Natureza & Conservação
Brazilian Journal of Nature Conservation
Supported by Boticário Group Foundation for Nature Protection
http://www.naturezaeconservacao.com.br

Research Letters

Animal-dispersed pioneer trees enhance the early regeneration in Atlantic Forest restoration plantations

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ARTICLE INFO

Article history:
Received 1 March 2014
Accepted 13 March 2015
Available online 30 May 2015

Keywords:
Frugivores
Natural regeneration
Restoration ecology
Seed dispersion
Tropical forest restoration

ABSTRACT

Planting of native trees has been adopted in many tropical regions worldwide as a central forest restoration method, but little is known concerning the role that these planted species play in catalyzing forest regeneration beneath their canopies. We investigated the role of animal-dispersed tree species in catalyzing the regeneration of woody species in the understory of restoration plantings. We assessed both the density and richness of tree seedlings within plots located beneath the canopy of both animal-dispersed and abiotic-dispersed tree species planted in three riparian forest restoration sites with ages of five, six and eight years. The proportion of animal-dispersed tree seedlings increased with plantation age. The richness of animal-dispersed tree seedlings was higher beneath animal-dispersed trees in the eight-year-old planting. The density of animal-dispersed tree seedlings was higher under animal-dispersed trees when sites were analyzed altogether. The top three species in regeneration density beneath the canopy were animal-dispersed trees, and from the top ten, seven were animal-dispersed species. We suggest that animal-dispersed pioneer trees which facilitate natural regeneration and promote a high density and richness of woody species beneath their canopies should be considered as "framework" species for tropical forest restoration.

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http://dx.doi.org/10.1016/j.ncon.2015.03.005

Introduction

Historical land uses in many human-modified tropical landscapes have compromised the resilience of natural ecosystems, and thus hampered their potential for self-recovery after abandonment (Chazdon, 2003). In order to recreate the conditions necessary for secondary succession in such a scenario, active restoration is needed to help overcome limitations concerning seed-dispersal and micro-site conditions (Holl and Aide, 2011). The planting of native trees has thus been adopted in many tropical regions worldwide as one of the main methods for restoring agricultural lands in this context (Rodrigues et al., 2011). Little is known however about the role that the species used in those plantings play in catalyzing forest regeneration beneath their canopies. Assessing the differing performances of planted tree species in permitting the spontaneous regeneration of other native species is thus a key tool for improving the ecological efficiency of restoration plantings.

Different approaches have been adopted toward the selection of tree species. They are usually based on the assumed functional role of the species in recovering degraded lands, and follow classifications such as: pioneer and non-pioneer species, filling and diversity species (Rodrigues et al., 2009), nurse plants (Padilla and Pugnaire, 2006), and "framework" species (Blakesley et al., 2002). Most of these approaches have focused on the reestablishment of a forest structure that is able to facilitate succession, but the role of such species in enhancing seed arrival remains little studied.

The reintroduction of animal-dispersed tree species in degraded lands may be particularly important for forest restoration in highly fragmented landscapes, since they can contribute to overcome dispersal limitation by attracting seed dispersers that may bring in their guts seeds they have consumed nearby (Lindell et al., 2012). However, animal-dispersed species do not form a homogeneous functional group, and may contain species with a distinct ability to attract frugivorous birds and bats to restoration sites, as a result of fruiting phenology, and fruit yield, size, nutritional value, smell and color (Wunderle, 1997). Consequently, outcomes for plant regeneration in restoration sites can differ widely amongst animal-dispersed species, and the identification and utilization of plant species that are more attractive to frugivores may enhance restoration success. An assessment of the regeneration community beneath the canopy of planted tree species may thus be useful for indicating which species should be favored in restoration plantings (Wydhayagarn et al., 2009). In this sense, we sought to investigate the role of animal-dispersed tree species in catalyzing the regeneration of woody species in the understory of restoration plantings. We aimed to answer the following questions: (1) is the richness and density of animal-dispersed tree seedlings higher under the canopy of animal-dispersed planted trees than under the canopy of abiotic-dispersed ones? (2) Is the regeneration of exotic animal-dispersed species higher under the canopy of animal-dispersed planted species? (3) Which planted tree species have a higher density of animal-dispersed tree seedlings under their canopies?

Material and methods

Study sites

The study was carried in Piracicaba, São Paulo State, south-eastern Brazil, in a region originally covered by Seasonally Tropical Dry Forest, within the Atlantic Forest biome (22°42′ S, 47°37′ W; altitude: 546 m; climate: Cwa, Koeppen's system). The study sites exist within a highly fragmented landscape with less than 10% forest cover that is principally a matrix of sugar-cane fields and urban zones. We selected three riparian forest restoration plantings with ages of five, six and eight years; the first two sites were previously occupied by pastures of the African grasses *Urochloa* spp., and the eight-year-old site by annual crops. Restoration planting was carried out in all sites using approximately 80 native tree species, which were planted in a 3×2 m spacing scheme (1.667 seedlings per ha) and stimulated by the control of exotic grasses (usually *Urochloa* spp. and *Panicum maximum*) via mechanical mowing and herbicide application. Bird communities in these plantings are dominated by generalist species, typical of disturbed sites (Alexandrino et al., 2013).

Data collecting

We counted and identified to species every tree seedling taller than 10 cm present in 2×3 m plots, these plots being located under the canopy of both animal-dispersed and abiotic-dispersed trees planted in each restoration site. The trunk of the tree was located at the center of each plot. We classified each surveyed tree seedling into three categories, each category consisting of two classes: species origin (native or exotic), colonizing status (local or immigrant) and dispersal syndrome (animal-dispersed or abiotic-dispersed species). We considered as native the seedlings belonging to species that are known to occur naturally in the study region and as exotic all those belonging to species that do not naturally occur in the study region. We classified as local the seedlings belonging to planted species and as immigrant those that do not belong to any of the tree species planted at the specific restoration site where the seedling was surveyed. To better explore the results when performing analyses, we created new categories by combining two or three of the seedling categories previously mentioned.

We evaluated 215 planted trees, amounting to 86, 74 and 55 trees at the five, six and eight-year old sites respectively. Altogether, we assessed natural regeneration under the canopy of 21 planted tree species (four to six animal-dispersed species, and four to seven abiotic-dispersed species per restoration site), including pioneers and non-pioneers (Table S1). All field data was collected in July 2011.

Data analysis

We calculated tree seedling species richness and density under the canopy of planted trees, in terms of the absolute and proportional values according to the total number of tree seedlings. These calculations were performed separately for each restoration site and for each of the three seedling