	1.47	2.36	0.79	*Guatteria guianensis*	3	0.0223	1	0.16	0.05	0.18	0.40	0.13
Cupania oblongifolia	14	0.1245	7	0.76	0.29	1.28	2.33	0.78	*Abarema cochliacarpos*	2	0.0270	1	0.11	0.06	0.18	0.35	0.12
Ceiba speciosa	10	0.0725	7	0.54	0.17	1.28	1.99	0.66	*Cassia ferruginea*	2	0.0238	1	0.11	0.05	0.18	0.35	0.12
Trichilia elegans	8	0.0373	8	0.44	0.09	1.47	1.99	0.66	*Morus nigra*	1	0.0454	1	0.05	0.10	0.18	0.34	0.11
Cordia ecalyculata	11	0.0620	6	0.60	0.14	1.10	1.84	0.61	*Ocotea aciphylla*	2	0.0207	1	0.11	0.05	0.18	0.34	0.11
Lacistema pubescens	7	0.0242	7	0.38	0.06	1.28	1.72	0.57	*Eugenia cerasiflora*	2	0.0112	1	0.11	0.03	0.18	0.32	0.11
Matayba elaeagnoides	8	0.0519	6	0.44	0.12	1.10	1.66	0.55	*Casearia sylvestris*	1	0.0326	1	0.05	0.07	0.18	0.31	0.10
Machaerium stiptatum	8	0.0462	6	0.44	0.11	1.10	1.64	0.55	*Guatteria guianensis*	2	0.0067	1	0.11	0.02	0.18	0.31	0.10
Tabernaemontana laeta	10	0.2324	3	0.54	0.53	0.55	1.63	0.54	*Inga cylindrica*	1	0.0293	1	0.05	0.07	0.18	0.31	0.10
Cecropia glaziovii	6	0.1848	4	0.33	0.42	0.73	1.48	0.49	*Hortia brasiliana*	1	0.0284	1	0.05	0.07	0.18	0.30	0.10
Anadenanthera colubrina	6	0.1025	5	0.33	0.24	0.92	1.48	0.49	*Ficus macbridei*	1	0.0282	1	0.05	0.06	0.18	0.30	0.10
Alchornea triplinervia	7	0.0758	5	0.38	0.17	0.92	1.47	0.49	*Protium heptaphyllum*	1	0.0137	1	0.05	0.03	0.18	0.27	0.09
Albizia polycephala	7	0.1394	4	0.38	0.32	0.73	1.43	0.48	*Pseudobombax grandiflorum*	1	0.0131	1	0.05	0.03	0.18	0.27	0.09
Allophylus edulis	6	0.0706	5	0.33	0.16	0.92	1.41	0.47	*Guettarda viburnoides*	1	0.0124	1	0.05	0.03	0.18	0.27	0.09
Aparisthmium cordatum	5	0.1551	4	0.27	0.36	0.73	1.36	0.45	*Nectandra lanceolata*	1	0.0095	1	0.05	0.02	0.18	0.26	0.09
Cupania vernalis	6	0.1159	4	0.33	0.27	0.73	1.33	0.44	*Siphoneugenea* sp. (1)	1	0.0084	1	0.05	0.02	0.18	0.26	0.09
Annona sylvatica	5	0.0354	5	0.27	0.08	0.92	1.27	0.42	*Myrtaceae* sp. (1)	1	0.0069	1	0.05	0.02	0.18	0.25	0.08
Ocotea corymbosa	7	0.0303	4	0.38	0.07	0.73	1.18	0.39	*Myrsine coriácea*	1	0.0067	1	0.05	0.02	0.18	0.25	0.08
Guapira opposita	5	0.0717	4	0.27	0.16	0.73	1.17	0.39	*Zanthoxylum fagara*	1	0.0054	1	0.05	0.01	0.18	0.25	0.08
Ficus clusiifolia	5	0.0597	4	0.27	0.14	0.73	1.14	0.38	*Cheiloclinium serratum*	1	0.0048	1	0.05	0.01	0.18	0.25	0.08
Apuleia leiocarpa	5	0.0559	4	0.27	0.13	0.73	1.13	0.38	*Dalbergia frutescens*	1	0.0048	1	0.05	0.01	0.18	0.25	0.08
Seguieria langsdorffii	6	0.1707	2	0.33	0.39	0.37	1.08	0.36	*Lamanonia grandistipularis*	1	0.0044	1	0.05	0.01	0.18	0.25	0.08
Eugenia florida	5	0.0191	4	0.27	0.04	0.73	1.05	0.35	*Trichilia hirta*	1	0.0044	1	0.05	0.01	0.18	0.25	0.08
Vitex sellowiana	4	0.0138	4	0.22	0.03	0.73	0.98	0.33	*Peltophorum dubium*	1	0.0040	1	0.05	0.01	0.18	0.25	0.08
Myrcia splendens	4	0.0526	3	0.22	0.12	0.55	0.89	0.30	*Cybistax antisyphilitica*	1	0.0039	1	0.05	0.01	0.18	0.25	0.08
Croton floribundus	3	0.0646	3	0.16	0.15	0.55	0.86	0.29	*Platypodium elegans*	1	0.0039	1	0.05	0.01	0.18	0.25	0.08
Vernonanthura divaricata	3	0.1378	2	0.16	0.32	0.37	0.85	0.28	*Trichilia catigua*	1	0.0030	1	0.05	0.01	0.18	0.24	0.08
Aspidosperma australe	4	0.0326	3	0.22	0.07	0.55	0.84	0.28	*Andira fraxinifolia*	1	0.0029	1	0.05	0.01	0.18	0.24	0.08
Guarea macrophylla	1	0.2507	1	0.05	0.57	0.18	0.81	0.27	*Aspidosperma spruceanum*	1	0.0029	1	0.05	0.01	0.18	0.24	0.08
Luehea divaricata	4	0.0853	2	0.22	0.20	0.37	0.78	0.26	*Prunus myrtifolia*	1	0.0029	1	0.05	0.01	0.18	0.24	0.08
Jacaranda macranta	3	0.0239	3	0.16	0.05	0.55	0.77	0.26	*Casearia oblongifolia*	1	0.0024	1	0.05	0.01	0.18	0.24	0.08
Maclura tinctoria	3	0.0197	3	0.16	0.05	0.55	0.76	0.25	*Dalbergia villosa*	1	0.0024	1	0.05	0.01	0.18	0.24	0.08

Discussion

The richest families in this study, Lauraceae, Myrtaceae, and Moraceae, follow the phytogeographical pattern found by Oliveira-Filho & Fontes (2000) for semideciduous seasonal forest formations in southeastern Brazil. The composition in botanical families suggest a more advanced successional stage for the surveyed area, due in particular to the dominance of families with zoochorous dispersal of fleshy fruits and large seeds, such as Annonaceae, Lauraceae, Myrtaceae, and Moraceae (Tabarelli & Peres 2002). Myrtaceae species are considered important for the development of low-growing vegetation communities, especially because their fruits are appreciated and dispersed by animals (Tabarelli et al. 1994). The *Ficus* genus stands out with four species within the Moraceae family, and according to Carauta (1989), fig trees are key components of many tropical forests, since a wide variety of animals feeds on their fruits, including mammals, birds, and even fish. These species are responsible for the dispersion of seeds, thus helping the regeneration of the forest. The Lauraceae family, which had one of the largest importance value in the study area, is considered to be relevant in the structural composition of large areas of the Atlantic Forest (Tabarelli et al. 1999, Tabarelli & Peres 2002).

The high species richness in terms of families including species with zoochoric dissemination can be directly related to two reasons: (1) the former anthropogenic management of the surveyed area, especially due to the former presence of coffee crops under shading; and (2) the high density of *E. edulis* trees in the community. Several studies showed that tropical forests grown after coffee crop abandonment have a high diversity of animal species and native plants (Perfecto et al. 1996, Pascarella et al. 2000, López-Gómez et al. 2008). It is believed that the trees of the former shading canopy remained after the abandonment could play an important role in the following succession, as they supply seeds for regeneration stored in the shaded soil, and shelter the recruitment of trees under their canopies even after the canopy closure (Chazdon 2008). From this perspective, the predominant species *E. edulis* in the investigated area could have substantially contributed to the observed diversity by attracting animals that scatter seeds of other tree species, thus effectively contributing to the creation of the forest food web (Reis & Kageyama 2000).

The Shannon's diversity index (H' = 2.92) observed in this study was consistent with those found in similar studies on nearby secondary forests with the same vegetation type. For example, Fonseca & Carvalho (2012) obtained an index H' = 2.82 in a forest fragment at the regeneration stage, while Moreira (2014) observed a value of 2.84 in a small forest after more than 40 years since the abandonment, and Brito & Carvalho (2014) reported a value of 3.30 in a forest patch in an intermediate stage of succession. However, the forest patch analyzed in this study showed a lower diversity value as compared with the other three adjoining areas. Indeed, the lower evenness value (J = 0.61) reflects the high density of *E. edulis* trees, indicating that only 61% of the maximum hypothetical diversity (H') was reached in the studied area. On the other hand, excluding this species from computations resulted in diversity indices of H' = 3.82 and J = 0.81 (more than 80% of the maximal hypothetical diversity). Slightly larger values were found by Garcia (2007) and Valente et al. (2011) in nearby conserved forests (H' = 4.29 and H' = 4.11, respectively) located in remote areas not inserted into the urban context. Such comparisons better highlight the results obtained in the study area, where the dominance of a single species (*E. edulis*) did not hamper the presence in the community of other 116 species, resulting in the highest richness and one of the highest diversities (H') observed for forests in the region.

In this study, phytosociological analysis revealed a strong ecological dominance by *E. edulis* and *P. gonoacantha*. According to Kent & Coker (1992), the most important species in terms of importance value (*IV*) are those better exploiting the habitat resources, representing the core of the community structure. According to Reis et al. (2000), *E. edulis* stands occur in habitat rich in water, organic matter, and shade. Indeed, the presence of springs and drainage channels in the study area suggests a high moisture content, which apparently is the key to the success of this species. Forest use history also contributed to the high density of *E. edulis*. This species occurs naturally in the area, but its density increased after the management related to the former coffee plantation. When intercropped with *P. gonocantha*, a rapid-growth large species used for coffee shading, it is likely that *E. edulis* found its optimal conditions, as it requires shading in the early stages of development. In fact, a high incidence of sunlight can result in drying of recalcitrant seeds of this species in the soil seed bank (Queiroz 2000, Reis et al. 1999).

The low percentage of dead standing trees observed in this study (4.7%) suggests that the forest community is in a more advanced successional stage as compared with studies on the same vegetation type in the area, whose percentage exceed 15% (Fonseca & Carvalho 2012, Brito & Carvalho 2014, Moreira 2014). According to Chazdon (2008), more developed forests tend to have a lower percentage of dead trees. This is fairly common in secondary forests where pioneer species are replaced by secondary species along the succession. With a low dominance of pioneer species, competition among lower diameter classes decreases, and thus the mortality rate in competition tends to be lower (Chazdon 2008).

Overall, our results support the hypothesis of a well-structured community in more advanced successional stages in relation to nearby secondary forests with similar periods of abandonment. The dominant species *E. edulis* seems to be an efficient attractor of associated fauna and flora. Our findings suggests that coffee cultivation under shading, intercropped with native species of commercial interest, can be a good option for both production and conservation of species diversity.

We also found a peculiar combination of species recorded for the first time for semideciduous seasonal forest formations of the Juiz de Fora region, mainly attributed to the high density of *E. edulis* and the high basal area of *Piptadenia gonoacantha*. This species combination, along with the naturalization of exotic species (*Coffea arabica, Eryobotria japonica, Morus nigra*, etc.) and the proximity to a major urban center, suggests that this area can be considered a "novel ecosystem" *sensu* Hobbs et al. (2006). According to these authors, "novel ecosystems" arise from altered biotic elements, such as soil fertility, degradation, and the introduction of species. Many characteristics of our study area are similar to those observed for "novel ecosystems" in abandoned coffee plantations in Puerto Rico (Lugo & Helmer 2004), *e.g.*, the increase in density of large individuals (DBH > 55 cm) of *P. gonocantha* in comparison with the surrounding forest communities, or the presence of dominant species in the community (Mascaro et al. 2012). In this study, only two native species (*E.edulis* and *P. gonacantha*) accounted for 48.4% of individuals.

Conclusion

Areas with a history of intensive coffee farming, especially monocultures, are common throughout southeast Brazil. Many of these areas were abandoned and regenerated naturally thereafter. Understanding these "novel ecosystems" is fundamental for conservation of biodiversity. In this study, we found 117 species belonging to 84 genera and 33 families in a forest patch grown in a former coffee plantation 70 years since its abandonment, This suggesting the potential of such secondary ecosystems in the conservation of local species. Our results showed that coffee cultivation under shading, intercropped with native species of commercial interest, could be a good option for both production and biodiversity conservation.

According to Marris et al. (2013), the adoption of the "novel ecosystems" concept in the analysis of ecological conditions of forests may improve the study of new features acquired in response to anthropogenic impacts and promote the conservation of ecosystems previously considered of poor interest.

Acknowledgements

We thank the researchers from Herbarium CESJ-UFJF, especially Daniel S. Pifano, Kelly Antunes and Ricardo Castro for their assistance in botanical identification; students of Plant Ecology Laboratory (Department of Botany, UFJF) and José Carlos, for assistance in the field work; Dr. Guilherme R. Rabelo (UENF) and Dr. Arthur S. M. Valente (IEF), for revising the manuscript; Postgraduate Program in Ecology (PG-ECOL-UFJF) for logistical support; CAPES, for granting scholarships to N.E. Oliveira-Neto; and FAPEMIG, for financial support (Project APQ 04438/10).

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