Journal for Nature Conservation 34 (2016) 24–32

Contents lists available at ScienceDirect

Journal for Nature Conservation

journal homepage: www.elsevier.de/jnc

# Limited effectiveness of artificial bird perches for the establishment of seedlings and the restoration of Brazil's Atlantic Forest

Adriana de Almeida[a], Márcia C.M. Marques[b], Marília de Fátima Ceccon-Valente[c], José Vicente-Silva[d], Sandra Bos Mikich[e,f,*]

[a] Programa de Pós-Graduação em Biologia Animal, Instituto de Biociências, Letras e Ciências Exatas, Universidade Estadual Paulista Júlio de Mesquita Filho, Rua Cristóvão Colombo 2265, 15054-000, São José do Rio Preto, SP, Brazil
[b] Laboratory of Plant Ecology, Department of Botany, Federal University of Paraná, CP: 19031, 81531-980, Curitiba, PR, Brazil
[c] Secretaria Municipal da Saúde, Prefeitura de Curitiba, Rua Francisco Torres 830, 80060-130, Curitiba, PR, Brazil
[d] Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, Trecho 2, Edifício Sede, 70818-900, Brasília, DF, Brazil
[e] Embrapa Florestas, Estrada da Ribeira Km 111, CP: 319, 83411-000, Colombo, PR, Brazil
[f] Department of Zoology, University of Oxford, South Parks Road, OX1 3PS, Oxford, UK

A R T I C L E I N F O

*Article history:*
Received 4 March 2015
Received in revised form 30 August 2016
Accepted 30 August 2016

*Keywords:*
Ecological restoration
Frugivory
Induced regeneration
Nucleation
Ornitochory

A B S T R A C T

Brazil's Atlantic Forest biome is severely degraded and fragmented throughout its range. Developing effective techniques to restore pasture and agriculture back to native vegetation is therefore a priority for legal and conservation purposes. In this study, we evaluate the ability of artificial bird perches to enhance the arrival of new seeds and seedling establishment in a degraded, semi-deciduous seasonal portion of the Atlantic Forest in southern Brazil. Specifically, we assess the influence of previous land use and habitat types on the abundance, species richness and ecological traits of bird-dispersed seeds, as well as on seedling establishment. Eight sampling sites were established, each containing one unit with seed traps and restoration plots under artificial perches and one similar unit without the perches. These sites were located in pasture and agriculture, distributed between riparian and sub-montane areas. Monthly sampling was conducted over two years between December 2005 and November 2007, resulting in the evaluation of 25,755 seeds and 56 endozoochoric seed species. The most abundant species were the pioneers *Cecropia pachystachya* Trécul and *Solanum americanum* Mill. Experimental units with perches received significantly more seeds than control units. Moreover, seed arrival was higher in sub-montane areas and on former pasture sites. Species richness followed a similar pattern of higher seed arrival, but there was no effect of vegetation type. Ecological characteristics of seeds were associated with land use type: former pastures received more tree seeds and pioneer species than expected by chance. Seedling establishment was very low in all treatments, with only eight seedlings established in perch plots by the end of the experiment. We conclude that despite artificial perches significantly increasing the arrival of endozoochoric seeds onto degraded lands, seedling establishment is drastically limited in these areas, compromising the efficacy of this technique for restoration purposes.



## 1. Introduction

The Atlantic Forest once covered almost the entire extent of the Brazilian coast, covering approximately 150 million ha and reaching into Paraguay and Argentina, but it is now restricted to 11.7% of its original area (Ribeiro, Metzger, Martensen, Ponzoni, & Hirota, 2009). Encompassing tropical and subtropical regions along its 29° of latitudinal range (Ribeiro et al., 2009), the Atlantic Forest is one of largest forests on the planet (da Silva & Casteleti, 2003). This biome has a variety of forest physiognomies which include semi-deciduous, evergreen, deciduous, sub-montane, and montane forests (Oliveira-Filho & Fontes, 2000). Due to extensive habitat loss and high concentration of endemic species, Brazil's Atlantic Forest is considered a "biodiversity hotspot" according to Myers and colleagues (Myers, Mittermeier, Mittermeier, da Fonseca, & Kent, 2000). Great part of the degradation of this forest is owing to land use change into agricultural and pasture fields over the late 20th

* Corresponding author at: Embrapa Florestas, Estrada da Ribeira Km 111, CP: 319, 83411-000, Colombo, PR, Brazil.
*E-mail addresses:* adri.dealmeida@hotmail.com (A. de Almeida), mmarques@ufpr.br (M.C.M. Marques), fc.marilia@gmail.com (M.d.F. Ceccon-Valente), ze.biologia@gmail.com (J. Vicente-Silva), sandra.mikich@embrapa.br (S.B. Mikich).

http://dx.doi.org/10.1016/j.jnc.2016.08.007
1617-1381/

and early 21st centuries. Presently, Brazilian law requires that at least 20% of the area of private rural lands in this Brazilian biome are preserved with native vegetation (Soares-Filho et al., 2014) and many land owners have to adequate to this situation by restoring portions of their lands.

The slow pace of natural regeneration has led conservationists to use management techniques that accelerate regeneration rates. Some of these methods are based on the concept of the successional mechanism of nucleation (Yarranton & Morrison, 1974), in which colonizing species recruit at high densities in a cluster which mimics natural successional processes (Corbin & Holl, 2012). These methods include artificial shelters for animals, soil and seed bank translocation, planting of tree islands, and installation of artificial perches for birds (McClanahan & Wolfe, 1993; Reis, Bechara, & Tres, 2010; Zahawi, Holl, Cole, & Reid, 2013). Restoration strategies based on natural processes (e.g. seed dispersal by animals) can have lower costs since they do not depend on seedling production and plantation. It can also enable surrounding forests to act as seed sources, enhancing natural succession.

Frugivorous birds play a key role in seed dispersal as they can disperse more seeds than any other vertebrate in the Atlantic Forest (Almeida-Neto, Campassi, Galetti, Jordano, & Oliveira-Filho, 2008). They have the habit of perching on structures to defecate or regurgitate previously ingested seeds (Reis, Bechara, Espíndola, Vieira, & Souza, 2003). This behavior has been exploited by restoration ecologists through the introduction and maintenance of natural and artificial perches in degraded landscapes (North America: McClanahan and Wolfe, 19933; Central America: Holl, 1998; Shiels & Walker, 2003; and South America: Zwiener, Cardoso, Padial, & Marques, 2014).

The effect of bird perches on the arrival of new seeds (seed rain) has been relatively well studied. However, this and similar restoration methods—such as use of essential oils to attract bats (Bianconi, Mikich, Teixeira, & Maia, 2007; Bianconi, Suckow, Cruz-Neto, & Mikich, 2012)—have recently been criticized, as despite increasing seed arrival, they do not necessarily improve seedling establishment or enhance the successional process (Graham & Page, 2012; Heelemann, Krug, Esler, Reisch, & Poschlod, 2012; Reid & Holl, 2013), and some bird assisted restoration studies fail to report the subsequent stages after seed dispersal (i.e. germination, seedling recruitment and survival) (Duncan & Chapman, 1999; Gonzales, Ingle, Lagunzad, & Nakashizuka, 2009; McDonnell & Stiles, 1983).

We aimed to systematically evaluate the effectiveness of artificial bird perches at increasing seed rain and seedling establishment (which includes seed germination) at the same time. We also studied the identity and ecological traits of the seed and seedlings encountered. We conducted the experiment under two land use types commonly found in tropical landscapes—agriculture and pasture—settled in two different forest habitats (riparian and submontane). We hypothesized that (1) seed deposition and seedling establishment (abundance, species density and richness) are higher in areas with bird perches, as found in previous studies; (2) the distribution pattern of seeds is similar for both land use types and habitats; while (3) the distribution pattern of seedlings differs according to land use type and habitat, especially regarding species' richness and ecological traits.

## 2. Methods

### 2.1. Study area and sites

The study took place at *Corumbataí* farm (23°56′11″ S and 51°56′59″ W; 440 m a.s.l.), municipality of Fênix, Paraná State (Fig. 1). According to an updated version of the Köppen-Geiger classification (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006), the climate is humid subtropical (Cfa), with hot summers (mean temperature 25 °C) and winters with rare frosts (mean temperature 16 °C), without a distinct dry season. Mean annual precipitation is 1683 mm and rain is concentrated during the summer months (Mikich & de Oliveira, 2003).

The study area was once covered by Semi-deciduous Seasonal Forest, or Interior Forests, one of the vegetation types of the Atlantic Forest biome (*see* Ledru, Montade, Blanchard, & Hély, 2016; Ribeiro et al., 2009; da Silva & Casteleti, 2003). This forest type is largely seasonal and 20–50% of its trees have deciduous behavior (Instituto Brasileiro de Geografia e Estatística, 2012). Due to intensive human activities, in the past few decades the Semi-deciduous Seasonal Forest has been reduced to small fragments surrounded by agriculture and pasture lands throughout its distribution (Mikich & Silva, 2001).

In the study region, the Semi-deciduous Seasonal Forest is characterized by two distinct sub-formations: 1) Riparian, distributed alongside the course of the rivers; and, 2) Sub-montane, located at higher altitudes (50–500 m) (Instituto Brasileiro de Geografia e Estatística, 2012). Besides altitude, the main difference between the two sub-formations is the amount of water in the soil: riparian forests are regularly under the influence of rivers' tides and some species, like *Sebastiania commersoniana* (Baill.) L.B. Sm. & Downs (Euphorbiaceae), *Calliandra foliolosa* Benth. (Leguminosae), and *Blechnum brasiliense* Desv. (Blechnaceae), are adapted to periods of flooding (Bianchini, Popolo, Dias, & Pimenta, 2003; Mikich and de Oliveira, 2003) while sub-montane species are not. Therefore, although these two sub-formations are similar in species richness (82 tree species in riparian and 83 species in sub-montane forests), there are some differences in species composition (about 53% of tree species are common to both types) (Mikich, Silva, & de Moura-Britto, 2004).

The Semi-deciduous Seasonal Forest in our study site is characterized by an emergent layer mainly composed by *Aspidosperma polyneuron* Müll. Arg. (Apocynaceae), *Gallesia integrifolia* (Spreng.) Harms (Phytolaccaceae), and *Ficus* spp. (Moraceae), whose individuals can reach up to 40 m high. The canopy is highly diverse and the main families include Meliaceae, Lauraceae, Leguminosae, and Arecaceae, with *Euterpe edulis* Mart. as the dominant species. The most common trees in understory are *Sorocea bonplandii* (Baill.) W.C. Burger, Lanj. & Wess. Boer, *Citrus sinensis* (L.) Osbeck, and *Trichilia* P. Browne. The shrubby-herbaceous vegetation comprises the families Dryopteridaceae, Thelypteridaceae, and Pteridaceae (all ferns), Poaceae, Marantaceae, Piperaceae, and Commelinaceae (Mikich & de Oliveira, 2003). The threatened animal species (according to IUCN, 2015) Bare-throated Bellbird (*Procnias nudicollis* [Vieillot, 1817]), Black-backed Tanager (*Tangara peruviana* [Desmarest, 1806]), Oncilla (*Leopardus tigrinus* [Schreber, 1775]) and White-lipped Peccary (*Tayassu pecari* [Link, 1795]), can be found in the study area.

### 2.2. Study design

To test the effectiveness of artificial perches for restoration purposes, we selected eight open sampling sites located nearby small forest patches. Half of the sites were covered by maize one month before the experiment started and cattle were grazed in the other half. Two sites of Riparian or Submontane forest were used for each former land use type (agriculture or pasture), leading to four treatments (with two replicates per treatment): riparian agriculture; riparian pasture; sub-montane agriculture; and, sub-montane pasture. All sites were located between 800–2100 m from the largest forest remnant in the study region, the *Vila Rica do Espírito Santo* State Park (Fig. 1), a protected area of 354 ha that is expected to be an important source of propagules and seed dispersers for the region (Mikich & de Oliveira, 2003).