*Bird Conservation International*

**www.cambridge.org/bci**

# Occurrence patterns of the endangered Yellow Cardinal *Gubernatrix cristata* in north-east Argentina: only in savannahs and at sites away from roads

Fabricio Reales[1*], Sebastián Dardanelli[1,2], Antonio E. Frutos[1] and Martjan Lammertink[3,4]

[1]Centro de Investigación Científica y de Transferencia Tecnológica a la Producción – CICYTTP (CONICET–Entre Ríos–UADER), España 149, (3105) Diamante, Entre Ríos, Argentina; [2]Instituto Nacional de Tecnología Agropecuaria (INTA), EEA Paraná, Oro Verde, Entre Ríos, Argentina; [3]Instituto de Biología Subtropical, CONICET–Universidad Nacional de Misiones, Puerto Iguazú, Misiones, Argentina and [4]Cornell Lab of Ornithology, Cornell University, Ithaca NY, USA

**Research Article**

**Cite this article:** Reales F, Dardanelli S, Frutos AE, Lammertink M (2023). Occurrence patterns of the endangered Yellow Cardinal *Gubernatrix cristata* in north-east Argentina: only in savannahs and at sites away from roads. *Bird Conservation International*, **33**, e26, 1–9
https://doi.org/10.1017/S0959270922000211

Received: 23 October 2020
Revised: 27 April 2022
Accepted: 09 May 2022

**Keywords:**
Espinal ecoregion; grazing; habitat use; herbivory; trapping

**Palabras clave:**
Ecorregión Espinal; pastoreo; uso de hábitat; herbivoría; captura

**Author for correspondence:**
*Fabricio Reales,
Email: fabrireales@gmail.com

## Summary

The endangered Yellow Cardinal *Gubernatrix cristata* is under pressure from habitat loss and from capturing for the cage bird trade. In north-east Argentina it is known to be associated with the Espinal ecoregion, but no information was available on habitat selection within this ecoregion. In Entre Ríos province, Argentina, we first sampled Yellow Cardinal presence in four environments: Espinal savannahs, Espinal open woodlands, riparian woodlands, and agricultural fields. Yellow Cardinals were only detected in savannahs. In a second set of surveys, transects were surveyed at sites with known presence of Yellow Cardinals and were placed within savannahs as well as nearby in open forests of only slightly different physiognomy. Yellow Cardinals were again only detected in savannahs. Tree density, shrub cover and height of herbaceous layer were lower in savannahs than in open woodlands. Ground-foraging Yellow Cardinals in savannahs foraged exclusively in grass patches with short grass of 3-12 cm height. Such short grass occurred in 75% of spots of savannahs sites, but only in 48% of open woodlands. Savannah sites with Yellow Cardinals were significantly further away from permanent roads than sites without Cardinals, likely a reflection of capture pressure near roads. We recommend establishing additional protected areas with a high proportion of savannah patches and with limited or no road access. The short grass used by foraging Yellow Cardinals requires maintenance through grazing. Rewilding with native herbivores in protected areas is preferable to attain natural herbivory, but during the initial stages of rewilding, cattle and sheep grazing are essential to avoid tree and shrub proliferation in savannahs. The Yellow Cardinal can also persist on private lands with Espinal vegetation under sustainable livestock grazing. Frequent and effective patrolling and road controls are essential to reduce illegal capturing.

## Resumen

El Cardenal Amarillo *Gubernatrix cristata,* en peligro de extinción, está bajo presión por la pérdida de hábitat y por la captura para el comercio de aves de jaula. En el noreste de Argentina se sabe que está asociado con la ecorregión Espinal, pero no se dispone de información sobre la selección de hábitat dentro de esta ecorregión. En la provincia de Entre Ríos, Argentina, primero muestreamos la presencia del Cardenal amarillo en cuatro ambientes: sabanas del Espinal, bosques abiertos de Espinal, bosques ribereños, y campos agrícolas. Los Cardenales amarillos solo se detectaron en las sabanas. En un segundo conjunto de muestreos, las transectas se midieron en sitios con presencia conocida de Cardenales amarillos y se colocaron dentro de sabanas, así como cerca en los bosques abiertos de fisonomía ligeramente diferente. Los Cardenales Amarillos nuevamente solo se detectaron en las sabanas. La densidad de árboles, la cobertura de arbustos y la altura del estrato herbáceo fueron menores en las sabanas que en los bosques abiertos. Los Cardenales amarillos que se alimentan en el suelo en las sabanas, se alimentan exclusivamente en parches de pasto corto de 3 a 12 cm de altura. Este pasto corto se presentó en el 75% de los sitios en sabanas, pero solo en el 48% en los bosques abiertos. Los sitios de sabana con Cardenales Amarillos se encontraban significativamente más lejos de las carreteras permanentes que los sitios sin Cardenales, probablemente un reflejo de la presión de captura cerca de los caminos. Recomendamos establecer áreas protegidas adicionales con una alta proporción de parches de sabana y con acceso por carretera limitado o nulo. El pasto corto utilizado por los Cardenales amarillos en busca de alimento requiere mantenimiento a través del pastoreo.

Es preferible repoblar con herbívoros nativos en áreas protegidas para lograr la herbivoría natural, pero durante las etapas iniciales de reintroducción de ganado vacuno y ovino, el pastoreo es esencial para evitar la proliferación de árboles y arbustos en las sabanas. El Cardenal Amarillo también puede persistir en tierras privadas con vegetación de Espinal bajo pastoreo de ganado sostenible. La vigilancia y los controles viales frecuentes y efectivos son esenciales para reducir las capturas ilegales.

## Introduction

The presence of birds is closely related to the condition of their environments. The physical structure and composition of vegetation directly influence the use and selection of bird habitats (Milesi *et al.* 2008, Zhang *et al.* 2013, Fourcade *et al.* 2018). Among the factors that affect the habitat use of a species are its physiological and morphological limitations, the interaction with other species and the abundance and distribution of resources (Wiens 1989, Lombardini *et al.* 2001, Pigot *et al.* 2016, Girma *et al.* 2017). Forest birds are often seriously threatened, particularly in regions where habitat transformation and fragmentation are well advanced (Kajtoch *et al.* 2012, BirdLife International 2017).

The Yellow Cardinal *Gubernatrix cristata* is a member of the passerine Thraupidae family and the only representative of the genus (Campagna *et al.* 2011). It is distributed in southern Brazil, Uruguay and, principally, Argentina (Reales *et al.* 2019). In Argentina, its range extends from the north-east to the centre of the country, mainly in areas with a mixture of xerophilous woodlands and savannahs (Reales *et al.* 2019). This region is severely affected by habitat loss and fragmentation (Dardanelli *et al.* 2006, Calamari *et al.* 2018, Dardanelli and Bellis 2021). Populations of the Yellow Cardinal are currently small and are in decline due to habitat degradation and loss, and high capture pressure for the cage bird trade (Collar *et al.* 1992, BirdLife International 2021). This context led to Red List recognition in 1994 as a globally 'Endangered' species, as well as recognition as a nationally endangered species in Argentina and Uruguay (BirdLife International 2021), and as critically endangered in Brazil (Serafini *et al.* 2013). Most of the distribution of this species falls in Argentina, in the Espinal ecoregion, with several records in the neighbouring Monte and Chaco ecoregions (Reales *et al.* 2019, Domínguez *et al.* 2020).

Previous studies of the Yellow Cardinal addressed distribution (López-Lanús *et al.* 2016, Reales *et al.* 2019, Domínguez *et al.* 2020), reproduction (Domínguez *et al.* 2015, Beier *et al.* 2017, Beier and Fontana 2019, Segura *et al.* 2019), genetics (Domínguez *et al.* 2017, 2019) and brood parasitism (Azpiroz 2015, Domínguez *et al.* 2015, Beier and Fontana 2019). However, information is lacking on the structure and composition of vegetation used by the Yellow Cardinal. In Entre Ríos and Corrientes provinces, the species is associated with the Espinal ecoregion (Domínguez *et al.* 2015, Reales *et al.* 2019), a semi-arid region with thorny trees smaller than 5 m. Within the Espinal, there are different environments with subtle differences in vegetation structure and composition, but with different uses by birds (Calamari *et al.* 2018), though the exact habitat use by the Yellow Cardinal in the Espinal has not yet been described. We aimed to assess which environments are used by Yellow Cardinals in the Espinal. We first sampled occurrence of Yellow Cardinals in all environments in the Espinal landscape, including savannahs, open woodlands, farmland, and riparian vegetation, in proportion to availability in the landscape. As Yellow Cardinals were only found in savannahs, we tested whether the Yellow Cardinal is indeed associated with savannah environments and avoids the similar but slightly denser open woodlands in the same region, by sampling with standardized effort in the two environments at sites with known presence of the species, to exclude the possibility that absence in open woodlands was caused by a factor not related to habitat, such as capturing. We measured the structure and floristic composition of savannahs and open woodlands in the Ñandubay District of the Espinal ecoregion and analysed the associated occurrence of the Yellow Cardinal. We assessed whether Yellow Cardinals preferentially forage in patches of short grass. As the Yellow Cardinal is heavily captured for the illegal cage bird market, we also investigated whether its local distribution was associated with savannah sites away from towns and permanently passable roads. The hypothesis behind this is that more remote sites may retain more Yellow Cardinals, because such sites will experience less capture pressure from poachers.

## Methods

### Study site

This study was conducted in north-east Argentina, in the departments of La Paz, Federal, Feliciano and Federación in the province of Entre Ríos (Figure 1).

Biogeographically, this area corresponds to the Chaqueño domain of the Neotropical realm. The Ñandubay District of the Espinal ecoregion mainly covers the south of the province of Corrientes and the north of the province of Entre Ríos. The dominant landscapes are undulating plains, low hills, floodplains, and alluvial valleys (Menéndez and La Rocca 2007, Oyarzabal *et al.* 2018). The climate of the region is subtropical with average annual rainfall between 1,000 and 1,300 mm, and average annual temperature between 18 and 20°C (Morello *et al.* 2012).

The vegetation of the Ñandubay District of the Espinal is characterized by open xerophilous low woodlands (6–12 m high) dominated by ñandubay *Prosopis affinis* and espinillo *Vachellia caven* trees. The shrub layer, when present, is 2–4 m high with up to 50% cover (Menéndez and La Rocca 2007). The herbaceous stratum is dense and continuous, with grasses up to 1 m high, dominated by the genera *Paspalum, Axonopus* and *Andropogon*. The two most extensively occurring environments in this region are savannahs and open woodlands (Figure 2). Savannahs look like grasslands with sparsely distributed trees, and without shrub stratum. On the other hand, open woodlands had more of a shrub stratum and a higher tree density. The distinction between these vegetation types follows Oyarzabal *et al.* (2018).

The main economic activity in the region is cattle and sheep grazing (Menéndez and La Rocca 2007, Beier and Fontana 2019), with grazing occurring in both woodlands and savannahs. Increasingly, woodlands and savannahs in the study region are being

https://doi.org/10.1017/S0959270922000211 Published online by Cambridge University Press

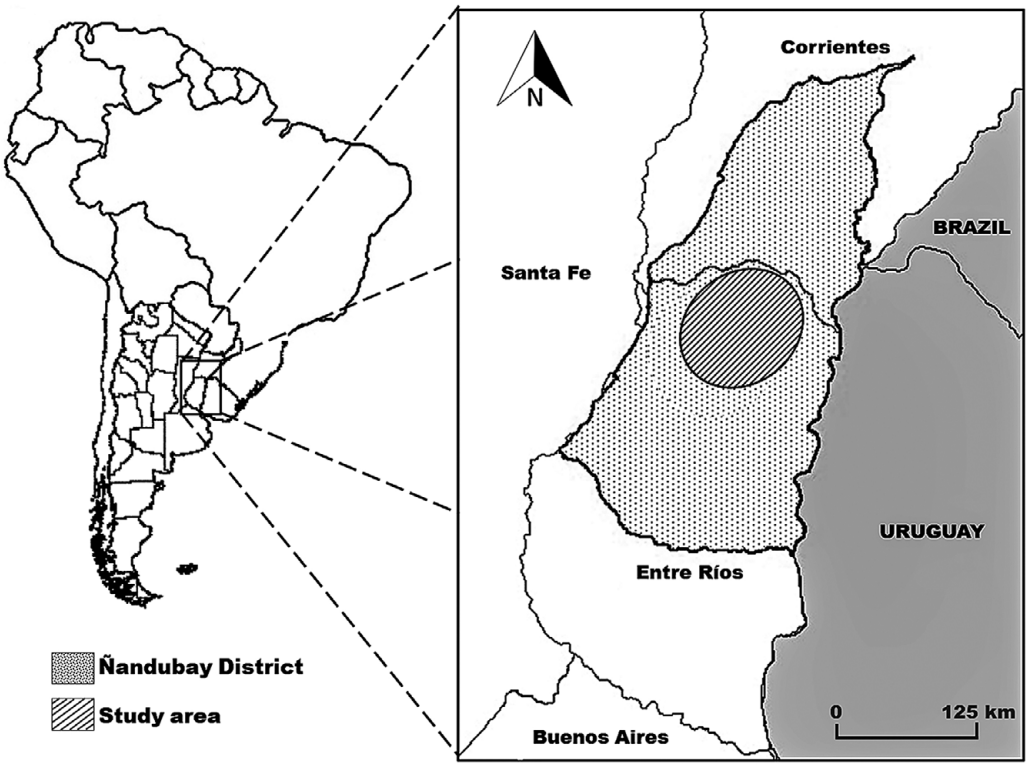


**Figure 1.** North-east Argentina (black line box), Ñandubay District of the Espinal ecoregion (grey-dotted area), and study area in Entre Ríos province (grey striped circle).

cleared, primarily for agriculture (Maldonado *et al.* 2012, Guida-Johnson and Zuleta 2013).

### *Data collection*

To select search areas for Yellow Cardinal populations we used Google Earth images, using as search criteria the presence of native vegetation (in satellite images readily distinguished by presence of irregularly scattered trees from featureless agricultural fields) and the presence of access roads. We ventured on foot up to 3 km from roads to avoid road-associated influences on habitats and bird populations. At the outset, no information was available on the preferential environments used by Yellow Cardinals within the Espinal ecoregion, so we sampled in all four environments within the Espinal: savannahs, open woodlands, riparian forests, and agricultural fields. We surveyed 36 search areas between May 2015 and July 2017, covering breeding and non-breeding seasons, in order to determine presence-absence of the species in the four environments. All study areas were on privately owned land with grazing by cattle and sheep, and occasionally horses, in Espinal woodland and savannahs, intermixed with agricultural fields of mostly soybean and corn crops. To locate Yellow Cardinals in each search area, we made up to three straight transects of 1 km in length covering all the different environments that were available in each site. Along each transect we performed three unlimited radius 10-minute point counts, at 500 m intervals (i.e. at 0, 500 and 1,000 m along each transect). At each point a recording of Yellow Cardinal song from southern Corrientes (provided by M. Dominguez, Aves Argentinas) was played to increase detections of the species. In addition, we surveyed 648 observation points with the use of playback from rural roads that connected the search areas. These rural roads were low-traffic dirt or gravel access roads connecting villages and small towns with livestock farms and farmland. The points were located where roads crossed Espinal vegetation and emerged from travel across four departments in search of Yellow Cardinals, with 70% of point locations having savannahs on at least one side of the road, and the remainder of points in open woodland. At each roadside or transect point, we surveyed 10 minutes with four repetitions of 30 seconds of playback followed by two minutes of listening and observation (Bibby *et al.* 2000).

Because in the first exploratory set of surveys only portions of transects passed through patches of savannahs and open woodlands, and Yellow Cardinals may have been absent due to a factor not related to habitat (for instance, capturing), or may have been influenced by playback, we aimed to confirm the avoidance of Espinal open woodlands in spite of their close similarity in physiognomy to Espinal savannahs (Figure 2). In a second set of surveys, we determined at sites with known occurrence of Yellow Cardinals, without use of playback, whether within Espinal vegetation Yellow Cardinals use savannahs or the similar open woodlands. We selected three sites (out of the original 36 search areas) with stable breeding populations of Yellow Cardinals, as evidenced by repeat sightings and presence of juveniles between 2015 and 2017. At each of these occupied sites, transects of 1 km were laid out, with each transect entirely in either an open woodland or savannah vegetation patch, and with pairs of savannah and open woodland transects laid out in parallel and separated by a standardized 300 m. The three sites were separated by 22 to 54 km, and in total contained 12 transects in savannah environments and nine in open woodland environments. We performed repeat transects of the same environment at a site separated by at least 250 m, determined as surpassing the maximum distance at which birds could be detected, thus avoiding

https://doi.org/10.1017/S0959270922000211 Published online by Cambridge University Press

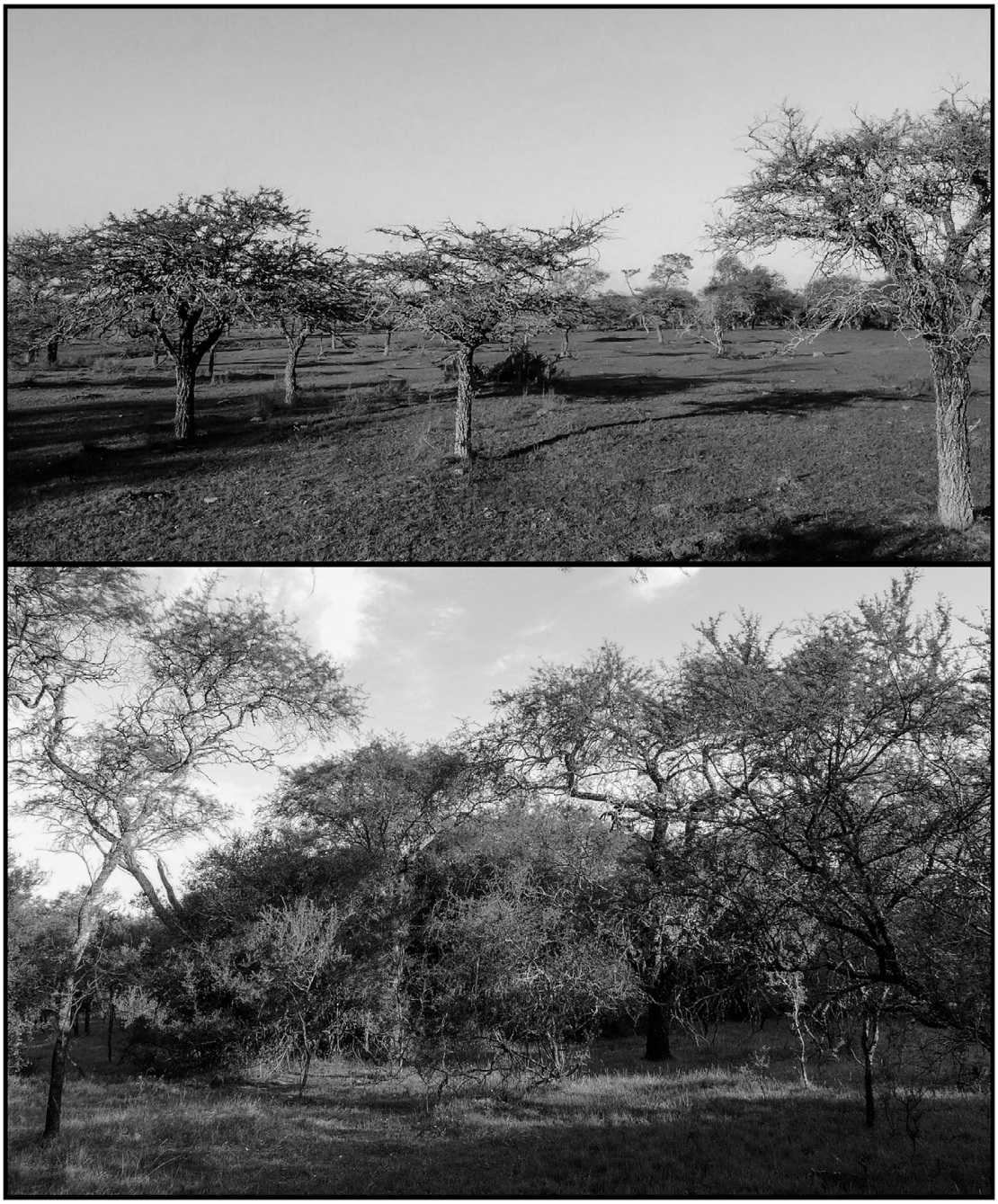

**Figure 2.** Two habitats surveyed for presence of Yellow Cardinals in the Espinal of northern Entre Ríos, Argentina: savannah (top) and open woodland (bottom).

pseudo-replication of detections. We surveyed the transects systematically for presence and abundance (number/km) of Yellow Cardinals, without playback, walked at a constant speed of 3 km/h, from dawn to 12h00 and from 15h00 to sunset, on days without rain and with wind speeds under 20 km/h. We performed surveys in spring and summer, four in 2017 and four in 2018 at each transect. The order in which each transect was visited was alternated. The total survey effort for these transect surveys was 84 h.

In order to relate presence of Yellow Cardinals to vegetation structure and composition in the two environments at the three sites, we measured the vegetation in three plots of 100 x 20 m perpendicular to each transect of 1 km. These plots were spaced at the positions of 0, 500, and 1,000 m along each transect. In the plots, the following variables we measured: 1) height (cm) of the herbaceous stratum, 2) percentage of shrub cover and 3) tree density by species, for trees >20 cm DBH. The percentage of shrub layer cover were estimated visually, and the height of the herbaceous stratum was measured using a ruler (Braun-Blanquet 1979, Matteucci and Colma 1982). We also recorded the height of grass vegetation at spots where Yellow Cardinals foraged and contrasted this with the available, measured grass heights in savannah environments.

Out of the first set of 36 search areas, 22 included savannah environments. We used these 22 search areas with savannahs to examine the relationship between Yellow Cardinal presence at sites

https://doi.org/10.1017/S0959270922000211 Published online by Cambridge University Press

and the distance of these sites to towns and roads. For each search area the straight distance to the nearest gravel or asphalt road, and the road distance to the nearest town, were measured in Google Earth. Distances to asphalt or gravel roads were considered because these are permanently accessible whereas dirt roads are frequently not passable after rains. Towns were regional population centres of between 5,000 and 10,000 inhabitants (San José de Feliciano, Federal, Las Paz, San Jaime de la Frontera and Chajarí) where most poachers are located, as judged from interviews with local landowners as well as from press coverage of seizures by police of illegally captured birds.

### Statistical analysis

Because our vegetation plots were separated by distances of 500 m, each plot was considered an independent measurement. Shapiro-Wilk tests indicated that our measurements of tree density, shrub cover and height of herbaceous layer in savannahs and open woodlands, as well as distances of savannahs with and without Yellow Cardinals to roads and towns, were not normally distributed. Contrasts in these measurements were tested with Mann-Whitney U tests. The use and availability of short grass patches by ground-foraging Yellow Cardinals, and frequency of short grass spots in savannahs versus open woodlands, were tested with Chi-square tests.

To compare the specific composition and density of tree species at transects with the two types of environments, we performed a non-metric multidimensional scaling (NMDS) analysis. To perform this analysis, iterations with random starts were made until the best solution for the ordering (the lowest stress value) was repeated in two runs. Additionally, to complement the NMDS, we performed similarity analysis (ANOSIM) to compare the degree of similarity in the composition of the tree stratum among the group transects (open woodland vs. savannah). ANOSIM is a permutation procedure that produces an R statistic, which is an absolute measure of distance between groups. Large positive values (up to 1) of R indicate low similarity between the groups while low values (close to 0) indicate high similarity between groups (Assis *et al.* 2015). For multivariate analyses (NMDS and ANOSIM) we used the Bray Curtis dissimilarity index on a matrix of density of tree species (Dixon 2003). We performed the analyses using the R 3.3.3 program (R Core Team 2017) using the vegan packages (Oksanen 2011). Significance was accepted when $P < 0.05$.

## Results

### Occurrence patterns: savannahs vs open woodlands

At 108 transects of 1 km randomly sampling the available environments of savannahs, open woodlands, riparian forest, and agricultural fields, and surveyed with playback, Yellow Cardinals were only detected in savannahs. We then placed 21 transects of 1 km entirely within savannah environments or nearby these (at 300 m distance) entirely within open woodland environments, at sites where we had established presence of Yellow Cardinal populations, and surveyed at standardized effort without playback. Yellow Cardinals were again only detected in savannah environments. During these standardized effort surveys Yellow Cardinals were detected at nine out of 12 transects in savannah environments, with a total of 24 detections and with one to four individuals recorded per detection.

### Structure and composition of vegetation in savannahs and open woodlands

The similarity analysis (ANOSIM) between groups of transects showed differences between the vegetation structure of open woodlands and savannahs (ANOSIM: $R = 0.275$, $P = 0.006$). Non-metric multidimensional scaling (NMDS) based on the specific composition of the tree community and the tree density of the species showed a clear separation of transects corresponding to open woodlands or savannahs. Among the 12 transects in savannahs, no differences were found in the vegetation of transects with or without detections of Yellow Cardinal. No significant relationships were found between the number of Yellow Cardinal detections at savannah transects and the vegetation measurements height of the herbaceous stratum, percentage shrub coverage, and tree density. The tree species that were more strongly associated with savannah transects were ñandubay *Prosopis affinis* followed by espinillo *Vachellia caven*, while in open woodlands transects it was algarrobo negro *Prosopis nigra*, followed by espinillo and guayabo *Myrcianthes cisplatensis*, and to a lesser extent chañar *Geoffroea decorticans*, coronillo *Scutia buxifolia* and others (Figure 3).

The density of trees was higher in open woodlands (139 ± 88.5 trees/ha, $n = 36$ plots) than in savannahs (58 ± 56.6 trees/ha, $n = 27$ plots, Mann-Whitney $U = 792$, $Z = -4.24$, $P < 0.001$). Similarly, shrub cover per plot was higher in open woodlands (32.9% ± 26.5%) than in savannahs (13.5% ± 13.5%, Mann-Whitney $U = 715$, $Z = -3.17$, $P = 0.002$). The herbaceous stratum was lower in savannahs (10.2 ± 8.7 cm, $n = 36$) than in open woodlands (15.6 ± 10.5 cm, $n = 27$, Mann-Whitney $U = 667$, $Z = -2.51$, $P = 0.01$).

### Use and availability of short grass vegetation for ground-foraging Yellow Cardinals

We observed 46 foraging events of 23 individuals of Yellow Cardinals in savannahs, with 11 foraging events from low perches and

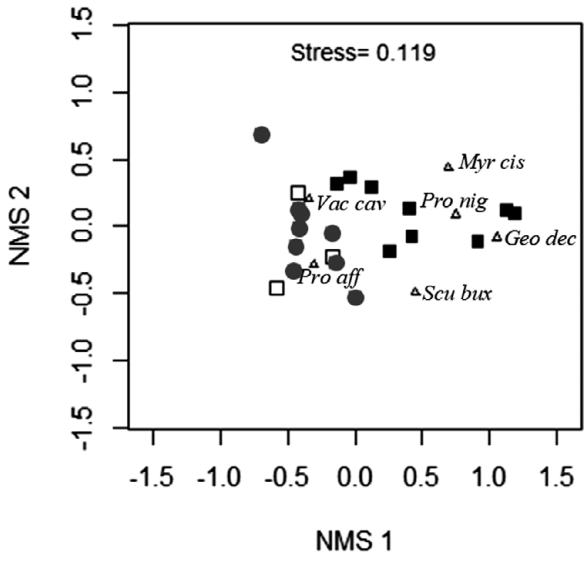


**Figure 3.** Analysis of non-metric multidimensional ordering (NMS) of the relative abundance of tree strata species between different transects. Solid grey circles indicate savannah with Yellow Cardinal detections; open black squares indicate savannah without detections of Yellow Cardinal, solid black squares indicate open woodland. The open black triangles represent the relative position of the tree species in relation to the samples. *Myr cis: Myrcianthes cisplatensis, Vac cav: Vachellia caven, Pro nig: Prosopis nigra, Pro aff: Prosopis affinis, Geo dec: Geoffroea decorticans, Scu bux: Scutia buxifolia.*

https://doi.org/10.1017/S0959270922000211 Published online by Cambridge University Press

35 foraging events on the ground. On all occasions that Yellow Cardinals foraged on the ground in savannahs they were in patches with short grass of 3–12 cm height, using such short grass patches in a higher proportion than available ($\chi^2 = 11.7$, df = 1, $P < 0.001$). The percentage of spots with short grass of 3–12 cm as used by ground-foraging Yellow Cardinals was higher in savannahs at 75% (out of $n = 36$) than in open woodlands at 48% (out of $n = 27$, $\chi^2 = 10.4$, df = 1, $P = 0.001$).

### *Presence-absence in savannahs vs distances to the nearest roads and towns*

At 648 playback stations in Espinal vegetation along rural roads, not a single Yellow Cardinal was detected. Among 22 savannah sites that we searched for Yellow Cardinals, distances to permanent roads were significantly larger for sites with presence of Yellow Cardinals than for sites without Yellow Cardinals, with means of 6.1 km and 1.2 km respectively (Table 1). We examined whether absence of Yellow Cardinals from savannahs near roads could be explained by a difference in the size of savannah areas relative to distances to roads, but this was not the case: the 22 savannahs varied in area from 29 to 337 ha, and there was no relation in the area of the savannahs with distance to roads ($r^2 = 0.0009$, $P = 0.90$). The mean distance to the nearest town was 30.8 km for savannah sites with presence of Yellow Cardinal and 18.1 km for sites with absence of Yellow Cardinal, but this difference was not significant (Table 1).

**Table 1.** Distances from sites with savannah environments to roads and towns and presence or absence of Yellow Cardinal *Gubernatrix cristata*.

| Site number | Yellow Cardinal status | Distance to the nearest permanent road (km) | Distance to the nearest village (km) |
|---|---|---|---|
| 1 | Absent | 0.5 | 19.0 |
| 2 | Absent | 2.0 | 23.5 |
| 3 | Absent | 2.5 | 16.0 |
| 4 | Absent | 0.5 | 5.0 |
| 5 | Absent | 0.5 | 8.5 |
| 6 | Absent | 0.5 | 6.0 |
| 7 | Absent | 0.5 | 26.0 |
| 8 | Absent | 0.5 | 33.0 |
| 9 | Absent | 0.5 | 17.0 |
| 10 | Absent | 0.5 | 19.0 |
| 11 | Absent | 0.5 | 25.0 |
| 12 | Absent | 6.0 | 15.5 |
| 13 | Absent | 0.5 | 3.0 |
| 14 | Present | 8.0 | 18.0 |
| 15 | Present | 1.5 | 11.0 |
| 16 | Present | 10.0 | 24.0 |
| 17 | Present | 0.5 | 26.0 |
| 18 | Present | 13.0 | 11.5 |
| 19 | Present | 0.5 | 24.0 |
| 20 | Present | 1.0 | 25.0 |
| 21 | Present | 14.0 | 62.0 |
| 22 | Present | 6.0 | 56.0 |
| N Absent | 13 | | |
| N Present | 9 | | |
| Mean absent | | 1.2 | 18.1 |
| Mean present | | 6.1 | 30.8 |
| Median absent | | 0.5 | 19.0 |
| Median present | | 6.0 | 24.5 |
| Mann-Whitney U, W | | 22.5 | 34.0 |
| *P* | | 0.01 | 0.11 |

## Discussion

### *Savannah habitat preference*

Yellow Cardinals were only detected in savannahs, indicating that they have a clear preference for inhabiting this environment in the Espinal ecoregion in north-east Argentina. Savannahs are dominated in the tree stratum by ñandubay trees. Our finding of an association of Yellow Cardinal with ñandubay-dominated savannahs agrees with observations by Domínguez *et al.* (2015), Beier *et al.* (2017) and Beier and Fontana (2019). These studies described the nesting habitat of the Yellow Cardinal as savannahs in the province of Corrientes, in north-east Argentina and in the state of Rio Grande do Sul, in southern Brazil with a physiognomy and species composition with characteristics as we found in northern Entre Ríos. These studies reported that the majority of Yellow Cardinal nests were built in ñandubay trees, and this agrees with our nesting observations in northern Entre Ríos (Reales 2020). At our transects with presence of Yellow Cardinals we found that more than 50% of the trees were ñandubay, so it seems the cardinals mostly use these trees in proportion to availability. However, it is possible that Yellow Cardinals are tied to savannahs dominated by ñandubay trees for other factors such as foraging or predator visibility, and so used ñandubay trees for nesting simply because of availability in this environment, rather than for a preference for ñandubay trees because of nesting requirements. Segura *et al.* (2019) found Yellow Cardinal nests in the south of the geographical distribution solely in chañar trees.

We found in savannahs that the most representative tree species was ñandubay, and that the most representative species of open woodland was algarrobo negro, while espinillo follows it in order of importance in both environments. Oyarzabal *et al.* (2018) also mention that savannah environments are composed of ñandubay and espinillo trees. Thus, presence of ñandubay trees, in combination with a wide spacing of trees and low shrub cover, can be used as criteria for search areas for Yellow Cardinal populations in this part of their global range, and can be used to select areas to release birds that were confiscated from cage bird traders or keepers (Domínguez *et al.* 2017).

The mean height of the herbaceous stratum was shorter in savannahs than in open woodland environments. On all occasions that we observed Yellow Cardinals foraging on the ground in savannahs they were in patches with short grass of 3–12 cm height. The foraging cardinals used short grass patches in higher proportion than that they used tall grass patches. Short grass allows Yellow Cardinals to walk on the ground for foraging (Beier and Fontana 2019). In the absence of native herbivores, grazing by cattle and sheep can be beneficial to generate and maintain the

https://doi.org/10.1017/S0959270922000211 Published online by Cambridge University Press

short grass patches that Yellow Cardinals uses for foraging. Menéndez and La Rocca (2007) indicated that livestock grazing is more intense in savannahs than in open woodlands. This difference in livestock grazing intensity between the two environments likely explains the difference in frequency of short grass spots we found and could contribute to the exclusive use of savannahs by Yellow Cardinals.

### Native herbivores and livestock in savannahs

The effects of livestock grazing on bird assemblages are highly variable (Davies *et al.* 2010, Neilly and Schwarzkopf 2019), partly because the effects of grazing livestock on ecosystems vary with the type of herbivore (Sankaran *et al.* 2008). Moreover, livestock grazing effects are difficult to assess due to scarcity of areas without livestock grazing (Bellis and Muriel 2015). Clarke (2002) and Jones (2000) showed that grazing decreases the survival of woody plants (shrubs and young trees), and Lenzi-Grillini *et al.* (1996) found an increase in woody species because of the exclusion of grazing in a protected ecosystem. If extensive cattle ranching in the Espinal is contrasted with the complete exclusion of livestock, as is usually the case in protected areas, the Yellow Cardinal may be particularly affected when livestock are removed (Duval *et al.* 2019). An example of these dynamics relevant to the Yellow Cardinal is El Palmar National Park in Argentina. At the time of its creation, the park had a physiognomy of savannahs with palm, ñandubay and espinillo trees and a herbaceous stratum maintained by livestock grazing. Then, with the exclusion of livestock, and absence of abundant native herbivores, a marked invasion of trees and exotic shrubs occurred (Batista *et al.* 2014). There are records of the Yellow Cardinal from El Palmar before and shortly after the national park was established (Chebez and Morandeira 2005, R. Fraga pers. comm.). However, there are no recent records of presence of Yellow Cardinal in this national park (Marateo *et al.* 2009). The exclusion of grazing in systems that have evolved in the presence of large herbivores can reduce or locally extinguish bird populations adapted to grazing-controlled vegetation (Bock 1999, García *et al.* 2008). In these environments, moderate loads of livestock can have positive effects on some bird species (Bock 1999, Macchi and Grau 2012), since grazing prevents the dominance of a few plant species with highly competitive capacity, as proposed by the hypothesis of intermediate disturbance (Connell 1978, Olff and Ritchie 1998). Native herbivores reduce the growth rate and foliar biomass of small trees and shrubs, having a positive effect on herbaceous cover (Augustine and McNaughton 2004). Similarly, cattle grazing depresses the woody cover when the animal load is moderate and may have some positive effects on ecological processes. It can sometimes be used to promote ecosystem or landscape restoration, especially in ecosystems with a long history of human use where the reintroduction of native herbivores is not possible anymore, or during transition to rewilding (Verdú *et al.* 2007, Sankaran *et al.* 2008, Ba Diao 2020). Livestock may replace the role of herbivores that existed in grassland and savannah environments in historical times (de Lima *et al.* 2018). The majority of introduced species are functional surrogates for extinct species and many restore metabolic functional groups (Lundgren *et al.* 2020). In the case of the espinal in north-east Argentina, the main natural herbivory came from pampas deer *Ozotoceros bezoarticus*, plain viscacha *Lagostomus maximus*), grey brocket deer *Mazama gouazoubira*, and capybara *Hydrochoerus hydrochaeris*. In recent history, populations of these species were reduced due to the transformation of their habitat by agriculture expansion and livestock grazing and the impact of hunting (Ripple *et al.* 2015, Perez-Carusi *et al.* 2017, Puechagut *et al.* 2018, Di Bitetti *et al.* 2020).

A factor affecting Yellow Cardinal reproduction that should be weighed in a choice between native herbivores and livestock is brood parasitism by Shiny Cowbird *Molothrus bonariensis*. Shiny Cowbird is an extremely generalist brood parasite (Lowther 2018) and is a threat to Yellow Cardinal populations through a clear negative impact on its reproduction (Azpiroz 2015, Domínguez *et al.* 2015, Beier and Fontana 2019, Atencio *et al.* 2020). Habitat fragmentation, opening of habitats and livestock supplemental food provisioning (including corn, sorghum, and oats in food lots that are readily exploited by cowbirds) associated with livestock farming generate favourable conditions for Shiny Cowbird range expansion and increase their populations (Arendt and Vargas-Mora 1984, Post *et al.* 1993, Robinson *et al.* 1995). Grazing management of savannahs with native herbivores will result in fewer Shiny Cowbirds and less nest parasitism.

### Yellow Cardinal occurrence away from permanent roads

In our wide-ranging search and transect counts in northern Entre Rios, Yellow Cardinals were only detected at savannah sites away from permanent roads, and this was independent from the sizes of savannahs relative to distance to roads. Capture pressure near roads likely explains this pattern of Yellow Cardinal absence, because most poachers work from roads with a car to carry poles, nets, a cage with a live lure Yellow Cardinal, and playback equipment, and are based in regional towns (Acosta 2013, Destro *et al.* 2019, Reales 2020), as also judged from personal observations, press coverage of illegal bird capturing, and conversations with local landowners and with police and gendarmes patrolling the study region. In a geographical analysis of the global distribution of the Yellow Cardinal, it was found that at 33% of points where the species was historically present but currently absent, suitable habitat remains as shown on satellite images. These absences were similarly interpreted as the result of capture pressure (Reales *et al.* 2019). López-Lanús *et al.* (2016) also pointed out the detrimental effect of captures on Yellow Cardinal populations. Alternative explanations for absence of birds near roads include habitat fragmentation, traffic noise, roadkill, and other disturbance, factors considered by Silva *et al.* (2017) to explain reduced species richness and abundance of birds near roads in an Espinal area in southern Brazil. However, Silva *et al.* (2017) found the main negative effects of these factors at only 10 m distance from roads, and that at 250 m negative impacts attenuated. As roads negatively affected Yellow Cardinal presence at a distance of up to 14 km, we consider capture pressure the more plausible explanation at such distances.

## Conclusion

In north-east Argentina, a major global stronghold of the Yellow Cardinal, this 'Endangered' species is closely associated with savannah environments with ñandubay trees, and mostly persists at sites 0.5–14 km away from permanent roads. We recommend the establishment of additional protected areas in the region with a high proportion of savannah patches and with limited or no road access. Rewilding with pampas deer, plain viscacha, grey brocket deer, and capybara in these areas is preferable to attain

https://doi.org/10.1017/S0959270922000211 Published online by Cambridge University Press

natural herbivory, to avoid Shiny Cowbird parasitism of Yellow Cardinals and to restore natural ecosystem interactions, but during the preparation and initial stages of reintroduction and recovery of native herbivores, it is essential to keep savannahs open with cattle and sheep grazing and avoid tree and shrub proliferation. The Yellow Cardinal can also persist in multiple-use areas on private lands with Espinal vegetation and livestock grazing, and there should be incentives for farmers to maintain this land use and avoid conversion to agriculture. In all areas with current or potential occurrence of Yellow Cardinal there should be frequent and effective patrolling and road controls to reduce illegal capturing.

**Acknowledgements.** We thank the private landowners who allowed us to survey birds on their properties. For assistance with Yellow Cardinal surveys, we thank Alonso Julián, Altamirano Eimi, Cataudela Francisco, Chappuis Andrea, Fernández-Osuna Alejandra, Guidetti Brenda, Jimenez Ana, Klavins Juan, Musuruana Jesica, Rivero Aymará, Sarquis Andrés, Savor Germán, Sigura Elías and Verón Silvina. Comments from three reviewers improved the manuscript. This work was supported by a Birdfair/RSPB Research Fund for Endangered Birds grant, the Neotropical Bird Club, INTA Project PNNAT1128053, and Fontagro grant FTG/RF-15461-RG. FR was supported by a PhD fellowship from the Consejo Nacional de Investigaciones Científcas y Técnicas (CONICET).

## References

Acosta, M. (2013) Caza y comercio ilegal de aves silvestres en la provincia de Santa Fe, Argentina. *BioScriba*, **6**: 9–15.

Arendt, W. J. and Vargas-Mora, T. A. (1984) Range expansion of the Shiny Cowbird in the Dominican Republic. *J. Field Ornithol.* **55**: 104–107.

Assis, R. L., Haugaasen, T., Schöngart, J., Montero, J. C., Piedade, M. T. and Wittmann, F. (2015) Patterns of tree diversity and composition in Amazonian floodplain paleo-várzea forest. *J. Veg. Sci.* **26**: 312–322.

Atencio, M., Reboreda, J. and Mahler, B. (2020) Brood parasitism leads to zero recruitment in the globally endangered Yellow Cardinal *Gubernatrix cristata*. *Bird Conserv. Internatn.* 1–7. doi:10.1017/S0959270920000660

Augustine, D. J. and McNaugthon, S. J. (2004) Regulation of shrub dynamics by native browsing ungulates on East African rangeland. *J. Appl. Ecol.* **41**: 45–58.

Azpiroz, A. B. (2015) Shiny Cowbird (*Molothrus bonariensis*) Parasitism records for three globally threatened species from the South American pampas. *Wilson J. Ornithol.* **127**: 746–752.

Ba Diao, M. (2020) Livestock production and conservation in and around protected areas: The Project for Integrated Ecosystem Management in Senegal. http://www.fao.org/3/a0532e/A0532e04.htm. Accessed 14 October 2020.

Batista, W. B., Rolhauser, A. G., Biganzoli, F., Burkart, S. E., Goveto, L., Maranta, A., Pignataro, G., Morandeira, N. S. and Rabadán, M. (2014) Las comunidades vegetales de la sabana del Parque Nacional El Palmar (Argentina). *Darwiniana, nueva serie* **2**: 5–38.

Beier, C. and Fontana, C. (2019) Breeding biology of the endangered Yellow Cardinal *Gubernatrix cristata* in Brazil. *Rev. Bras. Ornitol.* **27**: 44–52.

Beier, C., Repenning, M., Da Silveira Pereira, M., Pereira, A. and Fontana, C. (2017) Cooperative breeding and demography of Yellow Cardinal (*Gubernatrix cristata*) in Brazil. *Rev. Bras. Ornitol.* **25**: 12–19.

Bellis, L. M. and Muriel, N. (2015) Response of the endemic Long-tailed Meadowlark (*Sturnella loyca obscura*) to grazing exclusion in herbivore dependent upland grasslands of Argentina. *Emu* **115**: 176–184.

Bibby, C. J., Burgess, N. D., Hill, D. A. and Mustoe, S. (2000) *Bird census techniques*. Amsterdam: Elsevier.

BirdLife International (2017) Threatened birds occur in all habitats, but the majority are found in forest. Downloaded from http://www.birdlife.org on 14/10/2020

BirdLife International (2021) Species factsheet: *Gubernatrix cristata*. Downloaded from http://www.birdlife.org on 12/10/2021.

Braun-Blanquet, J. (1979) *Fitosociologia. bases para el estudio de las comunidades vegetales*. Madrid, Spain: Ediciones H. Blume.

Bock, C. E. (1999) *Birds and bovines: effects of livestock grazing on birds in the West*. Boulder CO: Public Lands Ranching Organization Press.

Calamari, N., Vilella, F., Sica, Y. and Mercuri, P. (2018) Patch and landscape responses of bird abundance to fragmentation in agroecosystems of east-central Argentina. *Avian Conserv. Ecol.* **13**: 3

Campagna, L., Geale, K., Handford, P., Lijtmaer, D. A., Tubaro, P. L. and Lougheed, S. C. (2011) A molecular phylogeny of the Sierra-Finches (*Phrygilus*, Passeriformes): extreme polyphyly in a group of Andean specialists. *Mol. Phylogenet. Evol.* **61**: 521–533.

Chebez, J. C. and Morandeira, N. S. (2005) Parque Nacional El Palmar. Pp.168-170 in A. S. Di Giacomo ed. *Áreas para la importancia para la conservación de las aves en Argentina, sitios prioritarios para la conservación de la biodiversidad, temas de Naturaleza y Conservación 5*. Buenos Aires: Aves Argentinas/Asociación Ornitológica del Plata.

Clarke, P. J. (2002) Experiments on tree and shrub establishment in temperate grassy woodlands: seedling survival. *Austral Ecol.* **27**: 606–615.

Collar, N. J., Gonzaga, L. P., Krabbe, N., Madroño Nieto, A., Naranjo, L. G., Parker, T. A. and Wege, D. C. (1992) *Threatened birds of the Americas: the ICBP/IUCN Red Data Book*. Cambridge, UK: International Council for Bird Preservation.

Connell, J. H. (1978) Diversity in tropical rain forest and coral reefs. *Science.* **199**: 1302–1310.

Dardanelli, S. and Bellis, L. M. (2021) Nestedness structure of bird assemblages in a fragmented forest in Central Argentina: the role of selective extinction and colonization processes. *Anim. Biodivers. Conserv.* **44**: 17–29.

Dardanelli, S., Nores, M. L. and Nores, M. (2006) Minimum area requirements of breeding birds in fragmented woodland of Central Argentina. *Diver. Distrib.* **12**: 687–693.

Davies, K. F., Melbourne. B. A., James, C. D. and Cunningham, R. B. (2010) Using traits of species to understand responses to land use change: Birds and livestock grazing in the Australian arid zone. *Biol. Conserv.* **143**: 78–85.

de Lima, D. O., Lorini, M. L. and Vieira, M. V. (2018) Conservation of grasslands and savannas: A meta-analysis on mammalian responses to anthropogenic disturbance. *J. Nat. Conserv.* **45**: 72–78.

Destro, G. F. G., De Marco, P. and Terribile, L. C. (2019) Comparing environmental and socioeconomic drivers of illegal capture of wild birds in Brazil. *Environ. Conserv.* **47**: 46–51.

Di Bitetti, M. S., Iezzi, M. E., Cruz, P., Varela, D. and De Angelo, C. (2020) Effects of cattle on habitat use and diel activity of large native herbivores in a South American rangeland. *J. Nat. Conserv.* 125900.

Dixon, P. (2003) VEGAN, a package of R functions for community ecology. *J. Veg. Sci.* **14**: 927–930.

Domínguez, M., Mahler, B. and Reboreda, J. C. (2015) Impact of Shiny Cowbird and botfly parasitism on the reproductive success of the globally endangered Yellow Cardinal, *Gubernatrix cristata*. *Bird Conserv. Internatn.* **25**: 294–305.

Domínguez, M., Tiedemann, R., Reboreda, J. C., Segura, L., Tittarelli, F. and Mahler, B. (2017) Genetic structure reveals management units for the Cardenal Amarillo (*Gubernatrix cristata*), endangered by habitat loss & illegal trapping. *Conserv. Genet.* **18**: 1131–1140.

Domínguez, M., Pizzarello, G., Atencio, M., Scardamaglia, R. C. and Mahler, B. (2019) Genetic assignment and monitoring of Yellow Cardinals. *J. Wildl. Manag.* **83**: 1336–1344.

Domínguez, M., Lapido, R., Gorrindo, A., Archuby, D., Correa, E., Llanos, F., Reales, F., Piantanida, F., Marateo, G., Meriggi, J., Andreani, L., Encabo, M., Gómez-Vinassa, M.L., Bertini, M., Perello, M., Banchs, R., Cirignoli, S., Verón, S. and Mahler, B. (2020) A citizen science survey discloses the current distribution of the endangered Yellow Cardinal *Gubernatrix cristata* in Argentina. *Bird Conserv. Internatn.* doi:10.1017/S0959270920000155.

Duval, V. S., Benedetti, G. M. and Campo, A. M. (2019) Fisonomía y diversidad del bosque secundario de *Prosopis caldenia*. Provincia de la Pampa, Argentina. *Rev. geogr. Am. Cent.* **62**: 164–185.

Fourcade, Y., Besnard, A. G., Beslot, E., Hennique, S., Mourgaud, G., Berdin, G. and Secondi, J. (2018) Habitat selection in a dynamic seasonal environment: Vegetation composition drives the choice of the breeding habitat for the community of passerines in floodplain grasslands. *Biol. Conserv.* **228**: 301–309.

García, C., Renison, D., Cingolani, A. M. and Fernández-Juricic, E. (2008) Avifaunal changes as a consequence of large-scale livestock exclusion in the mountains of Central Argentina. *J. Appl. Ecol.* **45**: 351–360.

Girma, Z., Mamo, Y., Mengesha, G., Verma, A. and Asfaw, T. (2017) Seasonal abundance and habitat use of bird species in and around Wondo Genet Forest, south-central Ethiopia. *Ecol. Evol.* **7**: 3397–3405.

Guida-Johnson, B. and Zuleta, G. A. (2013) Land-use land-cover change and ecosystem loss in the Espinal ecoregion, Argentina. *Agric. Ecosyst. Environ.* **181**: 31–40.

Jones, A. (2000) Effects of cattle grazing on North American arid ecosystems: a quantitative review. *West. N. Am. Nat.* **60**: 155–164.

Kajtoch, Ł., Żmihorski, M. and Bonczar, Z. (2012) Hazel Grouse occurrence in fragmented forests: habitat quantity and configuration is more important than quality. *Eur. J. For. Res.* **131**: 1783–1795.

Lenzi-Grillini, C. R., Viskanic, P. and Mapesa, M. (1996) Effects of 20 years of grazing exclusion in an area of the Queen Elizabeth National Park, Uganda. *Afr. J. Ecol.* **34**: 333–341.

Lombardini, K., Bennetts, R. E. and Tourenq, C. (2001) Foraging success and foraging habitat use by cattle egrets and little egrets in the Camargue, France. *Condor* **103**: 38–44.

López-Lanús, B., Ibañez, H., Velazco, A. and Bertonatti, C. (2016) Diagnóstico sobre la situación general del Cardenal Amarillo (*Gubernatrix cristata*) en la provincia de Entre Ríos, *Argentina.* Not. Faun. **200**: 1–16.

Lowther, P. E. (2018) *Lists of victims and hosts of the parasitic cowbirds (Molothrus)*. V.05 Sep 2018. Chicago: Field Museum.

Lundgren, E. J., Ramp, D., Rowan, J., Middleton, O., Schowanek, S. D., Sanisidro, O., Carroll, S. P., Davis, M., Sandom, C. J., Svenning, J. C. and Wallach, A. D. (2020) Introduced herbivores restore Late Pleistocene ecological functions. Proc. Natl. Acad. Sci. *USA*. **117**: 7871–7878.

Macchi, L. and Grau, H. R. (2012) Piospheres in the dry Chaco. Contrasting effects of livestock puestos on forest vegetation and bird communities. *J. Arid Environ.* **87**: 176–187.

Maldonado, F. D., Sione, W. F. and Aceñolaza, P. G. (2012) Mapeo de desmontes en áreas de bosque nativo de la provincia de Entre Ríos, Argentina. *Ambiência* **8**: 523–532.

Marateo, G., Povedano, H. and Alonso, J. (2009) Inventario de las aves del Parque Nacional El Palmar, Argentina. *Cotinga* **31**: 47–60.

Matteucci, S. D. and Colma, A. (1982) *Metodología para el estudio de la vegetación (Vol. 22).* Washington, DC: Secretaria General de la Organización de los Estados Americanos.

Menéndez, J. L. and La Rocca, S. M. (2007) *Primer inventario nacional de bosques nativos: informe regional Espinal, segunda parte. Inventario de campo de la región Espinal, Distritos Caldén y Ñandubay*. Buenos Aires: Secretaría de Ambiente y Desarrollo Sustentable de la Nación SAyDS.

Milesi, F., López de Casenave, J. and Cueto, V. (2008) Selection of foraging sites by desert granivorous birds: vegetation structure, seed availability, species-specific foraging tactics, and spatial scale. *Auk* **125**: 473–484.

Morello, J., Matteucci, S. D. and Rodríguez, A. F. S. (2012) *Ecorregiones y complejos ecosistémicos argentinos*. Buenos Aires: FADU.

Neilly, H. and Schwarzkopf, L. (2019) The impact of cattle grazing regimes on tropical savanna bird assemblages. *Austral Ecol.* **44**: 187–198.

Oksanen, J. (2011) *Multivariate analysis of ecological communities in R: vegan tutorial*. R package version 1: **1**–43.

Olff, H. and Ritchie, M. E. (1998) Effects of herbivores on grassland plant diversity. *Trends Ecol. Evol.* **13**: 261–265.

Oyarzabal, M., Clavijo, J., Oakley, L., Biganzoli, F., Tognetti, P., Barberis, I., Maturo, H. M., Aragón, R., Campanello, P. I., Prado, D., Oesterheld, M. and León, R. J. C. (2018) Unidades de vegetación de la Argentina. *Ecol. Austral* **28**: 40–63.

Perez-Carusi, L. C., Beade, M. S. and Bilenca, D. N. (2017) Spatial segregation among pampas deer and exotic ungulates: A comparative analysis at site and landscape scales. *J. Mammal.* **98**: 761–769.

Pigot, A. L., Trisos, C. H. and Tobias, J. A. (2016) Functional traits reveal the expansion and packing of ecological niche space underlying an elevational diversity gradient in passerine birds. *Proc. Royal Soc. B* **283**: 20152013.

Post, W., Cruz, A. and McNair, D. B. (1993) The North American invasion pattern of the Shiny Cowbird. J. Field Ornithol. **64**: 32–41.

Puechagut, P. B., Politi, N., Ruiz de los Llanos, E., Lizarraga, L., Bianchi, C. L., Bellis, L. M. and Rivera, L. O. (2018) Association between livestock and native mammals in a conservation priority area in the Chaco of Argentina. *Mastozool. Neotrop.* **25**: 407–418.

R Core Team (2017) *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing.

Reales, F., Sarquis, J. A., Daradanelli, S. and Lammertink, M. (2019) Range contraction and conservation of the endangered Yellow Cardinal. *J. Nat. Conserv.* **50**: 125708.

Reales, F. (2020) *Distribución, ecología y conservación del Cardenal Amarillo (Gubernatrix cristata) (Thraupidae, aves).* Tesis Doctoral. Universidad Nacional de Córdoba.

Ripple, W. J., Newsome, T. M., Wolf, C., Dirzo, R., Everatt, K. T., Galetti, M., Hayward, M. W., Kerley, G. I. H., Levi, T., Lindsey, P. A., Macdonald, D. W., Malhi, Y., Pintor, L. E., Sandom, C. J., Terborgh, J. and Van Valkenburgh, B. (2015) Collapse of the world's largest herbivores. *Sci. Adv.* **1**: e1400103.

Robinson, S. K., Rothstein, S. I., Brittingham, M. C., Petit, L. J., Grzybowski, J. A., Martin, T. E. and Finch, D. M. (1995) Ecology and behavior of cowbirds and their impact on host populations. Pp. 482–460 in T. E. Martin, D. M. Finch, eds. *Ecology and management of Neotropical migratory birds*. New York: Oxford University Press.

Sankaran, M., Ratnam, J. and Hanan, N. (2008) Woody cover in African savannas: the role of resources, fire and herbivory. *Global Ecol. Biogeogr.* **17**: 236–245.

Segura, L. N., Perelló, M., Gress, N. H. and Ontiveros, R. (2019) The lack of males due to illegal trapping is causing polygyny in the globally endangered Yellow Cardinal *Gubernatrix cristata*. *Rev. Bras. Ornitol.* **27**: 40–43.

Serafini, P. P., Martins-Ferreira, C., Bencke, G. A., Fontana, C. S., Dias, R. A., Repenning, M., Damiani, R. V., Mauricio, G. N., Gianuca, A. T., Krugel, M. M., Franz, I., Rovedder, C. E., Rupp, A. E., Pereira, M. S., Vizentin-Bugoni, J., Joenck, C. M., Straube, F. C., Reinert, B. L., Bornschein, M. R., Dias, D. and Vieira, B. P. (2013) *Plano de Ação Nacional para a Conservação dos Passeriformes Ameaçados dos Campos Sulinos e Espinilho*. Brasília, Brazil: Instituto Chico Mendes de Conservaça o da Biodiversidade.

Silva, V. P., Deffaci, A. C., Hartmann, M. T. and Hartmann, P. A. (2017) Birds around the road: effects of a road on a savannah bird community in Southern Brazil *Ornitol. Neotrop.* **28**: 119–128

Verdú, J. R., Moreno, C. E., Sánchez-Rojas, G., Numa, C., Galante, E. and Halffter, G. (2007) Grazing promotes dung beetle diversity in the xeric landscape of a Mexican Biosphere Reserve. *Biol. Conserv.* **140**: 308–317.

Wiens, J. A. (1989) *The ecology of bird communities. Vol. 1. Foundations and patterns*. Cambridge, UK: Cambridge University Press.

Zhang, J., Kissling, W. D. and He, F. (2013) Local forest structure, climate and human disturbance determine regional distribution of boreal bird species richness in Alberta, *Canada.* J. Biogeogr. **40**: 1131–1142.

https://doi.org/10.1017/S0959270922000211 Published online by Cambridge University Press