



ORIGINAL
ARTICLE

Role of exotic tree stands on the current distribution and social behaviour of Swainson's hawk, *Buteo swainsoni* in the Argentine Pampas

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ABSTRACT

Aim The Argentine Pampas was extensively and abruptly altered by European colonization. Between 1880 and 1885 the indigenous human inhabitants were completely displaced, and native grasslands were replaced by exotic pasture plants and crops. One of the most important ecological changes in the Pampas landscape, the introduction of tall exotic tree species, has received little attention, and its effect on wildlife has never been assessed. We have made an intensive survey of habitat use of Swainson's hawk, *Buteo swainsoni* in its most important non-breeding quarters, the Pampas of Argentina, aiming to characterize the sites used by hawks for communal roosting.

Location Pampas grasslands, Argentina.

Methods We surveyed 30,000 km of roads by car during the austral summer from 2001 to 2004, covering the main non-breeding area occupied by Swainson's hawks. Their roost sites were located by direct observation of birds roosting in tree stands close to the roads, by surveying potential roost sites around places where groups of pre- and post-roosting hawks were recorded, and by gathering information from local farmers.

Results Swainson's hawks exclusively used stands of exotic tree species for roosting. *Eucalyptus viminalis* was present in all 34 roosts surveyed, and in 59% of them it was the only species present. The remaining exotic tree species were the Siberian elm, *Ulmus pumila*, pines (*Pinus* spp.) and cypress (*Cupressus* spp.). Flock sizes at roost sites were unusually high for a raptor, with an average of 658 individuals (range 8–5000 hawks, $n = 27$ flocks).

Main conclusions The introduction of exotic trees may have resulted in the expansion of the suitable habitat for Swainson's hawks, permitting a recent colonization of the Argentine Pampas. Tree stands may have also changed the communal roosting behaviour of this raptor, by virtue of their providing new structural elements in a region that almost completely lacked trees prior to European occupation.

Keywords

Anthropogenic landscape, Argentine Pampas, *Buteo swainsoni*, exotic tree, roost site, social behaviour, Swainson's hawk.

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INTRODUCTION

For communally roosting raptors, the availability of suitable roost sites is considered a limiting factor in their non-breeding grounds (Newton, 1979). Among Neotropical migratory birds,

one of the raptor species that would be potentially affected by roost availability is Swainson's hawk, *Buteo swainsoni*. This hawk breeds in North America and migrates to southern South America during the boreal winter (England *et al.*, 1997), performing a migratory trip of *c.* 10,000 km (Fuller *et al.*,

1998). Although their primary austral range is located in the Pampas of Argentina, Swainson's hawks have been reported irregularly in small numbers in Brazil, Colombia, Costa Rica, Panama, and Mexico (England *et al.*, 1997).

On the breeding grounds, Swainson's hawks are solitary and territorial, with pairs occupying home ranges that lead to a spacing of 1.5–2.5 km mean distance between neighbouring nests (England *et al.*, 1997). During migration and wintering, the hawks become gregarious, hunting in flocks and roosting communally. The shift in spatial distribution between breeding and non-breeding grounds is linked to seasonal changes in feeding habits. The breeding-season diet of the Swainson's hawk is similar to that of other temperate-zone buteos (England *et al.*, 1997). The non-breeding season diet is atypical and almost exclusively insectivorous (White *et al.*, 1989; Jaramillo, 1993). In the Pampas, flocks of up to 12,000 birds have been reported following grasshopper (Orthoptera) outbreaks (Goldstein, 1997).

The majority of Swainson's hawks congregate during the austral summer in the Pampas, a region that has been highly modified by humans during the last century. In this region the natural grasslands have been converted to arable lands (Soriano, 1992; Viglizzo *et al.*, 1997), but have also been altered structurally by the introduction of exotic tree species (Zalba *et al.*, 2000; Zalba & Villamil, 2002) (Fig. 1). Although habitat use by Swainson's hawks in this area has recently been assessed at a landscape scale (Canavelli *et al.*, 2003), no information exists regarding specific characteristics of roost sites used by hawks on their non-breeding grounds in Argentina. Several authors (reviewed in White *et al.*, 1989; but see also Woodbridge *et al.*, 1995; Goldstein *et al.*, 1996, 2000; Canavelli *et al.*, 2003), however, suggest the use of introduced *Eucalyptus* as roost sites.

Tall-tree stands are novel in the Pampas and their introduction has added structural complexity to the rather two-dimensional grasslands of this region. Typically, every ranch house in the Pampas is surrounded by a tree stand

locally called 'monte'. Properties usually comprise several hundred hectares, whereas the montes cover less than 10 ha (Fig. 1). In this work, we assess the characteristics of roost sites used by Swainson's hawks through an intensive survey of the region considered to be the main non-breeding grounds for the species in the Americas. Our aim was to determine the use of groves of exotic tree species as communal roosts by this species. Based on our results, we discuss the implications that the stands of exotic tree may have in the current distribution and communal roosting behaviour of the species in Argentina, as well as possible past scenarios for the relationship between hawks and the Pampas landscape prior to European colonization.

MATERIALS AND METHODS

Locating roost sites

Between 2001 and 2004 we surveyed 30,000 km of roads by car in central Argentina, including La Pampa, Córdoba, Buenos Aires and Santa Fe provinces (Fig. 2). This region, commonly called the Argentine Pampas, comprises c. 58 million ha of more or less fertile land suitable for cattle rearing and crop production. The climate is humid to subhumid temperate, with annual rainfall ranging from 600 mm in the south-west to 1100 mm in the north-east (Bukart *et al.*, 1999).

Roost sites used by Swainson's hawks were located during road surveys in three ways: (1) by direct observation of hawks roosting in stands close to roads, (2) by surveying potential roost sites where pre- and post-roosting hawks were observed, mainly perched on the ground and fence posts in the early morning and at sunset, and (3) by gathering information provided by local farmers. For situations (1) and (2) we were able to estimate the number of hawks using the roost by direct counting. When information about the use of a roost site was provided by landowners, we corroborated this finding by looking for indirect evidence of occupancy by Swainson's



Figure 1 Aerial view of the southern Argentine Pampas near Balcarce, Buenos Aires province. Cropland has replaced native grassland in most of the area, while human settlements and the establishment of the 'estancias' have been accompanied by the introduction of small stands of exotic tree species for timber, shade and as shelter belts (Photo by R.C. León, reprinted from Soriano, 1992).

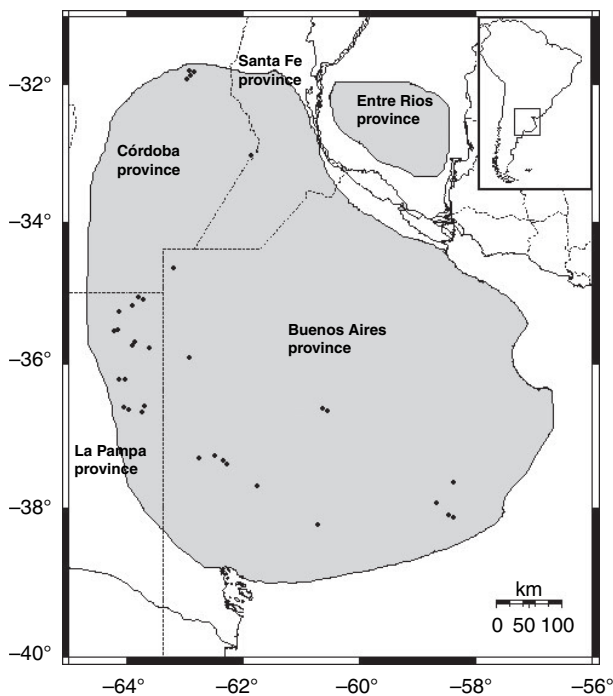


Figure 2 Argentine Pampas (shaded area) according to Viglizzo *et al.* (1997) and Zalba & Villamil (2002). The area surveyed for this work includes the Pampas region comprising Buenos Aires, La Pampa, Córdoba and Santa Fe province, excluding Entre Ríos. Black points are the locations of the Swainson’s hawk roost sites found during 2001 to 2004 austral summers.

hawks (e.g. moulted feathers and regurgitation pellets on the ground). We followed the same procedure to confirm the use of a roost when hawks gathered near a potential roost site.

Roost-site characteristics

For each roost site we recorded the percentage of every tree species in the grove and the total area occupied by the tree stand. We did this by walking the perimeter of each roost with a Global Positioning System and estimating the area using OziExplorer 3.95 mapping software. As planted trees within a stand are all typically of the same age, the mean tree height was obtained from five randomly selected trees using a Suunto clinometer. The trees were selected at random points along the long axis of the roost (roost length, see below). When the roost was composed of more than one tree species, we randomly selected individuals from the main tree species in the roost. The percentage of canopy cover was estimated using a convex spherical densiometer (Lemmon, 1956) at five randomly located points inside the roost selected in the same way as for tree-height measurements. Finally, the total tree density was calculated by counting every tree in the stand and dividing this number by the area occupied by the roost. We also estimated the linear distances from the centre of the roost to the nearest human building and paved road.

Using mapping software, we calculated a shape index for the roost sites as follows:

$$S = \frac{L - W}{L},$$

where *L* is the length of the major axis crossing the centre of the roost (roost length), and *W* is the length of the minor axis also crossing the centre of the roost (roost width). This index ranges from 0, when length and width of the roost are equal, to 1, for the maximum difference between these two measures. We correlated the estimated number of hawks using the roost against roost size, shape index, lineal edge and roost orientation using nonparametric Spearman’s rank correlation procedure (Zar, 1996).

RESULTS

We found a total of 34 roost sites used by Swainson’s hawks (3, 18 and 13 in 2001–2002, 2002–2003 and 2003–2004 austral summers, respectively) in Buenos Aires (*n* = 14), La Pampa (*n* = 15) and Córdoba provinces (*n* = 5) (Fig. 2). Twenty-seven of these roosts were found by direct observation of hawks, either leaving or arriving at the roost or perching nearby, while the remaining seven were reported by local farmers. The mean size of roosting flocks (± SD) was 658 ± 1318 birds, with values ranging from 8 to an estimate 5000 hawks.

All roost sites were composed of exotic tree species. Fifty-nine per cent of the roost sites were mono-specific groves of *Eucalyptus viminalis* (Labill. 1806), the remaining being mixed groves composed of variable percentages of *E. viminalis*, Siberian elm (*Ulmus pumila* Linneaus 1753), pine (*Pinus* spp.) and cypress (*Cupressus* spp.) (Table 1). *Eucalyptus viminalis* was the only tree species present in all roost sites sampled. The density of trees and high canopy cover (Table 2) also evidenced the artificial nature of the roost sites. The number of Swainson’s hawks using a roost was negatively correlated with the linear edge of the groves (*r*_s = -0.44, *t*₂₅ = -2.46, *P* = 0.02) but was not correlated either with the size (*r*_s = 0.20, *t*₂₅ = 1.03, *P* = 0.30), shape (*r*_s = -0.30, *t*₂₅ = -1.61, *P* = 0.11) or with the orientation of the roosts (*r*_s = 0.09, *t*₂₅ = 0.45, *P* = 0.65), where *s* denotes the use of Spearman rank correlation instead of Pearson correlation coefficient. The elongate shape of the roosts (Table 2) reflected one of the main purposes of tree planting in the area, namely to create windbreaks.

Table 1 Tree species composition (expressed as the percentage of each species) in 34 tree groves used by Swainson’s hawks for roosting in the Argentine Pampas. The number of roosts is in the body of the table

	1–30%	31–60%	60–99%	100%
<i>Eucalyptus viminalis</i>	2	3	9	20
<i>Ulmus pumila</i>	5	1	1	0
<i>Cupressus</i> spp.	6	0	1	0
<i>Pinus</i> spp.	5	1	0	0

Table 2 Roost characteristics of Swainson's hawks in the Argentine Pampas ($n = 34$ groves)

	Mean	SD	Min	Max
Area (ha)	5.7	5.9	0.4	26.1
Shape index	0.76	0.25	0.17	0.98
Tree height (m)	20.3	4.2	10.8	29.0
Plant density (tree ha ⁻¹)	288.2	227.7	86.4	1111.1
Canopy cover (%)	87.9	12.9	34.3	100.0
Distance to nearest road (m)	570.7	591.8	0.0	2030.0
Distance to nearest building (m)	445.6	486.1	7.0	1700.0

DISCUSSION

All groves used by Swainson's hawks for roosting were small tree plantations of exotic tree species. The majority of the roosts were located in groves around farmhouses and stables. This suggests that the close proximity of humans and their pets, such as cats and dogs, did not deter the hawks from roosting in inhabited groves.

Grove size did not seem to be a limiting factor for the number of hawks roosting in a plantation, at least for the roost sizes and hawk flocks we recorded. Based on the spatial distribution of pellets and moulted feathers found on the ground of the largest roosts, we observed that Swainson's hawks were not homogeneously distributed within the tree stand and selected peripheral trees for perching. This pattern was most evident where large groves supported fewer birds than would be predicted based on area or edge length of the habitat. The relationship between habitat edge length and bird number was significant but negatively correlated. These data suggest two possible explanations for the relationship between bird abundance and tree availability at roosts that are not mutually exclusive. First, the hawks favour edges over interiors of woodlots because they are not well adapted to flying in confined areas (del Hoyo *et al.*, 1994). Second, whatever birds are feeding in an area are drawn to the roost site, and it is hawk density per unit area, rather than tree density, that drives this relationship. A spatial analysis of the spatial density of woodlots relative to the density of hawks is needed to resolve this pattern fully.

The Argentine Pampas prior to European colonization

As in other lowland areas worldwide, in the Argentine Pampas the area of cultivated lands increased greatly in the twentieth century at the expense of natural areas, most of them grasslands and pseudo-steppes (Viglizzo *et al.*, 1997). Until the early nineteenth century, trees were virtually absent from the region, and shrubs formed only a minor component of the vegetation (Darwin, [1898] 1983), to the point that the shortage of firewood was a major inconvenience to travellers in the Pampas (Zalba & Villamil, 2002). The only native trees present in the interior of the Pampas before European settlements were the 'ombú' (*Phytolaca dioica* Linnaeus 1762), which grew scattered through the grasslands and the 'sauce colorado' (*Salix humboldtiana* Willdenow 1805), the

latter of which was restricted to riparian areas. The establishment of the 'estancias' (the local name for ranches) was accompanied by afforestation using foreign species for timber, shade, and as shelter belts (Hudson, [1918] 1963; Zalba & Villamil, 2002).

Exotic tree stands and the distribution of Swainson's hawks

The ecology and distribution of the Swainson's hawk in its austral grounds before the arrival of European colonizers are unknown. The first references found in the literature to the species in this region came from pioneer naturalists and ornithologists who surveyed the area at the beginning of the twentieth century. Some of these authors already reported flocks roosting in *Eucalyptus* trees (Ambrosetti, 1919; Delius, 1953; Olog, 1967). None of these authors mentioned the adaptive implications of the use of these small, man-made forests by Swainson's hawks. The lack of prior observations, and the rapid acceptance of the trees by the hawks did not allow these initial observers to see this as a process of behavioural adaptation. Given the strong relationship observed between exotic tree species and roost sites selected for Swainson's hawks, several key questions are raised. If the first exotic tree stands were planted in the Pampas c. 125 years ago, what effects have these small and man-made woodlands on the ecology of Swainson's hawks during the non-breeding season?

Swainson's hawks are known to be highly vagile, raising the possibility of rapid range expansion. Goldstein *et al.* (2000), for example, found that four out of 22 radio-tagged hawks were using an area located 500 km north of the site where they had been captured 2 months earlier in Argentina. These data suggest that Swainson's hawks could respond to improved resource availability by enlarging their effective non-breeding area in a few years. The Argentine Pampas may have been marginal areas in the distribution of Swainson's hawks in the past, with most of the hawk population inhabiting savannas and steppes with at least some arborescent growth, for example the Chaco, and the ecotone regions among Pampas grasslands and the xerophitic forest of the Espinal biome to the north. If this were the case, the Pampas could have been rapidly colonized by the hawks following exotic tree introduction.

We are not aware of any other example of a raptorial bird that may have increased its distribution as a result of introduced plant species. Contrarily, introduced *Eucalyptus* tree forests have been reported to decrease the probability of the presence of native common buzzards *Buteo buteo* (Linnaeus 1758) in southern Spain (Bustamante & Seoane, 2004).

As for possible effects of the large aggregations of Swainson's hawks on other species of the Pampas (see e.g. Terborgh *et al.*, 2001), the latter should be remembered that it is an artificial ecosystem in which the original distribution and abundances of other species, whether possible competitors or prey, have surely been altered. It seems, however, that the Swainson's hawk is the only bird species in the area specializing in grasshopper consumption.

CONCLUSIONS

The current landscape of the Argentine Pampas comprises small stands of exotic tree species scattered among a matrix of crops and grasslands, most of which are 'improved'. This landscape contrasts with the natural, almost treeless grasslands found by the first European colonizers. Based on habitat-use studies, Swainson's hawks seem well adapted to the agricultural setting that results from the transformation of native grasslands (Canavelli *et al.*, 2003). However, a key feature of this habitat use may be the presence of trees planted to form shelter belts. Although changes in roosting behaviour cannot be discounted, the practice of planting *Eucalyptus* appears to have enlarged the available habitat for Swainson's hawk in its austral grounds, allowing hawks to occupy areas where they were probably absent in the past. Current patterns of distribution, habitat use and spatial aggregation of Swainson's hawks have certainly been influenced by the incorporation of exotic tree stands in the Argentine Pampas.

ACKNOWLEDGEMENTS

We wish to thank Miguel Santillan, Maximiliano Galmes, Ramón Sosa and Alejandro Travaini for their valuable help in locating and measuring roost sites and conducting bird surveys, and the Subsecretaría de Ecología de la Provincia de La Pampa for providing logistical support to this project. We thank Rolando J. C. León for providing pictures, Elsevier Co. for authorizing photograph reproduction, and George Taylor for improvements to the English text. We appreciate the collaboration of many local landowners who gave us permission to survey groves located on their ranches. This study received financial support from the James L. Baillie Memorial Fund (Canada), the Wildlife Conservation Society (USA), and Universidad Nacional de La Pampa (Argentina). While doing this research, J.H.S. was supported by a scholarship from Consejo Nacional de Investigaciones Científicas y Técnicas de Argentina (CONICET).

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Editor: Mark Bush