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Foraging by burrowing parrots has little impact on agricultural crops in northeastern Patagonia, Argentina

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ABSTRACT
Conflicts between wildlife and agriculture have increased as cultivation has expanded into previously unexploited areas. As frequent consumers of such crops, parrots (Psittaciformes) are often persecuted, despite the lack of measured economic impacts they may cause. This situation has compromised attempts to manage potential damage and endangered parrot populations. Here, we evaluate and measure actual crop damage and characterize the foraging areas used by the burrowing parrot (*Cyanoliseus patagonus*) in northeastern Patagonia, Argentina. We found that damage to field crops was economically insignificant, affecting 0.1%–0.4% of the sunflower harvest, with no damage detected in other more important crops in the region. The parrots mainly consumed grain left or spilled after harvesting, and unharvested grain from cultivated pastures and road margins. This grain represents a loss attributable to harvest machines, being independent from the presence of parrots. Given the negligible damage measured here, we conclude that there is no need for management of parrots as crop pests in northeastern Patagonia. Our study provides further support to the view that parrot damage has been often exaggerated and overstated.

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Aves; burrowing parrot; crop damage; *Cyanoliseus patagonus*; field crop; Patagonia; stratified sampling; spilled grain; sunflower; unharvested grain

1. Introduction

Parrots which are considered agricultural pests present a unique conservation problem, as some are also in danger of extinction (Bucher 1992; Warburton & Perrin 2006; Menchetti & Mori 2014; Saunders et al. 2014). As Psittaciformes are among the most endangered birds (Olah et al. 2016), inappropriate or unnecessary management may exacerbate the problem and lead species to extinction. Several parrot species once considered agricultural pests have been heavily persecuted, triggering serious conservation problems (Bucher 1992; Snyder et al. 2000; Bodrati et al. 2006; Martin et al. 2014). Persecution was carried out regardless the lack of data objectively measuring the actual extent of damage, and evaluation of the need and economic viability of taking such actions (e.g. Dabbene 1935; Bucher 1984, 1992; Canavelli et al. 2012).

One species facing this conflict is the burrowing parrot (BP, *Cyanoliseus patagonus*) from the arid to semi-arid shrub regions of Argentina and Chile (Bucher & Rinaldi 1986; di Iorio et al. 2010; Masello et al. 2011). Formerly, BPs were common, but they are now absent from large parts of their historic range (Rojas Martínez 2008; Masello et al. 2011). The IUCN categorizes the species as "least concern" but specifies the current population trend as "decreasing" (IUCN 2016). The decline is particularly strong in Chile and in northwestern Argentina (Rojas Martínez 2008; Masello et al. 2011), caused by a combination of trapping for the pet trade (Masello et al. 2006), persecution as crop pests (Failla et al. 2008; Rojas Martínez 2008), and habitat loss and degradation (Pezzola et al. 2004). BPs are colonial birds that require soft rock or earth cliffs to excavate burrows, where they breed once a year (from September to January; Masello & Quillfeldt 2004). The species is a partial migrant, occupying the colonies some months before laying and leaving them gradually as the young fledge (Bucher & Rinaldi 1986; Bucher & Rodríguez 1986).

In Argentina, BPs are perceived as a threat to agricultural production, widely blamed for damage to a variety of crops including maize, barley, sunflower, wheat, millet, almonds, apples, walnuts, and vineyards (Bucher & Bedano 1976; Bucher 1984; Failla et al. 2008). Although the few studies to date found BP damage to agriculture to be a local phenomenon, the species has long been considered a national agricultural pest in Argentina and persecuted in a variety of ways (Bucher & Rinaldi 1986; Bucher 1992; Masello et al. 2006; Failla et al. 2008). As a part of the official program of agriculture pest control, the largest known colony of the BP containing some 50,000 nests was poisoned with the organochloride endrin (Voitzuk 1975). The colony is today reduced to 0.6% of its former size (Grilli et al. 2012). At present, only Buenos Aires considers the BP a crop pest

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(Ministerio de Agroindustria de la Provincia de Buenos Aires 2016).

The largest BP colony is located close to El Cóndor, at the estuary of the Río Negro in Patagonia (Figure 1). It contains 37,000 nests on average, distributed along 12.5 km of sandstone cliffs (Llanos et al. 2011). Until the end of the 1990s, parrots from El Cóndor migrated north, but, since the mid-2000s, a large part of the population remains at the colony through the winter (JFM unpublished data). El Cóndor colony concentrates 71% of the total population of the species (Masello & Quillfeldt 2012). Unfortunately, El Cóndor colony is subjected to a number of threats and currently has no legal protection (Masello et al. 2006).

Most claims of crop damage by the BP originate from the region around the El Cóndor colony (Figure 1; Bucher & Rinaldi 1986; Failla et al. 2008). Until the end of the 1990s, most of the local farmers claimed damage to wheat. However, these are agricultural marginal areas where climatic and edaphic limiting factors favor poor crop growth and, therefore, may enhance parrot access to the crops (Bucher 1992). During that time, the governments of the provinces of Buenos Aires and Río Negro poisoned the parrots with the intent of minimizing the damage to wheat (Bucher & Rinaldi 1986; Masello et al. 2006). At the end of 1990s, a combination of rainfall increase in the region (Masello & Quillfeldt 2004) and irrigation projects allowed agricultural intensification and the cultivation of maize. Since the mid-2000s, local farmers claim that maize is the most affected crop in the region by the BP, followed by sunflower, oat, wheat, and millet (Failla et al. 2008). However, during a questionnaire, only 16% of farmers surveyed mentioned any damage caused by the BP to their crops (Failla et al. 2008).

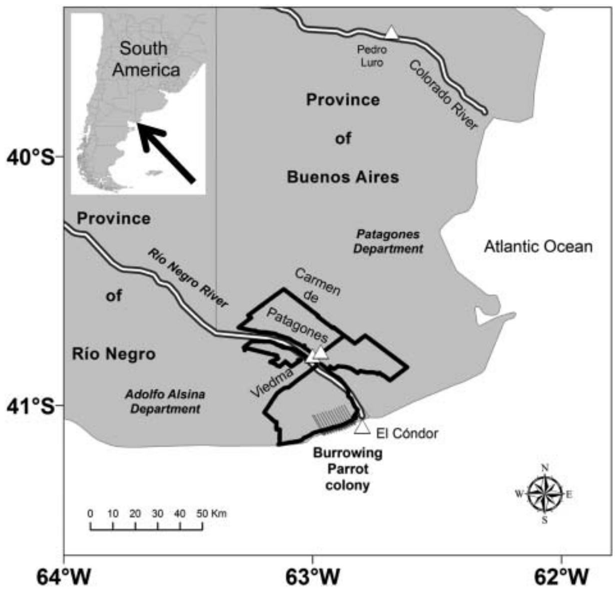

Figure 1. Study area and roads surveyed in northeastern Patagonia, Argentina. Towns and villages are marked with triangles, their names are underlined. The burrowing parrot (*Cyanoliseus patagonus*) colony at El Cóndor is marked with lines perpendicular to the coast.

Apart from a questionnaire to farmers (Failla et al. 2008) and opportunistically collected data (Bucher & Bedano 1976; Bucher 1984, 1992; Bucher & Rinaldi 1986), there is a lack of objective research on quantifiable damage caused by the BP to crops. This lack of information compromises of efforts to manage potential damage, particularly under the decreasing population trend faced by some of the BP populations (*sensu* Masello et al. 2011, 2015). A detailed understanding of the actual damage caused by the BP is, therefore, needed to inform future management priorities and strategies. Information on habitat use is also needed. The specific objectives of our study were, therefore, to (1) characterize the foraging areas of the BP in northeastern Patagonia and the use of the land in those areas, and (2) to identify and quantify crop damage in the region.

2. Materials and methods

2.1. Study area

The study was carried out in northeastern Patagonia (Argentina), comprising the departments of Patagones (province of Buenos Aires) and Adolfo Alsina (province of Río Negro; Figure 1) during 2007−2008. The region is characterized by plains ("mesetas"), slight undulations, and closed depressions (del Río et al. 2005; Masera 2005). The climate of the region corresponds to arid cold steppes, with an annual mean temperature of 13.5 °C and prevailing winds from the west (Paruelo et al. 1998; Masello et al. 2011). Annual precipitation in the region reaches 380 mm in Patagones but less in El Cóndor (350 mm) and in Adolfo Alsina (250 mm). Precipitation in this region is strongly correlated with the phases of El Niño Southern Oscillation (ENSO), with precipitation reduced to 5% of the long-term average during La Niña phase of ENSO (Masello & Quillfeldt 2004). The soil is sandy and very permeable, covered with shrub and subshrub steppes corresponding to the "Monte" phytogeographical province (hereafter, Monte) and to its transition zone to the "Espinal" phytogeographical province in the northern part of the studied region (Abraham et al. 2009; Bisigato et al. 2009; Labraga & Villalba 2009).

2.2. Land use

The area was traditionally used for cattle ranching, based on both natural as well as cultivated pastures. Using dry land farming methods, winter wheat has been cultivated in agricultural marginal areas of northeastern Patagonia for a long time. Since the 1970s, the continuous agricultural expansion in northeastern Patagonia greatly reduced and fragmented the natural

Monte vegetation, triggering strong wind-driven land degradation (Pezzola et al. 2004). The annual rate of clearance of the native vegetation in the studied area was estimated at 3.7% (Pezzola et al. 2004). Since the 1990s, maize and oilseed crops like sunflower are produced in central pivot-irrigated fields.

2.3. Population level: sampling, habitat use and diet

A study area of approximately 250,000 hectares was selected to cover the region visited daily by the BPs breeding at El Cóndor colony. During a previous aerial survey, most feeding flocks of BPs were found at distances of up to 66 km from the colony (Masello et al. 2006; Figure 1). Constrained by track availability, permissions granted to enter private property, and aspiring to cover the most possible area and diversity of habitats, four roads were selected for surveys (Figure 1). The surveys were carried out from a vehicle at low speed (maximum 30 km/h) during the time of the day when most of the parrots were foraging (0500 to 1800 h; Masello et al. 2006). The study area was first visited for a pilot study between 23–28 July 2007. During the pilot study, the feasibility of methods was tested and some data on parrot abundance were collected. Afterward, six surveys were carried out on the following dates: 16–19 October, 15–18 November, and 13–17 December 2007, and 21–25 January, 11–15 March, and 26–30 May 2008 (Table 1). The dates were selected in order to cover the phenology of the crops in the region, as well as that of wild plants (see Kröpfl et al. 2005) and the breeding (from September to January) and non-breeding seasons of the parrots (Masello & Quillfeldt 2002). During each visit to the study region, each road was surveyed twice on different days and times of the day. During the surveys, all parrots were noted up to a distance of 200 m on both sides of the road. When the parrots were observed, the vehicle was stopped and the following information was recorded: (1) number of individuals, (2) type of behavior, i.e. flying over or feeding, (3) if feeding, item being consumed, (4) type of habitat/land use type and its extent, and (5) the relative position of parrot flocks in the crop, i.e. center or border, in the case of cultivated land. Tests of inter-observer reliability revealed that flock size was simple to determine up to several hundred individuals. In the case of larger flocks (1000–4000 individuals), numbers were estimated to the best of our capacity usually to the nearest 100 birds. Given the huge size of the area daily used by the BP of El Cóndor colony, it was not possible to detect the total number of parrots using it at a particular time. Thus, the numbers presented here are a subsample of the total population in El Cóndor. The food items

Table 1. Extent of the habitat types available on both sides of the roads, the number (*n*) of burrowing parrots (*Cyanoliseus patagonus*) observed in each habitat, the number of parrots observed on the road margins and flying over, the total distance surveyed, and the total of parrots observed per survey in northeastern Patagonia (Argentina) during 2007–2008.

		October	November	December	January	March	May
Monte vegetation	km	105.1	104.2	106.9	104.7	99.7	99.7
	%	27	25	24	27	23	23
	N	73	54	0	278	0	60
Natural pastures	km	83.1	106.9	118.7	86.9	101.5	101.5
	%	22	25	27	22	24	24
	N	0	0	3	118	0	116
Cultivated pastures	km	88.3	111.2	118.4	139.6	76.7	60.4
	%	23	26	27	36	18	14
	N	1070	481	160	56	0	0
Wheat	km	76.1	69.5	45	4.7	69.9	37.0
	%	20	16	10	1	16	9
	N	168	0	1026	70	0	0
Maize	km	0	0.2	0.7	0.4	4.9	3.2
	%	0	0.05	0.2	0.1	1.1	0.7
	N	0	0	0	30	0	0
Sunflower	km	4.4	4.4	4.4	4.4	4.4	0
	%	1	1	1	1	1	0
	N	0	0	60	745	0	0
Rapeseed	km	0	1.2	0.7	0.9	1.2	1.2
	%	0	0.3	0.2	0.2	0.3	0.3
	N	0	0	0	0	0	0
Other crops	km	1.6	2.9	7.0	2.8	2.9	2.9
	%	0.4	0.7	1.6	0.7	0.7	0.7
	N	0	0	0	0	0	0
Stover	km	5.2	4.9	0.0	0.4	0.0	4.1
	%	1	1	0	0.1	0	0.9
	N	800	0	0	2204	0	3050
Cleared land	km	23.2	17.8	42.9	42.9	68.5	122.1
	%	6	4	10	11	16	28
	N	150	0	0	0	7	0
Road margins	*N*	201	77	307	954	2	1055
Flying over	*N*	247	75	382	289	28	484
Total distance surveyed	km	387.1	423.1	444.7	387.6	429.7	432.1
Total parrots observed	*N*	2709	687	1938	4744	37	4765

consumed were typically easy to identify due to the monospecific agricultural fields in the region and to the relatively low diversity of shrubs of the Monte consumed by the BP.

Based on previous surveys of the study area (Masello et al. 2006), habitats and land-use types (thereafter, "habitat") on both sides of the roads were classified as follows: (1) Monte vegetation, characterized by shrubs like chañar (*Geoffroea decorticans*), piquillin (*Condalia microphylla*), molle (*Schinus johnstonii*), yao-yin (*Lycium chilense*), and small *Larrea* spp. shrubs, (2) natural pastures, (3) cultivated pastures, mainly oat, (4) field crops, such as maize, wheat, sunflower, and rapeseed, (5) other crops, including walnuts and almonds, and several fruit trees and vegetables, (6) land with stover left behind after maize or sunflower harvesting, (7) land cleared of vegetation at the time of sampling, and (8) road margins, usually covered by a mixture of natural grasses (see Kröpfl et al. 2005), introduced plants like wild oat (*Avena fatua*), narrowleaf dock (*Rumex crispus*), spiny cocklebur (*Xanthium spinosum*) and common cocklebur (*X. strumarium*), and small patches of wheat and oats. On several occasions, parrot flocks were observed flying over the sectors surveyed but not descending. Previous aerial surveys from a Cessna 182 (Masello et al. 2006) showed that those flocks mostly fly to Monte patches in the NW of the study sector. However, during current road surveys, we were not able to determine the landing place of those flocks. Thus, during current surveys, observations of parrots flying and not landing were recorded as "flying over" and not assigned to any habitat. The extension of each of the habitats along the roads at the time of the road surveys is shown in Table 1. The total distance surveyed varied among visits, as not all parts of the roads were accessible in all surveys (Table 1). For that reason, the extension of the habitats is given also as the proportion of distance surveyed. However, the small variation in the extent of the habitats with natural vegetation (see "Monte and natural pastures" in Table 1) makes us confident of the representativeness of the surveyed habitats with respect to the available habitats in the region. The extension of the road margins is not given in Table 1, as it corresponds in all cases to two times the total surveyed.

In order to properly evaluate the significance of crop damage, we also determined the phenology of the crops cultivated in the study area, particularly maize, wheat, sunflower, and oat. This was done through direct observations and consultation with experts from the *Instituto de Tecnología Agropecuaria* (INTA) and officials of the agriculture departments of Buenos Aires and Río Negro, and is summarized as follows:

Wheat: the strains cultivated in the region correspond to winter wheat. Sowing is carried out from the beginning of May to the end of June. The flowering stage usually starts at the end of October. Although varying according to weather conditions, the harvesting is usually carried out in the second part of December. The grain lost among the stover is available on the fields throughout summer and until May.

Oat: strains for pasture are sowed during January—February, while the ones for the production of grain are sowed in July. The flowering stage usually starts in October—November, while grains mature during the first days of December. Harvesting is usually carried out during the first part of December. In this case, the grain wasted among the stover is available in the fields until July.

Maize: it is planted around the beginning to mid-October, and flowering occurs at the beginning of January. The grains mature from the end of February to the end of March. Depending on the strains planted, harvesting is carried out in April—June. The grain lost among the stover is available throughout the winter.

Sunflower: the planting is carried out around the beginning of October, and flowering starts in mid-January. The grains mature at the end of March and harvest is usually carried out at the beginning of April. The grain lost among the stover is available in the fields until next October.

2.4. Quantifying damage to crops

Cultivated grains become available to parrots in two different ways: (1) pre-harvesting mature grain on plants (which is susceptible to damage of economic significance), and (2) wasted grain on the ground left by harvesting machines, which is another source of grain loss independent of the presence of parrots. We estimated pre-harvesting crop damage by checking places where BPs were observed feeding on crops. In order to assess the "border effect", field crops were divided into two strata: border and center. The "border area" was defined as the space between the fences and an imaginary line running parallel to them 20 m towards the center of the field crop. The remaining of the field was defined as "center." In the case of central pivot-irrigated fields, the border and the center were defined as shown in Figure 2.

Every time parrots were observed in crop fields, a 200 m transect across the border and the center was surveyed on foot in search for parrot damage. Damage was considered significant if at least five plants presented signs of parrot damage (i.e. five plants/200 m). In case of significant damage, a stratified sampling was carried out, considering the border and center as different strata. In each of them, 10 random 10 m transects were surveyed for parrot damage. In each of the 10 transects, 15 plants growing at 70 cm intervals were checked for parrot damage (150 plants in total per stratum). Then, damage on sunflower was quantified in complementary ways: (1) the proportion of plants damaged and (2) the percentage

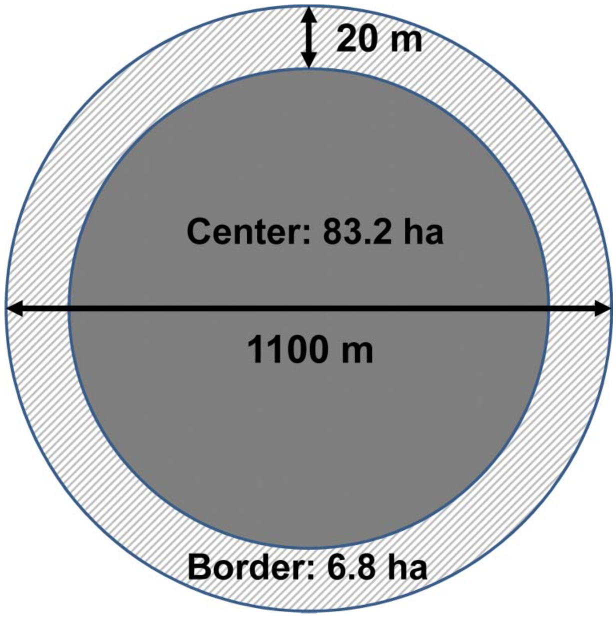

Figure 2. Graphical representation of the central pivot-irrigated fields in northeastern Patagonia, Argentina, showing the definition of "border" and "center" used.

loss of the surface of the head. The latter was carried out using two flexible crossed wires, marked at 2 cm intervals, which were centered on the sunflower head following the method by Dolbeer (1975). The cross divides the head into quarters, providing the observer with good reference points, thus, allowing good visual estimations of the percentage of the seeded surface area that is damaged (Dolbeer 1975).

3. Results

3.1. Population level

The extension of the different habitats recorded during the surveys is shown in Table 1. More than half of the land was devoted to cultivation, whereas, the areas of Monte vegetation and natural pastures were used for cattle ranching. Wheat was the most significant field crop followed by sunflower represented by four central pivot-irrigated fields located in Patagones along the northwesternmost surveyed road (1.1 km each; 40°45′24.11″S, 63°01′42.90″W; Figure 2, Table 1).

The number of BPs observed and the preferred habitats varied during the year (Table 1, Figure 3). The

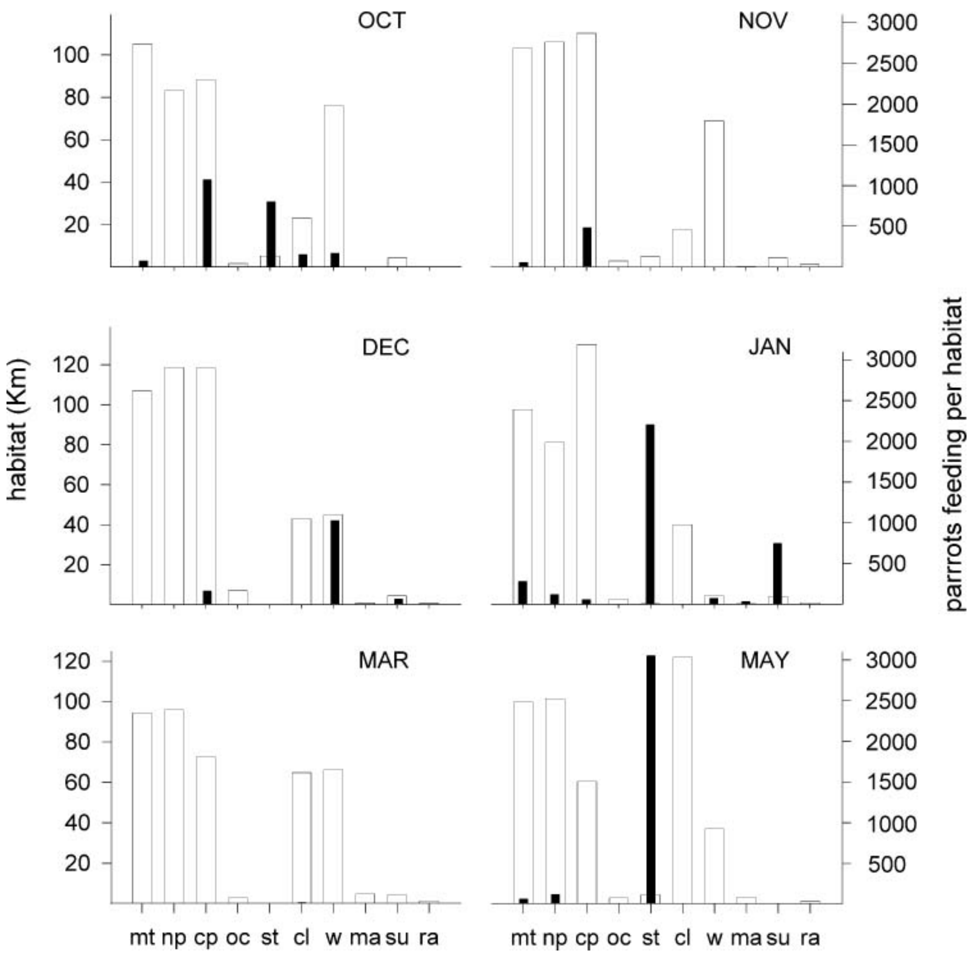

Figure 3. The number of burrowing parrots (*Cyanoliseus patagonus*) observed feeding (black thin bars, right *y*-axis) superimposed to the extent of each habitat (white bars, left *y*-axis) in northeastern Patagonia, Argentina, from October 2007 to May 2008.
Note: mt: Monte vegetation, np: natural pastures, cp: cultivated pastures, st: field with grain lost among the stover after the harvesting of maize and sunflower, w: wheat, ma: maize, su: sunflower, ra: rapeseed, oc: other crops, cl: cleared land.

highest number of parrots was observed in winter, including a large flock of 3050 parrots (May 2008; Table 1). The decrease in the number of parrots observed in November and in March and the increase in numbers in January (Table 1) are notable. During March 2008, only seven BPs were detected feeding on a patch of cleared land but the item consumed could not be identified (Figure 3).

The habitat where most parrots were recorded feeding was the stover left behind after wheat, maize, or sunflower harvesting (6054 birds; 41% of observations; Table 1, Figure 3). This was true, despite stover being found in only 0%−1% of the habitats surveyed (Table 1, Figure 4). The stover left behind after the maize and sunflower harvest accounted for 64% of the observed parrots in May (winter; Table 1, Figure 4). Similarly the stover left behind after wheat harvest was important in January (summer), accounting for 46% of parrot observations (Table 1, Figure 4). Additionally, during the pilot survey in July 2007, a flock of 4000 BPs was observed feeding on the stover left after maize harvesting (Figure 4).

The habitat second in importance for the BP was the cultivated pasture, where 1767 individuals were recorded (12% of observations). Parrots used the oat strains sowed for pasture during spring and summer, the time when the extension of this habitat was highest (Table 1, Figure 4). BPs were also observed feeding on the road margins (1505 birds; 10% of observations), mainly during the secondary flush of wild oat in the fall. Wheat attracted 1264 BPs (8% of observations) during the harvest in December−January (Table 1, Figure 3). Sunflower fields were visited by the parrots during the flowering season in relatively low numbers (December−January; 805 individuals; 5% of observations; Table 1, Figure 3). Characteristic shrubs of the Monte vegetation were consumed in lower percentages (465 individuals recorded; 3% of observations) but almost all through the year: chañar (4% in the pilot study in July 2007), piquillin (4% in November), and yao-yin (5% in January; Table 1, Figure 3).

3.2. Quantifying damage to crops

Of all crops in northeastern Patagonia (Table 1), our results suggest that BP caused significant damage only to sunflower productivity. In all other cases, the damage observed was less than five plants/200 m and, thus, no stratified sampling was carried out. No damage was observed in wheat and oat field crops.

Two central pivot-irrigated sunflower fields (A and B) located in Patagones were selected for stratified quantification of parrot crop damage (Figures 1 and 2). Quantifications were carried out shortly before harvesting in May 2008 (Table 2). Crop damage by BPs was only found in the border sectors with no plants affected in the central sectors (Table 2). The proportion of plants damaged and the percentage loss of the surface of the head are given in Table 2. In these central pivot-irrigated fields, an average of 650 kg/ha are harvested (Estancia El Progreso, personal communication). Thus, the damage measured in those pivot-irrigated fields would imply a loss of 2.9−6.1 kg/ha, i.e. 257.4−549.9 kg per irrigated field.

4. Discussion

Conflicts between parrots and agriculture appear to have increased as result of the expansion of cultivated areas into previously marginal habitats for agriculture, combined with opportunistic foraging by several species of Psittaciformes (Bucher 1992; Bucher & Aramburú 2014). A central challenge to understanding this conflict has been the lack of objectively gathered information on damage levels usually coupled with uncorroborated claims by farmers (Bucher 1992;

Figure 4. A partial view of a very large flock of burrowing parrots (*Cyanoliseus patagonus*) (about 4000 individuals) attracted to the grain lost among the stover after the harvesting of maize on 25 July 2007. The picture was taken in the Department of Patagones (province of Buenos Aires), northeastern Patagonia, Argentina. Photo credit: Roberto Ure.

Table 2. Damage to sunflowers caused by burrowing parrots (*Cyanoliseus patagonus*) in the Department of Patagones (province of Buenos Aires), northeastern Patagonia, Argentina.

Field	Number of days to harvest	Sector	Surface (ha)	Surface (%)	Proportion of plants with some damage (%)	Loss of the surface of the head (%)	Combined damaged (%)[a]
A	3	Border	6.8	8	43.3	12.5	
		Centre	83.2	92	0	0	
		Total	90	100	3.3		0.4
B	10	Border	6.8	8	23.3	5.8	
		Centre	83.2	92	0	0	
		Total	90	100	1.8		0.1

[a] As a proportion of plants affected in a proportion of the head affected.

Bomford & Sinclair 2002). As such, northeastern Patagonia offered a unique opportunity for the study of potential conflict between parrots and agriculture. This region combines, (1) a strong recent agriculture expansion (Pezzola et al. 2004; Villagra et al. 2009), (2) the largest known parrot breeding colony in the world (Masello et al. 2006), (3) a long tradition of unconfirmed farmer's claims regarding crop damage by parrots, and (4) extensive and intensive management of parrots as crop pests (Bucher & Rinaldi 1986; Failla et al. 2008).

4.1. Foraging area preferences

Although we found that wheat was by far the most significant field crop in the studied region, followed to a minor extent by sunflower, BPs largely ignored growing crops, and strongly preferred the stover left behind after wheat, maize, or sunflower harvesting (Table 1). This preference recurred in every season the stover was available (Figure 3). Moreover, very large flocks congregated in fields with stover regardless of the relative scarcity of this habitat type (Figures 3 and 4), and the long distances that parrots needed to commute in order to find it (250,000 hectares; Figure 1). Evidently, an important reward attracted the BPs to these fields: the grain lost among the stover and on the access paths to the fields. From an agriculture and economic perspective, this grain represents a loss attributable to the farmers' harvest methods, and occurs independent of the presence of parrots. Consumption of post-harvest grain by the BP, therefore, does not constitute crop damage.

From a parrot perspective, however, this grain constitutes an additional food source that could increase the carrying capacity of the environment (Newton 1998). As the other two requirements for the successful establishment of BP colonies, namely permanent water supply and soft cliffs for the nests, are widely met in the region (Masello et al. 2011), the possibility of an increase in the carrying capacity is conceivable. The outbreaks of the eared dove (*Zenaida auriculata*) populations in relationship with spilled harvest grain present a similar situation from other parts of South America (Bucher & Ranvaud 2006). The second and third most used habitats during this study, cultivated pastures and the road margins, respectively, provided additional unharvested grain for BPs also without implying any crop damage. The additional food could explain why a region almost completely converted to agriculture, where most of the natural vegetation was cleared in the last three decades (Pezzola et al. 2004), can still sustain the largest Psittaciformes colony of the world (Masello et al. 2006). The additional food resources could also explain why a large part of the BPs now use the El Cóndor colony over winter, when they typically migrated north until the 1990s (Bucher & Rinaldi 1986). This change in parrot migratory behavior coincides with a marked expansion of agriculture in northeastern Patagonia in recent years (Pezzola et al. 2004; Villagra et al. 2009).

4.2. Parrot abundance and flock size

The largest numbers of parrots as well as the largest flocks were observed in winter, while the lowest numbers were recorded in November and in March (Table 1, Figure 3). Large flocks, particularly in winter, are common in BPs as well as in other parrots from arid environments (Cannon 1984). This strategy may enable birds to efficiently exploit localized and temporary patches of food (Ward & Zahavi 1973), like the grain lost in stover left behind after harvesting, and help ensuring the survival of the juveniles over their first winter (Cannon 1984). Nevertheless, the peaks in late fall and early winter will probably show great variations between years according to climate and the availability of each habitat. The low numbers seen in November may relate to a significant part of the El Cóndor population incubating eggs, whereas, the increased numbers in January may account for many thousands of fledglings joining their parents for the foraging trips (Masello & Quillfeldt 2002, 2004). Minimal numbers in March may relate to emigration, as a part of the BPs of El Cóndor continues to migrate to the north in fall (Bucher & Rinaldi 1986; Masello & Quillfeldt 2012).

4.3. Quantification of damage to crops

Wheat attracted BPs during the harvest; however, only sunflower presented significant damage (Figure 3,

Table 2). The damage was only found in the border of the sunflower fields, while no damage was found in the center of the fields surveyed. Although the damage in the borders appeared to be high (up to 43%) and the damage to individual sunflower heads was significant (up to 12.5%), the combined damage, i.e. the proportion of plants affected in a proportion of the head affected for both the border and the center of the field, ranged from 0.1% to 0.4% (Table 2). These values represent a low damage level to sunflower by BPs. Moreover, considering that the sunflower fields accounted for up to a maximum of 1% of the total field crops in the surveyed area (Table 1), the regional significance of damage attributable to the BP is economically insignificant. Our results are in line with a previous study investigating the damage to citrus by blue-fronted amazon (BFA, *Amazona aestiva*) in Tucumán, Argentina (Navarro et al. 1991). BFA damage extended on average to 1% of the citrus crop, with a maximum of 2% in the particular case of lemons. Our results are also in line with a study on monk parakeets (MPs, *Myiopsitta monachus*) from Paraná, Argentina, that found damage concentrated in the borders of maize fields with no damage in the central parts (Canavelli et al. 2012). Although some cases of significant parrot damage have been reported for galah (*Cacatua roseicapilla*), long-billed corella (*Cacatua tenuirostris*), sulfur-crested cockatoo (*Cacatua galerita*), cockatiel (*Nymphicus hollandicus*), little corella (*Cacatua pastinator*), crimson rosella (*Platycercus elegans*), and rainbow lorikeet (*Trichoglossus haematodus*) in Australia (Bomford & Sinclair 2002), black-cheeked lovebird (*Agapornis nigrigenis*) in Zambia (Warburton & Perrin 2006), and rose-ringed parakeet (*Psittacula krameri*) in Pakistan (Ahmad et al. 2012), our results from BPs and those from BFAs and MPs provide further support for the conclusion that parrot damage tends to be overstated by farmers, especially in the case of conspicuous species and in countries where governmental agencies are involved in the control of vertebrate pests (Bucher 1992; Tracey et al. 2007; Failla et al. 2008). This appears not only to be the case for parrots. A similar situation was recently described for rodents (Laurenzi et al. 2016), suggesting the results of our study may have broader significance.

5. Conclusions

Our measurements show that BP damage to field crops in northeastern Patagonia is insignificant, with a damage level ranging from 0.1% to 0.4% of the sunflower harvest and no damage to other more important crops in the region. Consequently, there is no scientific or economic justification for management of BP populations in this region or mitigation for their impacts on agriculture at present. Any management action intended to prevent the non-significant level of damage found in this study will probably result in economic costs higher than the damage occurring. Our study also shows that this population of BPs makes use of spilled grain after harvest and may benefit from it. It remains to be investigated if this opportunistic behavior of the birds will further contribute to changes in migratory behavior and the carrying capacity in the region.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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