Can exotic tree plantations preserve the bird community of an endangered native forest in the Argentine Pampas?

Lacoretz, Mariela V.*, Depalma, Daniela M., Torrella, Sebastián A., Zilli, Cecilia, Ferretti, Valentina and Fernández, Gustavo J.


Fernández, G. J. GIEFAS-INIBIOMA, Asentamiento Universitario San Martín de los Andes (AUSMA). Universidad Nacional del Comahue, Pasaje de la Paz 235, San Martín de los Andes, Neuquén, Argentina

Corresponding author: Lacoretz, Mariela V., (e-mail: mlacoretz@ege.fcen.uba.ar).
Abstract

Worldwide, the areas covered by native forests are declining while those of tree plantations are increasing. This has raised the question of whether tree plantations are able to preserve native forest species. In Argentina, the main native forests of the Pampas region, called talares, are endangered and their disappearance is imminent. Although exotic tree plantations are increasing in this region, their role in maintaining the bird diversity of talares has not been studied in Argentine Pampas. We compared the bird community attributes and vegetation structure of talares native forest with those of tree plantations. Plantations exhibited markedly lower bird richness than talares, up to 80% lower, and all forest-dependent bird species were absent in plantations. Talares and plantations differed also in some aspects of vegetation structure, which usually are key determinants of bird abundance. Given the extreme importance of talares for forest birds, this bird community will be deeply affected if it continues to decline, as nearby plantations do not offer suitable habitat. In order to maintain the bird diversity of talares, and probably the diversity of other unstudied taxa related to them, we recommend management actions that should be applied urgently in these endangered forests of the Argentine Pampas.

Keywords: biodiversity conservation, bird diversity, Celtis tala, management actions, talares.
Introduction

A major part of the world’s biodiversity depends on native forests to survive (Brockerhoff et al. 2013). While tree plantations are expanding globally (Payn et al. 2015), substantial areas of native forest are being lost each year (FAO 2015) leading to a great loss of biological diversity (Brook et al. 2003). Such native forest cover reductions occur mainly in South America (FAO 2015). In fact, during the 1982–2016 period, three South American countries, Brazil, Paraguay and Argentina, suffered the largest deforestation of the world (Song et al. 2018).

The main native forests of the Argentine Pampas are the talares (forests dominated by Celtis tala), although their continuous reduction is conducting them to an imminent disappearance (Arturi and Goya 2004). Given its degradation, this forest has been recently classified as an endangered ecosystem (Ferrer-Paris et al. 2019). Originally, this native forest was widely distributed along the coast of central Argentina, but currently only small fragments remain (Guerrero 2019). These small forest fragments are the only native arboreal component in a region dominated by grasslands. The main causes of talares’ declines are urbanization, wood and shell extraction, and exotic tree planting (Arturi and Goya 2004). At the same time, the establishment of exotic tree plantations is increasing in the region (Matteucci 2012). While a law that promotes the protection of native forests in this region has been recently approved (Provincial Act No. 14 888, 2017), its implementation has not yet become effective (Aguiar et al. 2018). This situation leaves the native forest ecosystem in danger, along with all the biodiversity it hosts within its area of distribution.

The continuous reduction of native forests together with the increase of plantations in Argentina, as in the rest of the world, have raised the question of whether
these new tree plantations are able to offer appropriate habitat to native forest species (Brockerhoff et al. 2008, 2013; Quine and Humphrey 2010). For this reason, and because bird communities are usually considered as suitable biodiversity indicators (Gardner et al. 2008), many studies have compared bird communities of native forests and tree plantations, sometimes with conflicting results (Castaño-Villa et al. 2019). On the one hand, some studies did not find differences in bird species richness between native forests and tree plantations (e.g., Lantschner and Rusch 2007; Castaño-Villa et al. 2014) suggesting that plantations could contribute to bird conservation of degraded ecosystems. On the other hand, most authors have observed significantly lower bird species richness along with compositional changes of bird communities in tree plantations compared to native forests (Marsden et al. 2001; Farwig et al. 2008; Paritsis and Aizen 2008; Irwin et al. 2014; Fujita et al. 2016; Phifer et al. 2017). In particular, forest-dependent birds, insectivores and cavity nesters usually show the greatest differences between these two tree cover types (Loyn et al. 2007, Volpato et al. 2010).

All these differences in bird community attributes may be related to the fact that birds can select both the structure and the composition of vegetation (Johnson 2007).

Vegetation characteristics can vary between native forests and tree plantations, but also among plantations, which may explain why only some tree plantations play an important role in biodiversity conservation (Castaño-Villa et al. 2019).

Given that native forests of the Argentine Pampas are endangered and plantations are increasing in this region, the objective of this paper is to determine the extent to which exotic tree plantations preserve the bird community of talares native forests. First, we compare quantitatively the bird community attributes (i.e., richness, abundance, composition) of talares native forests and two types of exotic tree plantations. Second, given that birds are associated with the vegetation characteristics of
the ecosystems they inhabit, we assess whether talares and plantations differ in their vegetation structure and analyze the magnitude of this difference. To the best of our knowledge, this is the first study to address this issue for the bird community of talares forests.

**Materials and methods**

**Study area**

We conducted our study in talares native forests and exotic tree plantations of the southern extreme of Samborombón Bay, Buenos Aires province, Argentina (Fig. 1.). The area belongs to the Flooding Pampas region, where mean temperature varies from 23°C in January to 9°C in July, and mean annual precipitation is 900 mm (Matteucci 2012). The original landscape consisted of a mosaic of extensive grasslands disrupted by small wetlands and talares (Arturi and Goya 2004). Since this forest only grows in non-flooding zones with highly permeable soil (Arturi and Goya 2004), it is limited to the upper parts of the landscape formed by shell ridges, which correspond to the locations of the coast at different times of the marine retreat (Cavallotto 2002). The actual original distribution of talares is unknown, although it is estimated to be much greater than their current distribution (Matteucci 2012). Given the discontinuous spatial distribution of its substrate, talares native forests exhibit a particular pattern of narrow, elongated patches surrounded by a grassland matrix which is often subjected to grazing (Arturi and Goya 2004). The dominant tree species are *Celtis tala*, *Jodina rhombifolia* and *Scutia buxifolia*, while *Sambucus australis* and *Schinus longifolius* have lower abundances (Arturi and Goya 2004).

In this area, probably as a consequence of national policies that promoted forestry (National Act No. 25 080 and 26 432), the transformation of land into tree
plantations has increased over the last decades (Matteucci 2012). Near the remaining talares’ area, tree plantations of mono-specific stands of *Pinus* spp. and, to a lesser extent, of *Eucalyptus* spp. and *Populus* spp., have been planted along the coast. Exotic tree plantations of this region are usually small, since they are used mainly for dune fixation, real estate ventures and smaller residencies (Table A1). As the historical distribution of talares is unknown, it is uncertain whether the plantations studied are settled in areas previously occupied by talares. However, some sections of the distribution of the plantations are non-floodable areas, elongated and narrow in shape, surrounded by floodable lowlands, which is reminiscent of the typical talares distribution.

**Sampling design**

During the southern hemisphere spring (early December) of 2014, we sampled birds and vegetation in 4 patches of talares native forest, 4 patches of pine plantations (*Pinus* spp.) and 4 patches of other plantations (2 patches of *Populus* spp. and 2 of *Eucalyptus* spp., Fig. 1). Due to the scarce surface covered by *Populus* spp. and *Eucalyptus* spp. plantations in the study area, we included them in a single category based on preliminary information about their similar vertical profile (i.e., both exhibit woody cover above 15 m height). We sampled those talares patches that were closest to tree plantations to minimize clustering of tree cover types. Native forest patches (NF) had a size range between 1.9 and 13.6 ha, pine plantation patches (PP) ranged from 9.4 to 24.8 ha and the other plantations’ patches (OP) ranged from 2.9 to 5.6 ha (Table A1). Thus, each plantation type represented a different size range of the talares native forest patches. Depending on the size and shape of the patch, between 1 and 7 sampling points were placed per patch (Table A1) with a minimum distance among neighbor points of 150 m. In each tree cover type (NF, PP and OP), points were selected randomly along
transects located within the patches by using the QGIS software (QGIS Development Team 2019).

**Bird sampling**

We recorded presence and individual abundance of bird species once for each point, between December 1st and December 15th of 2014. To avoid differences in vegetation structure from interfering in the detection of individuals, we used the fixed radius point count method (Bibby et al. 1998) with a small radius of 20 m. In addition, since these native forest patches are usually elongated and narrow in shape, the 20-meter radius allowed the sampling area to be contained within the forest at all points. Samplings were performed from dawn to mid-morning (9:30 a.m.), avoiding rainy and windy days (Bibby et al. 1998). During 10 minutes, one observer (ML) recorded birds seen or heard within the sampled area, disregarding birds flying above points.

**Vegetation sampling**

We sampled vegetation structure at the same points where bird surveys were conducted within a radius of 20 m centered on the point. In each circle, we distributed eight locations randomly and, in each location, we raised a 9-meter demountable marked rod. When vegetation was taller than 9 m, measurements were estimated by projection. In each location, vertical cover was determined by recording the presence of intersections of woody vegetation at each 1-meter interval of the rod. We also recorded the presence or absence of woody species in each location in order to estimate tree cover. Thus, for each point we defined the following vegetation structure characteristics: one value of tree cover (percentage of locations with presence of woody species), vertical intersections (number of intercepted intervals across locations), and maximum height. We also built a vegetation profile in which we determined, for each
tree cover type and height interval, the percentage of points with intersections. In addition, we estimated the area covered by trees within a radius of 100 m around each sampling point using Google Earth satellite images in QGIS software (QGIS Development Team 2019).

**Data analysis**

All the analyses were executed with the R v.3.6.0 (R Core Team 2019). We compared bird community attributes (richness and abundance per point) and vegetation characteristics (tree cover within 20 m and 100 m radius, maximum height and vertical intersections) among tree cover types, with linear mixed-effects models with function “lme” in the “nlme” package (Pinheiro et al. 2019). In all cases, the tree cover type was the fixed factor and, in order to take into account the potential interdependence among points belonging to the same patch, the patch was considered as a random factor. When data did not meet the assumptions of homogeneity of variances, we used the most suitable variance structures for appropriate model estimation (Zuur et al. 2009). We also verified the absence of spatial autocorrelation in the residuals of each model through the spline correlogram, using the “spline.correlog” function in “ncf” package (Bjornstad 2019). We performed multiple comparisons with the Tukey method with the "emmeans" function in the "emmeans" package (Lenth 2019).

In addition, we compared total bird richness among tree cover types by individual-based rarefaction and extrapolation curves, where non-overlapping 95% confidence intervals indicate significant differences between tree cover types and estimated total richness for each tree cover type by the Chao estimator with the "iNEXT" package (Hsieh et al. 2019).
We compared bird community composition among tree cover types with a PERMANOVA analysis, using the Euclidean distance and 999 permutations. To account for the interdependence of sites belonging to the same patch, we used the “nested.npmanova” function of the “BiodiversityR” package (Kindt and Coe 2005), that allowed us to nest groups of sites within patches. A dummy variable containing only values equal to 1 was added to the original database, since at certain census points bird species richness was zero. This action is appropriate in cases where communities are impoverished for biological reasons, and it avoids the undefined dissimilarity indices between sites (Clarke et al. 2006). We applied a Hellinger transformation, which calculates each species’ abundance as the square root of its relative abundance per site (Legendre et al. 2005). Then, pairwise comparisons were made between tree cover types. We previously checked the assumption of homogeneity of multivariate dispersion, since our design was unbalanced (Anderson and Walsh 2013).

We defined forest-dependent species as those only found in woodland habitats, and habitat-generalist species as those occurring in woodland habitats and one or more other habitat types, such as rural areas, grasslands, marshes, based on published data (Narosky and Yzurieta 2003). Also, bird species were classified according to their trophic group using bibliographic data, and assigned to one of the following categories: carnivores, granivores, herbivores, insectivores, nectivores, and omnivores (Cueto and Lopez de Casenave 2000; Giraudo et al. 2006). In addition, bird species were classified according to their nesting substrate (trees, ground, or shrubs) and whether they were cavity nesters or not (de la Peña 2015). We compared mean richness per point of habitat-generalist species, main trophic groups (i.e., insectivores and granivores) and cavity nesters among tree cover types, in the same way we had compared overall...
richness per point. This analysis was not carried out for forest-dependent species since no forest-dependent birds were recorded within any of the plantations.

**Results**

**Bird community attributes**

Bird communities of talares native forest and tree plantations were different. Total bird richness of plantations was less than half of talares’ richness, regardless of the differences in sampling effort (Fig. 2, Table 1). That difference was even more evident when comparing mean bird richness per point, being the richness of pine and other plantations 80% and 55% lower than the talares’ richness, respectively (Table 1). The same pattern was obtained with mean bird abundance per point that was 79% and 44% lower in the pine and other plantations, respectively, compared to talares native forests (Table 1).

In addition, bird community composition varied among tree cover types (Nested Permanova, $F_{2,33} = 4.7, p < 0.001$; *a posteriori* comparisons: NF-PP, $F_{1,29} = 3.3, p = 0.032$, NF-OP, $F_{1,13} = 2.14, p < 0.033$, OP-PP, $F_{1,24} = 1.73, p = 0.027$), with the assumption of multivariate variance homogeneity being met ($F_{2,42} = 0.02, p = 0.98$).

Such difference was due not only to the observed differences in species richness, but to the identity of the dominant species and the greater evenness of the talares native forest compared to tree plantations (Fig. 3). In that sense, the native forest exhibited 16 unique bird species, in contrast to three found in pine plantations and two found in other plantations, one of the latter two being an exotic species (Table 2). In addition, all 10 forest-dependent species were only present in the native forest (Fig. 3, Table 2), being *Elaenia parvirostris* the species with the highest relative frequency in the native forest (i.e., 0.69, Table 2). The native forest also had on average more than 3 times the habitat-
generalist richness per point than the pine plantation, although there were no differences with respect to the other plantations (Table 1). The main bird trophic group richness was also different between tree cover types. Mean richness per point of insectivorous birds was 85% lower in pine plantations, and 47% lower in other plantations, with respect to native forest (Table 1). Likewise, mean richness per point of granivores was 80% and 69% lower in the pine plantation and in other plantations, respectively, compared to the talares native forests (Table 1). Regarding nesting substrate, nearly all bird species nest in trees (except Zonotrichia capensis which nests on the ground and Sporophila caerulescens which nests in shrubs) and 22% are cavity nesters (Table 2). The mean cavity nester richness per point was 89% lower in the pine plantation compared to talares native forest, but no differences were found between talares and the other plantations (Table 1).

**Vegetation characteristics**

Tree cover differed between native forest and tree plantations depending on the scale. Within a 20-m radius, the mean percentage of tree cover did not differ among tree cover types (Table 1). However, within a 100-m radius, mean tree cover was greater in the pine plantation than in the talares native forest, while no differences were found with respect to the other plantations (Table 1). Vegetation profiles varied among all tree cover types. The maximum cover of the talares native forests was at a height of 2-5 m, while the maximum cover of pine plantations was found at 4-11 m and the other plantations, at 7-22 m (Fig. 4). The shrub stratum (1-2 m height) was better represented in talares, with 85% of cover, compared to pine plantation with 37%, and other plantations with 13% (Fig. 4). In addition, the number of vertical intersections did not differ between the talares native forest and the pine plantation, but they were lower in the talares native forest than in the other plantations (Table 1). Maximum height varied
as well, being lower in talares and in the pine plantation than in the other plantations (Table 1). Finally, talares exhibited more woody species than plantations (Table 1), since they hosted all the woody species of the native forest of the region: *Celtis tala, Jodina rhombifolia, Scutia buxifolia, Sambucus australis* and *Schinus longifolius*.

**Discussion**

This study provides the first evaluation of the potential role of tree plantations in preserving the bird community of the talares native forest of the Argentine Pampas. Tree plantations showed markedly lower bird richness and abundance and substantial differences in bird community composition compared to the talares native forest, especially regarding forest-dependent bird species. Such differences call into question the role of tree plantations as a safeguard of bird diversity. These results are consistent with other findings not only from other regions of Argentina (Zurita et al. 2006; Paritsis and Aizen 2008; but see Lantschner and Rusch 2007) but also from different parts of the world (Marsden et al. 2001; Farwig et al. 2008; Irwin et al. 2014; Fujita et al. 2016; but see Castaño-Villa et al. 2014).

**The impact of plantations on bird community features**

Total bird species richness of plantations was half the richness found in talares. Moreover, mean richness and abundance per point were approximately five times higher in talares than in pine plantations. Even if mean richness and abundance per point were higher in other plantations than in pine plantations (which at some points exhibited zero individuals), their total richness did not differ. This result suggests that plantations cannot properly sustain the bird diversity of the native forest, regardless of the tree species of the plantations. As Sekercioglu (2002) proposed in his study, due to the general low abundance of individuals within plantations, birds inhabiting these tree
cover types may not be able to form viable populations but rather depend on individual
dispersion from nearby talares. Furthermore, plantations presented lower bird
community diversity, since they had a lower evenness in addition to their lower bird
species richness. The substantial differences found among tree cover types suggest that,
even though a 20 m radius could have reduced the sampling effort of point counts,
given the shape and distribution of the forest patches in our field site the sampling effort
was sufficient for the purpose of this study.

Forest-dependent birds and the main trophic groups had lower richness in
plantations with respect to the native forest. Indeed, all forest-dependent species were
absent in tree plantations, and in pine plantations even the richness of habitat-generalists
was lower. These results are similar to those obtained in other studies where forest-
dependent species were less common in plantations than forest-generalists (Sekercioglu
2002; Zurita et al. 2006; Volpato et al. 2010). In general, the richness of the different
trophic groups was also lower in plantations. The number of insectivorous species was
notably low in plantations, especially in pine plantations where richness of insectivores
was 85% less than in talares, being this difference even greater than the difference
observed for overall bird richness in this type of tree cover. The lower richness of
insectivorous bird species in plantations has also been reported by other studies,
suggesting that these birds may be more sensitive to environmental disturbances
(Volpato et al. 2010; Fujita et al. 2016). Unlike other studies where granivorous birds
were favored in disturbed environments (Gray et al. 2007), in our study granivores’
richness also was lower in both plantation types compared to native forest, probably due
to the lack of vegetation cover in the lower strata exhibited by these habitats. Carnivores
were the only trophic group whose number of species was greater in plantations than in
talares. For example, pine plantations were the only tree cover type in which we
recorded the raptor species *Phalcoboenus chimango* and *Rupornis magnirostris*, which might be associated to plantations as they may take advantage of the high perches with good visibility to seek prey (Phifer et al. 2017). Similarly, other plantations were the only tree cover type where we recorded the one exotic bird species detected in this study (*i.e.*, *Passer domesticus*). As for nesting substrate, *Zonotrichia capensis* is the only species that nests on the ground and was much more abundant in the native forest than in the plantations (Table 2). *Sporophila caerulescens*, a shrub nesting species, was only present in the native forest, probably related to the lack of the lower stratum in the plantations. Similar to what has been found in other systems (Loyn et al. 2007), cavity nesters tended to have higher richness in the native forest than in plantations, although this difference was only significant in comparison to the pine plantations.

Such differences in bird community attributes between native forests and tree plantations are not attributable to an impossibility of birds to colonize tree plantations, given that the distance between these forest types (approximately 10 km) is short from a bird’s perspective (Paradis et al. 1998). Thus, the differences in bird community features among talares native forest and plantations could be related to the extent to which these tree cover types differ in terms of their vegetation characteristics. Although the identity and origin (*i.e.*, native or exotic) of the dominant tree species were different because of the very nature of the tree cover types chosen, plantations did not differ in all vegetation structural characteristics with respect to the native forest. Tree cover within 20 m and 100 m and patch sizes were similar between talares native forest and at least one plantation type. The same applies to maximum height of vegetation and vertical intersections. Thus, the differences found in bird community features may not be attributable to these structural characteristics. Instead, other characteristics differed markedly between plantations and talares. Woody species richness was lower in
plantations, and their shrub stratum was less represented, as well as in plantations from other regions (Aubin et al. 2008). Therefore, it is possible that these characteristics may be more related to the observed differences in bird community attributes between native forest and plantations.

Talares native forest and tree plantations differed both in tree species composition and in some aspects of vegetation structure, which usually are key determinants of bird abundance and distribution (Wiens 1989). Bird richness and abundance are often positively associated with trees’ age (Poulsen 2002), with habitat heterogeneity (Fleishman et al. 2003) which increases the number of available microhabitats (Tews et al. 2004), and with the amount of habitat available in the landscape (Fahrig 2013). In this sense, talares contain mature trees and shrubs that are widely used as nesting sites by the local bird community (de la Peña 2015). Their higher woody species richness likely provide a more heterogeneous spatial configuration and probably positively affects the availability of food items such as invertebrates and fruits (Cueto and Lopez de Casenave 2002; Blendinger et al. 2016). However, talares native forest also had lower vertical heterogeneity than other plantations and less tree cover than pine plantations at the wider scale, and yet had greater bird species richness than tree plantations. It is possible that tree plantations are not considered habitat (sensu Fahrig 2013) by some forest birds, and thus their greater cover does not increase bird species richness. In this regard, it has been observed that several bird species of the talares native forest do not nest in exotic trees (Gonzalez et al. 2019) or that they are not successful nesting on them (Segura et al. 2020). Further research is needed to determine if the availability of fruits and invertebrates could explain bird community differences between plantations and the talares. All these results suggest that bird richness of talares is more strongly associated with the presence of different native tree species, each one
with different physical characteristics, added to its developed understory, than with the
other measured structural attributes of the vegetation. Given the extreme importance of
talares for forest birds, if this ecosystem continues to decline, the bird community would
be deeply affected, since nearby plantations would not offer suitable habitat.

**Concluding remarks**

None of the plantations studied here properly preserved the bird community of
the talares native forest. While tree plantations have been suggested to be relevant for
biodiversity conservation in other regions such as North America (Sax 2002), Europe
(Proença et al. 2010), and Australia (Loyn et al. 2007), this does not seem to be the case
in the native forests of the Argentine Pampas. On the one hand, it should be noted that
in other regions, tree plantations often consist of native trees (Payn et al. 2015) which
usually have less negative effects on the bird community than exotic tree plantations
(Castaño-Villa et al. 2019). Such systems might resemble the native forest in terms of
vegetation composition and, perhaps over time, vegetation structure. Instead, in South
America, more than anywhere else in the world, these plantations are mainly of exotic
trees (i.e., 88% of plantations are exotic; Payn et al. 2015), and thus they may never
resemble the native forest. Nevertheless, studies conducted in South America have
compared bird communities in native forest and native tree plantations and they found
both, substantial (Zurita et al. 2006) and not important differences (Castaño-Villa et al.
2014) between their bird communities. On the other hand, it has also been proposed that
tree plantations could favor biodiversity conservation through mechanisms such as
habitat complementation, connectivity and buffering (Brockerhoff et al. 2008), but these
mechanisms may not be the most relevant in talares native forests due to their naturally
discontinuous spatial pattern. Moreover, plantations of the Argentine Pampas are not
only irrelevant for forest bird conservation but could even lead to underlying negative
consequences for biodiversity (i.e., bioperversal consequences *sensu* Lindenmayer (2009)). In this sense, some studies carried out in this region reported that tree plantations can lead to increased soil salinization and acidification, and extract significant amount of water from the watertable (Jobbágy and Jackson 2004, Jackson et al 2005, Besteiro 2014). All in all, our results suggest that the role of tree plantations in biodiversity conservation may be situation-specific, and particular systems should be carefully evaluated before making generalizations (Bremer and Farley 2010).

**Management implications**

In order to maintain the bird diversity of talares, and probably, the diversity of other unstudied taxa related to them, management actions should be applied urgently in this endangered ecosystem of the Argentine Pampas. Since the birds of the talares are strongly associated with vegetation composition, the establishment of native rather than exotic tree plantations should be encouraged. In addition, given that the presence of a lower stratum was one of the structural vegetation differences between native forest and plantations, we recommend promoting the increase of shrub vegetation by stand density management. This management involves increasing the light passage by initial tree spacing and canopy density reduction through thinning, which promotes the development of the shrub stratum (Bauhus and Schmerbeck 2010). These actions have been positively related to bird and arthropod diversity in tree plantations of other regions (Bauhus and Schmerbeck 2010). Moreover, as cavity nesting bird species were less represented in plantations, provision of artificial cavities (nest-boxes) may also be recommended (Loyn et al. 2007).

Apart from recommending managements actions for tree plantations, given that talares are apparently irreplaceable, it is essential to preserve the remaining native forest
fragments, and to increase their connectivity through restoration actions. To reach this goal, we should use the management tools that already exist. The Argentine Forest Law (National Act No. 26 331) promotes research, conservation and restoration of native forests, establishing three protection categories for the remaining forests of the country ("high", "intermediate" and "low"). However, most of the southern talares we studied here are only categorized as "intermediate" despite their proximity to the Campos del Tuyu National Park and their high conservation value. We urge that the value of these talares be recognized, and we suggest switching their category to "high". During the years we conducted our study we have seen the extraction of wood from these forests in private land, leading to a steady and deep decline in the area covered by this native habitat. These practices have to be stopped by implementing the above-mentioned law, but also by increasing the conservation categorization and priority of these forests.

Moreover, although the Argentine Forest Law was a breakthrough in forest conservation, it is poorly funded since only 3% of its budget was allocated to its implementation in 2020 (Argentine General Budget Law, 2019). This prevents almost completely the fulfillment of the law’s objectives, and is putting in danger not only the talares but all the forests of Argentina.

Acknowledgments

The authors gratefully acknowledge M. Beade for the logistical support provided, V. Blanco, M. Taborda, P.D. Pintos and C. Guevara for their collaboration in the fieldwork, and the Municipalidad de La Costa, Buenos Aires, for the accommodation provided during fieldwork. We appreciate the improvements in English usage made by Elizabeth Hobson through the Association of Field Ornithologists' program of editorial assistance. This work was supported by The Rufford Foundation (12684-1, 2014-2015) and the University of Buenos Aires (20020110100079, 2012-2015 UBACYT program).
References


https://CRAN.R-project.org/package=ncf.


Hsieh, T.C., Ma, K.H., and Chao., A. 2019. iNEXT: iNterpolation and EXTrapolation

http://chao.stat.nthu.edu.tw/blog/software-download/.

Irwin, S., Pedley, S.M., Coote, L., Dietzsch, A.C., Wilson, M.W., Oxbrough, A.,
Sweeney, O., Moore, K.M., Martin, R., Kelly, D.L., Mitchell, F.J.G., Kelly, T.C.,
O’Halloran, J., and Halloran, J.O. 2014. The value of plantation forests for plant,
invertebrate and bird diversity and the potential for cross-taxon surrogacy.

Jackson, R.B., Jobbágy, E.G., Avissar, R., Roy, S.B., Barrett, D.J., Cook, C.W., Farley,
doi:10.1126/science.1119282.

Jobbágy, E.G., and Jackson, R.B. 2004. Groundwater use and salinization with
2486.2004.00806.x.


common statistical methods for ecological and biodiversity studies. World
Agroforestry Centre.

Argentina.

Lantschner, M. V, and Rusch, V. 2007. Impacto de diferentes disturbios antrópicos
sobre las comunidades de aves de bosques y matorrales de Nothofagus antarctica

Legendre, P., Borcard, D., and Peres-Neto, P.R. 2005. Analysing beta diversity:


Table 1

Bird community attributes and vegetation features in talares native forest and exotic tree plantations in the Argentine Pampas. Mean and 95% confidence interval of variables are shown. Different letters denote significant differences within rows ($p < 0.05$), a–c ranked highest to lowest. Estimated bird species richness was calculated by Chao index. There was no spatial autocorrelation of the residuals in any model. Detail of pairwise comparisons for different variables is in the Table A2.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Native Forest</th>
<th>Pine Plantations</th>
<th>Other Plantations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bird community attributes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total observed richness</td>
<td>31</td>
<td>13</td>
<td>15</td>
</tr>
<tr>
<td>Total estimated richness</td>
<td>32.59</td>
<td>16.93</td>
<td>15.88</td>
</tr>
<tr>
<td>Per point</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Richness</td>
<td>9.62 ± 2.10 a</td>
<td>1.92 ± 0.63 c</td>
<td>4.25 ± 1.65 b</td>
</tr>
<tr>
<td>Abundance</td>
<td>13.38 ± 2.78 a</td>
<td>2.75 ± 1.01 c</td>
<td>7.50 ± 2.33 b</td>
</tr>
<tr>
<td>Forest-dependent richness *</td>
<td>2.69 ± 0.9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Forest-generalist richness</td>
<td>6.92 ± 1.68 a</td>
<td>1.92 ± 0.63 b</td>
<td>4.25 ± 1.61 a</td>
</tr>
<tr>
<td>Insectivores richness</td>
<td>5.77 ± 1.48 a</td>
<td>0.85 ± 0.53 c</td>
<td>3.00 ± 1.39 b</td>
</tr>
<tr>
<td>Granivores richness</td>
<td>2.46 ± 0.92 a</td>
<td>0.50 ± 0.31 b</td>
<td>0.75 ± 0.64 b</td>
</tr>
<tr>
<td>Cavity nesters</td>
<td>1.92 ± 0.98 a</td>
<td>0.21 ± 0.20 b</td>
<td>1.00 ± 0.62 a</td>
</tr>
<tr>
<td><strong>Vegetation features</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tree cover 20 m (%)</td>
<td>74.1 ± 19.0 a</td>
<td>81.7 ± 17.4 a</td>
<td>77.7 ± 20.8 a</td>
</tr>
<tr>
<td>Tree cover 100 m (Ha)</td>
<td>1.01 ± 0.52 b</td>
<td>2.04 ± 0.50 a</td>
<td>1.80 ± 0.56 ab</td>
</tr>
<tr>
<td>Vertical intersections</td>
<td>7.61 ± 2.51 b</td>
<td>11.05 ± 2.36 ab</td>
<td>12.40 ± 2.70 a</td>
</tr>
<tr>
<td>Maximum height (m)</td>
<td>7.12 ± 2.83 b</td>
<td>11.92 ± 2.77 b</td>
<td>19.74 ± 2.87 a</td>
</tr>
<tr>
<td>Woody species richness</td>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

* No analysis was performed since there was no variability in this variable for the plantations.
Table 2

Bird species found in the different tree cover types, native forest (NF), pine plantations (PP), and other plantations (OP) in the Argentine Pampas. Relative frequency (relfrq) was calculated as the number of sampled points with the presence of a particular bird species relative to the total number of points sampled in a tree cover type. The trophic groups (TG) found were carnivores (C), granivores (G), herbivores (H), insectivores (I), nectivores (N), and omnivores (O). Bird species were also classified as forest-dependent (D) or habitat-generalist (G).

<table>
<thead>
<tr>
<th>Order</th>
<th>Family</th>
<th>Common name</th>
<th>Scientific name</th>
<th>relfrq NF</th>
<th>relfrq PP</th>
<th>relfrq OP</th>
<th>TG</th>
<th>D/G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accipitriformes</td>
<td>Accipitridae</td>
<td>Roadside Hawk</td>
<td>Rupornis magnirostris</td>
<td>0.00</td>
<td>0.04</td>
<td>0.00</td>
<td>C</td>
<td>G</td>
</tr>
<tr>
<td>Trochilidae</td>
<td>Trochilidae</td>
<td>Glittering-bellied Emerald</td>
<td>Chlorostilbon lucidus</td>
<td>0.15</td>
<td>0.00</td>
<td>0.00</td>
<td>N</td>
<td>G</td>
</tr>
<tr>
<td>Trochilidae</td>
<td>White-throated Hummingbird</td>
<td>Leucocloris albicollis</td>
<td>0.00</td>
<td>0.08</td>
<td>0.00</td>
<td>N</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Columbidae</td>
<td>Columbidae</td>
<td>White-tipped Dove</td>
<td>Leptotila verreaux</td>
<td>0.31</td>
<td>0.00</td>
<td>0.00</td>
<td>G</td>
<td>D</td>
</tr>
<tr>
<td>Columbidae</td>
<td>Columbidae</td>
<td>Picazuro Pigeon</td>
<td>Patagioenas picazuro</td>
<td>0.23</td>
<td>0.25</td>
<td>0.13</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>Columbidae</td>
<td>Columbidae</td>
<td>Eared Dove</td>
<td>Zenaida auriculata</td>
<td>0.15</td>
<td>0.08</td>
<td>0.13</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>Cuculidae</td>
<td>Cuculidae</td>
<td>Dark-billed Cuckoo</td>
<td>Coccyzus melacoryphus</td>
<td>0.08</td>
<td>0.00</td>
<td>0.00</td>
<td>I</td>
<td>D</td>
</tr>
<tr>
<td>Cuculidae</td>
<td>Guira Cuckoo</td>
<td></td>
<td>Guira guira</td>
<td>0.08</td>
<td>0.04</td>
<td>0.00</td>
<td>O</td>
<td>G</td>
</tr>
<tr>
<td>Falconidae</td>
<td>Falconidae</td>
<td>Chimango Caracara</td>
<td>Phalcoboenus chimango</td>
<td>0.00</td>
<td>0.33</td>
<td>0.00</td>
<td>C</td>
<td>G</td>
</tr>
<tr>
<td>Emberizidae</td>
<td>Rufous-collared Sparrow</td>
<td>Zonotrichia capensis</td>
<td>0.77</td>
<td>0.17</td>
<td>0.25</td>
<td>G</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Fringillidae</td>
<td>Hooded Siskin</td>
<td>Sporagra magellanica</td>
<td>0.15</td>
<td>0.00</td>
<td>0.13</td>
<td>G</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Furnariidae</td>
<td>Rufous Hornero</td>
<td>Furnarius rufus</td>
<td>0.54</td>
<td>0.17</td>
<td>0.25</td>
<td>I</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Furnariidae</td>
<td>Tufted Tit-Spinetail</td>
<td>Leptasthenura platensis†</td>
<td>0.31</td>
<td>0.00</td>
<td>0.00</td>
<td>I</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>Hirundinidae</td>
<td>White-rumped Swallow</td>
<td>Tachycineta leucorhoa†</td>
<td>0.15</td>
<td>0.00</td>
<td>0.00</td>
<td>I</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Icteridae</td>
<td>Grayish Baywing</td>
<td>Agelaioides badius†</td>
<td>0.15</td>
<td>0.00</td>
<td>0.13</td>
<td>I</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Icteridae</td>
<td>Shiny Cowbird</td>
<td>Molothrus bonariensis</td>
<td>0.08</td>
<td>0.00</td>
<td>0.00</td>
<td>O</td>
<td>G</td>
<td></td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Tropical Parula</td>
<td>Setophaga pityayumi</td>
<td>0.46</td>
<td>0.00</td>
<td>0.00</td>
<td>I</td>
<td>D</td>
<td></td>
</tr>
</tbody>
</table>

†Indicates species that are not strictly flycatchers.
<table>
<thead>
<tr>
<th>Order</th>
<th>Family</th>
<th>Common name</th>
<th>Scientific name</th>
<th>relfrq NF</th>
<th>relfrq PP</th>
<th>relfrq OP</th>
<th>TG</th>
<th>D/G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passeriformes</td>
<td>Passeridae</td>
<td>House Sparrow</td>
<td><em>Passer domesticus</em></td>
<td>0.00</td>
<td>0.00</td>
<td>0.13</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Polioptilidae</td>
<td>Masked Gnatcatcher</td>
<td><em>Polioptila dumicola</em></td>
<td>0.15</td>
<td>0.00</td>
<td>0.00</td>
<td>I</td>
<td>D</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Thraupidae</td>
<td>Red-crested Cardinal</td>
<td><em>Paroaria coronata</em></td>
<td>0.23</td>
<td>0.00</td>
<td>0.00</td>
<td>G</td>
<td>D</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Thraupidae</td>
<td>Blue-and-yellow Tanager</td>
<td><em>Pipreidea bonariensis</em></td>
<td>0.23</td>
<td>0.00</td>
<td>0.00</td>
<td>O</td>
<td>D</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Thraupidae</td>
<td>Saffron Finch</td>
<td><em>Sicalis flaveola</em></td>
<td>0.31</td>
<td>0.00</td>
<td>0.00</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Thraupidae</td>
<td>Double-collared Seedeeater</td>
<td><em>Sporophila caerulescens</em></td>
<td>0.31</td>
<td>0.00</td>
<td>0.00</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Tityridae</td>
<td>White-winged Becard</td>
<td><em>Pachyrampphus polychopterus</em></td>
<td>0.15</td>
<td>0.00</td>
<td>0.00</td>
<td>I</td>
<td>D</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Troglodytidae</td>
<td>House Wren</td>
<td><em>Trogloides aedon</em></td>
<td>0.77</td>
<td>0.21</td>
<td>0.38</td>
<td>I</td>
<td>G</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Turdidae</td>
<td>Rufous-bellied Thrush</td>
<td><em>Turdus rufiventris</em></td>
<td>0.54</td>
<td>0.00</td>
<td>0.00</td>
<td>O</td>
<td>G</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Tyrannidae</td>
<td>Small-billed Elaenia</td>
<td><em>Elaenia parvirostris</em></td>
<td>0.69</td>
<td>0.00</td>
<td>0.00</td>
<td>I</td>
<td>D</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Tyrannidae</td>
<td>Great Kiskadee</td>
<td><em>Pitangus sulphuratus</em></td>
<td>0.77</td>
<td>0.42</td>
<td>0.75</td>
<td>I</td>
<td>G</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Tyrannidae</td>
<td>Vermilion Flycatcher</td>
<td><em>Pyrocephalus rubinus</em></td>
<td>0.23</td>
<td>0.00</td>
<td>0.13</td>
<td>I</td>
<td>G</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Tyrannidae</td>
<td>Yellow-browed Tyrant</td>
<td><em>Sarpapa icterophrys</em></td>
<td>0.08</td>
<td>0.00</td>
<td>0.00</td>
<td>I</td>
<td>D</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Tyrannidae</td>
<td>White-crested Tyrannulet</td>
<td><em>Serpophaga subcristata</em></td>
<td>0.54</td>
<td>0.04</td>
<td>0.00</td>
<td>I</td>
<td>G</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Tyrannidae</td>
<td>Tropical Kingbird</td>
<td><em>Tyrannus melancholicus</em></td>
<td>0.23</td>
<td>0.04</td>
<td>0.38</td>
<td>I</td>
<td>G</td>
</tr>
<tr>
<td>Passeriformes</td>
<td>Tyrannidae</td>
<td>Fork-tailed Flycatcher</td>
<td><em>Tyrannus savana</em></td>
<td>0.23</td>
<td>0.00</td>
<td>0.63</td>
<td>I</td>
<td>G</td>
</tr>
<tr>
<td>Piciformes</td>
<td>Picidae</td>
<td>Campo Flicker</td>
<td><em>Colaptes campestris</em></td>
<td>0.00</td>
<td>0.00</td>
<td>0.13</td>
<td>I</td>
<td>G</td>
</tr>
<tr>
<td>Piciformes</td>
<td>Picidae</td>
<td>Green-barred Woodpecker</td>
<td><em>Colaptes melanochloros</em></td>
<td>0.23</td>
<td>0.00</td>
<td>0.25</td>
<td>I</td>
<td>G</td>
</tr>
<tr>
<td>Psittaciforms</td>
<td>Psittacidae</td>
<td>Monk Parakeet</td>
<td><em>Myiopsitta monachus</em></td>
<td>0.31</td>
<td>0.04</td>
<td>0.50</td>
<td>H</td>
<td>G</td>
</tr>
</tbody>
</table>

* Exotic species. † Cavity nesters.
Figure captions

**Fig. 1.** Field work was carried out in the southern extreme of Samborombón Bay, in the Argentine Pampas, *left*. Talares native forest (NF), in green; pine plantations (PP), in blue; and other plantations (OP), in red; *right*. The location of the patches sampled in this study is indicated with black shapes.

**Fig. 2.** Rarefaction curves based on individuals of talares native forest and exotic tree plantations in the Argentine Pampas. NF: native forest, PP: pine plantation and OP: other plantations. Extrapolation curves were plotted until double the individuals of each tree cover type and 95% confidence intervals were estimated. Rarefaction curves achieved an asymptote which indicates that the sampling effort was enough for a proper estimation of bird richness.

**Fig. 3.** Differences in relative abundances of bird species in talares native forest and exotic tree plantations in the Argentine Pampas. Relative abundance was calculated as the proportion of a particular bird species relative to the total number of birds in one tree cover type. (a) Native forest (NF) compared to (b) pine plantations (PP) and (c) other plantations (OP) has different dominant species and greater evenness. Only the native forest has presence of forest-dependent bird species (bars in black).

**Fig. 4.** Woody vegetation profile of talares native forest and exotic tree plantations in the Argentine Pampas. NF: native forest, PP: pine plantation and OP: other plantations.
Fig. 1
Fig. 2
Fig. 3
Fig. 4