ECOLOGICAL AND HUMAN DIMENSIONS OF THE MONK PARAKEET DAMAGE TO CROPS IN ARGENTINA

By

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To my husband, Carlos, and our lovely daughters, Luciana and Eugenia
To my parents, Marina (deceased) and Juan Carlos

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TABLE OF CONTENTS

page

LIST OF TABLES

LIST OF FIGURES

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Doctor of Philosophy

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The Monk Parakeet (*Myiopsitta monachus*) is considered among the most important bird pest species causing damage to crops in Argentina. In this study, I explored habitat features influencing abundance and damage of monk parakeets to crop fields and density of nests in inhabited farms with eucalyptus trees at multiple spatial levels. Additionally, I examined socio-psychological and socio-demographic factors influencing farmers´ preferences about management of monk parakeet damage to crops.

Monk parakeet abundance and damage was greater in sunflower than in corn fields. Landscape variables, such as distance to nearest sites with trees, percentage of landscape with trees, and availability of foraging sites for monk parakeets around the crop fields, were more important than local variables in explaining monk parakeet damage to crop fields. However, local variables, such as field area, plant density and percentage of field border with trees, also were related to damage. Conversely, the density of monk parakeet nests in inhabited farms with eucalyptus trees was not clearly explained by any variable or combination of variables modeled in this study.

Farmers preferred population control strategies, such as nest destruction and killing of birds, for decreasing monk parakeet damage to crops. Preferences of farmers for management strategies were related more strongly to attitudes toward monk parakeets than to any other factor considered in this study. Other important socio-psychological factors were perceived efficacy and previous knowledge about management strategies. Perceptions of magnitude of damage by monk parakeets practically were not related to preferences. Socio-demographic factors, such as age and education, were related to preferences in different ways depending on the management strategy.

Based on this study, managers should consider both local and landscape factors when planning management measures to prevent monk parakeet damage to crop and reduce nesting on farms. Additionally, extension actions should be oriented to modifying attitudes toward monk parakeets as well as communicating and showing the efficacy of alternative management strategies. Given the current uncertainties in the outcome of management actions, an adaptive management approach would be useful to evaluate the efficacy of strategies other than lethal or reproductive control.

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CHAPTER 1
INTRODUCTION

Ecological and Human Dimensions of Conflicts between Birds and Crop Production

Conflicts between wildlife and human activities have existed historically. However, the number and severity of conflicts have increased and are expected to continue to increase in the future as a consequence of human population growth (Fall and Jackson 2000; Messmer 2000; Bruggers *et al*. 2002; Linz *et al.* 2002). Additionally, public attitudes towards of wildlife are changing, with increasing public concern over the welfare of animals, including overabundant species (Messmer 2000; Bruggers *et al.* 2002). As a consequence, the need for effective, environmentally safe and science-based management methods and strategies probably is more critical today than in the past. Underlying the development of efficient management strategies to prevent and/or decrease wildlife damage is a good understanding of species behavior and ecology and the behavior of people in response to the damage and its management (Conover 2002).

Granivorous bird species associated with agroecosystems cause damage to crops, feedlots and stored grains world-wide (Pinowski and Kendeigh 1977; De Grazio 1978; Feare 1993; Bruggers and Zaccagnini 1994). The number of species causing this damage is relatively small, but their impacts often are significant (Pinowski and Kendeigh 1977; De Grazio 1978; Feare 1993; Bruggers *et al.* 1998). Some species, such as red-winged blackbirds (*Agelaius phoeniceous*) in North America, eared doves (*Zenaida auriculata*) in South America and red-billed quelea (*Quelea quelea*) in Africa, comprise flocks and communal roosts of many thousands of individuals and range widely (Beletsky 1996; Bucher 1992a; and Bruggers and Elliot 1989, respectively). Other species that cause damage, including the rose-ringed (*Psittacula krameri*) and the monk parakeets (*Myopsitta monachus*), although less numerous and more sedentary, are also very social and visible (Spreyer and Bucher 1998; Kahn 2003). The conspicuousness of these birds and the damage they cause, plus the high variability in damage, make objective estimation of damage by farmers difficult (Conover 2002) and contribute to a tendency to overestimate losses (Dyer and Ward 1977; Bucher 1992a; 1998). As a result, farmers often apply management measures to decrease bird damage that are not economically effective or are contrary to research findings (Bomford and Sinclair 2002; Tracey *et al.* 2007).

The deficiencies observed when planning management strategies to decrease bird damage to crops, as well as the lack of effectiveness of many of these strategies have been attributed to failures to consider the human dimensions of the problem, including sociological and psychological aspects (Timm 1991 in Clergeau 1995; Bomford and Sinclair 2002). The biology, physiology and ecology of some vertebrate pests species, including birds, is relatively well-known and, for this reason, the failures of management programs often are due to the lack of considerations of human dimensions (Timm 1991 in Clergeau 1995). However, the dynamics of species distribution are not always well known, particularly at landscape scales, when related to problems with birds in crop fields (Clergeau 1995).

Birds move at greater scales than individual properties of particular crop fields, using both cultivated and non-cultivated fields in their life cycles (e.g., starlings, Bruun and Smith 2003; blackbirds, Beletsky 1996; Orians 1985). The availability of cultivated site and alternative foraging locations around a crop field, as well as uncultivated sites used for roosting and/or breeding by bird pest species, influence bird abundance and damage on particular crop fields (Otis and Kilburn 1987; Tourenq *et al.* 2001; Amano *et al.* 2004, 2008; Hagy *et al.* 2008). Additionally, the characteristics of the crop field, such field area, plant density or weed abundance, also could influence the abundance and damage by birds on particular crop fields (Otis and Kilburn 1987; Tourenq *et al.* 2001; Amano *et al.* 2004, 2008; Hagy *et al.* 2008). Therefore, studying the ecology of bird pest species requires the consideration of multiple scales of observation, from particular fields (or patches) to the surrounding landscape or region (Clergeau 1995). However, with exception of few works (Bucher 1990; Bucher and Ranvau 2006, Cavallero 2010), practically no studies had considered multiple scales of observation with neotropical bird pest species in South America.

Conflicts between Monk Parakeets and Crop Production

The monk parakeet is a medium-size (90-120 g) neotropical parrot species commonly involved in human-wildlife conflicts in its native range (South America) and non-native areas of distribution (North America and Europe, Spreyer and Bucher 1998). In Argentina and Uruguay, the monk parakeet is among the most important bird pest species causing damage to grain crops (Bucher and Bedano 1976; Bucher 1984, 1992a, b; Bruggers y Zaccagnini 1994; Bruggers *et al.* 1998). This species also causes damage in other settings (e.g., fruit crops and electric utility structures, Bucher 1992a; Bucher and Martin 1987). In North America and Europe, the monk parakeet primarily causes problems in urban settings related to location of nests, including damage to electric utility structures that lead to power outages (Avery *et al.* 2002) and disturbance to tranquility of human neighborhoods, due to the noise parakeets produce (Santos 2005; Burger and Gochfeld 2009). Currently, the monk parakeet is a threat to agriculture production or native biota in some non-native areas, but if its populations continue to expand, this species could cause more problems in the future (Sol *et al.* 1997; Tillman *et al.* 2000; Domenech *et al.* 2003).

Traditionally, lethal control has been preferred as the most effective method for decreasing monk parakeet-crop conflicts, particularly in Argentina (Bucher 1984, 1992). Several methods have been used, including nest burning or destruction, shooting, payment of bounties, trapping, netting, toxic baits, and spraying of nests with insecticides. Since the 1980s, the primary lethal control method has been insecticides mixed with grease and applied on nest openings to produce intoxication and potentially death of birds entering to the nest (Aramburú 1991). However, objections to this method are increasing and new methods are required (Canavelli and Zaccagnini 2007; Canavelli and Aramburú, *in press*). Additionally, monk parakeets represent conflicting values for different groups of people because, although they are considered a pest species, this species also is valued as a domestic pet (Moschione and Banchs 2006).

Currently, most information about monk parakeets´ biology and ecology in Argentina is focused in population demographics and social behavior (Bucher *et al.* 1991; Aramburú 1991; Navarro *et al.* 1992; Eberhard 1998). However, the available information is relatively scarce, particularly in aspects such as habitat use (Spreyer and Bucher 1998). Consequently, understanding habitat features influencing the use of crop fields and nesting sites for by monk parakeets in agricultural landscapes of Argentina may help the management of conflicts with this species, not only in Argentina but in other native and non-native areas of distribution. In addition, research on the human dimensions of the problem could improve the comprehension of the social situation in which management occurs and, consequently, contribute to increased success of management strategies in the future. Currently, no information is available about social and psychological factors underlying farmers' preferences for management strategies to decrease conflicts with monk parakeets (Canavelli and Zaccagnini 2007).

Research Overview

The goals of this study were to: 1) identify habitat features influencing the abundance of monk parakeets in crop fields and damage by parakeets to crops, 2) identify habitat features that influence abundance of nests, and 3) examine factors influencing the decision-making process by farmers about management of monk parakeet damage to crops. Because habitat selection involves a hierarchy of decisions at multiple scales (Hildén 1965; Johnson 1980; Cody 1985; Wiens *et al.* 1987), I used a multi-level approach for analyzing local and landscape factors influencing the abundance and damage of monk parakeets in corn and sunflower fields and the density of monk parakeet nests in sites with eucalyptus trees in central Argentina. Chapter 2 focuses on monk parakeet damage to crop fields, while Chapter 3 focuses on density of monk parakeet nests in sites with eucalyptus trees.

Chapter 4 focuses on the human dimensions of conflicts with monk parakeets and crop production. I applied a behavioral decision approach to determine farmers' preferences for management strategies to decrease damage from monk parakeets to crops in Argentina and to evaluate socio-psychological factors and socio-demographic factors that influenced those preferences. Finally, in Chapter 5, I summarize the results and management implications from the previous chapters. This study is one of the first studies applying a multi-level analysis to understand monk parakeet ecology in agricultural landscapes and, to my knowledge; it is the first study to apply a human behavioral model in bird pest management worldwide.

CHAPTER 2

MONK PARAKEET ABUNDANCE AND DAMAGE TO CROP FIELDS IN RELATION TO LOCAL AND LANDSCAPE VARIABLES

Background

Bird damage to agricultural crops is a cause of economic loss for farmers in many parts of the world (De Grazio 1978; Conover 2002). Understanding the underlying factors favoring damage on specific sites is crucial for predicting occurrence of damage and, consequently, focusing resources to reduce damage on sites and/or times where damage is more likely (Amano *et al.* 2008). Additionally, understanding factors favoring use and damage of a particular crop field by birds could help with design and evaluation of science-based management strategies for preventing damage, such as alternative feeding areas or lure crops (Amano *et al.* 2007; Hagy *et al.* 2008).

Factors influencing use and damage of a particular crop field by birds act at multiple scales (Clergeau 1995). For instance, local characteristics related to the crop field, such as crop structure (e.g., plant density and height) and weed density have been found to be related to damage by red-winged blackbirds (*Agelaius phoeniceus*) in sunflower fields (Otis and Kilburn 1987). However, characteristics of the landscape around the sunflower fields, such as availability of nesting or alternative food habitats near the crop field, may be more important than local characteristics for explaining blackbird damage to sunflower fields (Otis and Kilburn 1987; Hagy *et al.* 2008). Landscape characteristics also have been found to be important predictors of damage to crops for other bird pest species, such as flamingos (*Phoenicopterus rubber roseus*) in rice fields (Tourenq *et al.* 2001) and white-fronted geese (*Anser albifrons*) in wheat fields (Amano *et al.* 2004, 2008).

Agricultural landscapes are a mixture of cultivated and uncultivated patches (fields), varying in composition (i.e., amount of land cover types in the landscape) and configuration (i.e., spatial arrangement of patches within the landscape) at multiple spatial and temporal scales (Forman and Godron 1986; Burel and Baudry 1995; Holt *et al.* 1995; Landis and Marino 1999). Mobile species using these landscapes, including bird species causing damage to crops, often use cultivated and non-cultivated patches in their life cycles. The abundance and distribution of these cultivated and non-cultivated patches in the agricultural landscape may influence the abundance and damage of a bird species on a particular patch or crop field (Otis and Kilburn 1987; Tourenq *et al.* 2001; Amano *et al.* 2004, 2008; Hagy *et al.* 2008).

Multi-level studies, in which researchers evaluate the influence of local and landscape variables on animal abundance and distribution in particular patches (or "focal patches", Brennan *et al.* 2002) have been proposed as a helpful tool for integrating multiple scales of observation about the behavior of bird pests in agricultural landscapes and designing rational management strategies (Clergeau 1995). Such multi-level studies are common in landscape ecology and conservation biology (see reviews in Mazerolle and Villard 1999 and Thorton *et al.* 2010). However, few studies evaluating bird pest damage to crop fields have explicitly addressed multiple scales of observation in the same study (but see Otis and Kilburn 1987; Tourenq *et al.* 2001; Amano *et al*. 2004, 2008; Hagy *et al.* 2008).

In this study, I applied a multi-level approach to analyze factors influencing the abundance and damage of monk parakeets (*Myiopsitta monachus*) to crop fields. The monk parakeet is among the most important bird pest species causing damage to grain crops in South America, particularly in Argentina and Uruguay (De Grazio and Besser 1975; Bucher and Bedano 1976; Bucher 1992a,b; Bruggers *et al.* 1998). Damage to grain crops by monk parakeets occurs principally to ripening sunflower and corn and occasionally sorghum, wheat and rice (Spreyer and Bucher 1998). Quantification of damage to crops by monk parakeets is very scarce, but indicates moderate (< 5%) to high (up to 20%) crop loss (De Grazio 1985; Bucher 1992a; Canavelli *et al.* 2008).

Key habitat elements for parrots, including monk parakeets, are suitable nesting sites and high-quality food (del Hoyo *et al.* 1992). In agricultural landscapes, suitable nesting sites for monk parakeets are varied because, unlike other parrots, the monk parakeet does not nest in cavities but rather constructs nests with sticks on tall natural and artificial structures, including native savanna trees (e.g., *Prosopis* spp. and *Acacia* spp.), introduced *Eucalyptus* trees, and utility poles (Spreyer and Bucher 1998). High-quality foods for monk parakeets in agricultural landscapes are maturing grain crops that they prefer, such as sunflower and corn (Spreyer and Bucher 1998; Aramburú 1997, 1998; Aramburú and Bucher 1999). However, parakeets also forage on wild seeds, fruit of native trees, and other grain and fruit crops (Spreyer and Bucher 1998).

Monk parakeets are central-place foragers (Stephens and Krebs 1985) because they use the nest all year around, both for breeding and roosting. They forage out from the nest and then return to that site. Daily movement from the nest site to foraging areas is generally between 3 and 5 km, although possibly longer (up to 24 km) during the non-breeding season (Spreyer and Bucher 1998).

Considering the wide range of daily movement of monk parakeets, I expected characteristics of the landscape around a particular crop field would influence the abundance and damage of parakeets in that particular field. Specifically, given that monk parakeets have a generalist foraging behavior (Bucher *et al.* 1991; Hyman and Pruett-Jones 1995), I expected availability of alternative foods on the landscape around a crop field to be related to abundance and damage of monk parakeets in the field. Additionally, because monk parakeets use trees for perching, nesting, or daily loafing, I expected abundance and distribution of patches with trees around a given crop field to be important for explaining the abundance and damage by monk parakeets in the field.

Methods

Study Area

The study was conducted in a 525,000-ha area comprising the Department of Paraná (Entre Ríos Province, Argentina, Figure 2-1). The area is characterized by diverse production activities, with a predominance of crops, beef cattle and milk production (Engler and Vicente 2009). Agricultural crops cover about 49% of the area, including in order of importance soybeans, wheat, corn, sunflower and sorghum. The Department of Paraná contains approximately 15% of the total agricultural area in the province and is the most important department in Entre Ríos in this respect (Engler and Vicente 2009). Mean annual temperature is 19ºC (12ºC in winter and 25ºin summer) and mean rainfall is approximately 1000 mm.

A gradient in production activities and, therefore landscape pattern, occurs in the study area from north-east to south-west. The north-east mostly is devoted to a mixture of crops and cattle production, with high interspersion of woodlands, pastures and crops. The south-west is intensively agricultural, with a few patches of woodland interspersed with large fields of annual crops.

Sampling Scheme

The study was conducted in the 2006-2007 and 2007-2008 austral summer seasons (December to February). Most damage to crops by monk parakeets occurs in summer, following their spring reproductive period (August-December, Bucher 1992a). I used a Geographic Information System (ArcGIS v.9.2) to place a 10x10-km grid over Paraná Department and selected 25 non-contiguous grid cells in 2006 and 31 cells in 2007 using systematic sampling with random start (first cell selected at random and every other cell selected thereafter). Taking the geographic coordinates for the central point of each cell as a reference in the field, I identified the most proximate corn or sunflower field to that point. Based on the type of crop I sampled on the first cell, when possible I choose a different type on the next cell in order to have both types of crop fields with a relatively even distribution throughout the study area (Figure 2-1). A crop field (or patch) was defined as a contiguous area covered by corn or sunflower, differing from its surroundings. Based on a first visit to each crop field, I planned the date for sampling bird abundance and damage to coincide with the ripening crop in each field, which is when damage by monk parakeets was expected. Study sites included 14 corn and 11 sunflower fields in the 2006-2007 summer season (hereafter 2007 season) and 15 corn and 26 sunflower fields in the 2007-2008 summer season (hereafter 2008 season). Because of problems during field sampling (early harvest, immature stage), one corn field sampled in 2007 and one sunflower field sampled in 2008 were eliminated from the data pool. Additionally, data from two fields (1 corn and 1 sunflower field) that were consistently outside the distribution range of values for all independent variables were eliminated from the pool of data, as well as three fields (1 corn and 2 sunflower fields) with missing values for at least one variable. Therefore, final sample size for statistical analyzes was 22 corn fields and 27 sunflower fields. The mean size (± s.e.) of corn fields was 22.52 ha (± 3.46), and the mean size of sunflower fields was 24.25 (± 2.99).

Bird Abundance Surveys

Monk parakeets were surveyed using unlimited-distance 5-min point counts (Bibby *et al.* 2000; Freemark and Rogers 1995). Because monk parakeets were difficult to observe once they entered the crop field and estimates of distance were difficult on the homogenous surface of a field, I used point counts with 180 º semicircles of unlimited distance in direction of the crop (Bibby *et al.* 2000; Freemark and Rogers 1995). I used number of birds observed/point/plot as an index of bird abundance in the field. All parakeets observed in the field, as well as entering or leaving the plot were recorded. The number of parakeets was counted for individual birds or small groups, or estimated otherwise.

Points were located on the border of the crop fields in proportion to their size, considering a minimum distance of 200 m between consecutive points to decrease the possibility of double counting birds (Freemark and Rogers 1995; Boutin *et al.* 1999a and 1999b; Best *et al.* 2001). Surveys were conducted between sunrise and mid-morning (10:00 h), with one field sampled per morning. The same observer conducted all point counts in 2007. In 2008, another observer with experience in bird counts in crop fields was included and observers were randomly assigned to crop fields. Relative abundance of monk parakeets was estimated for each crop field as the average number of birds observed per point per field.

Estimation of Crop Damage

Each crop field was sampled for monk parakeet damage in a fixed number of small plots (n= 36 in 2007 and n=80 in 2008) distributed along transects in the field (Figure 2-2, Otis 1992; Zaccagnini 1998; Linz 1999). Based on the size and shape of the field, the field was divided in 2-4 sections containing an equal number of rows. A row was randomly selected in the first section and the rows for the other sections were placed at a fixed distance from each other so that sampled rows were systematically distributed over the width of the field. Three strata were sampled perpendicular to each sample row: field edge (first line with crop plants), border (25 m from the edge of the field) and center of field. Sample plots on the field edge corresponded to plants on the first line, and sample plots on the border and the center sections of each row were systematically placed with a random start in order to have a fixed number of samples per stratum per field (8 plots in field edge, 16 plots in border and 12 plots in center in 2007 and 12 plots in field edge, 36 in border and 32 in center in 2008, Figure 2-2). In 2008, four of the 12 plots in the field edge and twelve of the 36 plots in the border were taken in four additional short transects (25 m) in one border of the field in an attempt to increase accuracy in damage estimations.

Each plot consisted of 5-plants perpendicular to the direction of the sampling row (Figure 2-2). In 2007, I registered the number of damaged and non-damaged plants for each plot (infestation or frequency of damage). Additionally, in 2007 I visually estimated intensity of damage (i.e., percentage of grain loss) on damaged plants as the damaged length of corn ear (De Grazio *et al.* 1969) and the percentage of sunflower head damaged (Dolbeer 1975; Zaccagnini and Cassani 1985; Zaccagnini and Tate 1992; Otis 1992). Sunflower plants always had one head per plant. The cases where I had 2 damaged corn ears in a plant (n=9 cases), damage was averaged between both corn ears in the plant. In corn fields, damage of ears was attributable to monk parakeets when no-signs of mammal activities, such as tracks or feces, were observed in the field, the external cover of the ear was opened and the ear physically damaged (for example, with the top part of the ear, Figure 2-3). Monk parakeet is the only bird species capable of producing this type of damage in the region (Bucher and Bedano 1976; Bucher 1992a). In sunflower fields, I differentiated damage by monk parakeets from other birds (doves and pigeons) based on the existence of physical damage on the head (e.g., some parts missing) in addition to husks from sunflower seeds on the plant or in the ground (Figure 2-4).

Because of the small magnitude of damage intensity and the high variation among fields ($\dot{X}$=0.18% grain loss, SD=0.32 in corn and $\dot{X}$ =0.91% of grain loss, SD=1.96 in sunflower), as well as a direct relationship between the frequency and intensity of damage (R^2=0.67, p= 0.09 for corn, R^2=0.76, p<0.001 for sunflower, see Canavelli *et al.* 2008 for more details), I only evaluated frequency of damage in 2008, increasing effort in each field from 36 to 80 plots per field in an attempt to increase precision in the estimator. Frequency of damage by monk parakeets in each field was estimated as the proportion of damaged plants over the total number of plants using a stratum weighted proportional estimator (Cochran 1977; Zaccagnini *et al.* 1983, 1985). The number of plants by stratum was estimated based on plant density (number of plants per square meter, estimated as the number of plants per meter of row divided by row distance in meters and multiplied by a square meter, O. Valentinuz, pers.com.) and the surface of each stratum in square meters was calculated using Patch Analyst extension in ArcGIS 9.2 (Rempel 2010).

Within-field and Field-level Variables

Variables that characterized crop structure within each crop field were chosen based on previous studies indicating the influence of these variables on the use of crop fields by bird pests (Otis and Kilburn 1988; Hagy *et al.* 2008). Sampling plots used for damage evaluation were used for measuring these within-field variables (n= 36 in 2007 and n=80 in 2008). In each plot (5 plants each), I recorded plant height and plant phenological stage for 3 of the 5 plants in the plot (one in the center and one at each extreme of the plot). Additionally, I measured number of rooted plants/ row meter and row width (both variables related to plant density) from the plant in the center of the plot and visually estimated weed coverage as the proportional coverage of a 1x1-m quadrat in each sampling plot (Otis and Kilburn 1988; Colbach *et al.* 2000). Measurements for crop structure variables at each plot were then averaged over all sampling plots in a field to obtain one value per field for each variable. Because plant density and plant height were substantially correlated (r≥0.60), with more dense crops having shorter plants, I used plant density for model construction (Statistical analyses).

Field-level variables characterized the field as a patch within the landscape. The percentage of the field border with trees was recorded in the field on a 3-point scale (1= 0-5%, 2= 5-50% or 3=>50%) as well as the presence of crops, pastures, weedy fields or woodland adjacent to the field. Based on field observations and discussions with each landowner, I determined that no control measures were taken against monk parakeets on the crop fields evaluated in this study. All crop fields (focal fields) were digitized using Google Earth and the geographic coordinates of crop borders recorded in the field. Polygons were then converted to a vector file and imported in ArcGIS (v 9.2). Using Patch Analyst extension for ArcGIS (Rempel 2010), I estimated field area, perimeter, and shape complexity (as a shape index). Because field area and perimeter were substantially correlated ($r \geq 0.60$), I used field area for model construction (Statistical analyses) based on the relationship between bird damage and field area, either negative (e.g., for red-winged blackbirds, Clark *et al.* 1982; Zaccagnini and Dabin 1985) or positive (e.g., for greater flamingos, Tourenq *et al.* 2001), as well as its simplicity for use and evaluation in the field.

Landscape-level Variables

I evaluated landscape context around each crop field using both distance-based measures and buffer-measures of landscape composition and configuration. Using Google Earth, I measured distance from the crop field to the nearest site with man-made structures, such as houses and barns, and trees, which are commonly used by monk parakeets as nesting sites (Chapter 3). Additionally, I examined the composition and configuration of the landscape within circular buffers of 3 different radii from the center of each crop field (1000, 3000 and 5000 m, Figure 2-5). These landscape extents were chosen based on the expected daily movement range of monk parakeets from the nest site to foraging areas while breeding (range: 3.5-8 km, mode: 3-5 km, Spreyer and Bucher 1998). I set an upper buffer limit of 5000 m to avoid the problem of overlapping buffers and potential spatial autocorrelation of the local landscapes around each crop field (Koper and Schmiegelow 2006; Renfrew and Ribic 2008; Boscolo and Metzger 2009). I did not use buffers smaller than 1000 m because of problems with artificial borders in estimation of landscape indices.

Buffers for crop fields sampled in 2007 and 2008 were obtained from Landsat TM images (226-82 21-Jan-2007 and 24-Jan-2008) classified by Noelia Calamari (INTA, EEA Paraná). Both images were classified using supervised classification. The 2007 Landsat image was classified using ECHO (Extraction and Classification of Homogeneous Objects) in MultiSpect Application v3.1 (2007) and the 2008 Landsat image was classified using ImageSVM (Support Vector Machine, van der Linden *et al.* 2009) in ERDAS imagine 9.1 (2006). Ten land cover types were identified: water; corn; sunflower; soybeans; sorghum; pastures and other agricultural uses (e.g., fallow and weedy fields); developed areas, plowed and some fallow fields (which could not be clearly distinguished); introduced trees; native trees; and riparian vegetation. Results from each classification were validated with 100 points per land cover type randomly selected using Quickbird images (available in GoogleEarthTM, http://earth.google.com) and ground sampling. Overall classification accuracy was 82 % and 84 % for 2007 and 2008 satellite images, respectively. Finally, to clearly distinguish among different land cover types and decrease the problem of artificial borders with raster images, I re-grouped the land cover types into 7 classes: water; crops susceptible to damage by monk parakeets (corn and sunflower); non-susceptible crops (soybean and sorghum, immature at the time the image was obtained); pastures and other agricultural uses (e.g. fallow and weedy fields); developed areas, plowed and some fallow fields (which could not be clearly distinguished); and tree patches, including native and introduced trees. I focused the analysis on the availability of three land cover classes: 1) crops that could be susceptible to damage by monk parakeets (corn and sunflower), 2) tree patches, potentially used as primary sites for perching, nesting or daily loafing, and 3) pastures and other agricultural uses (e.g., fallow and weedy fields), which can include food items for monk parakeets such as flowers and seeds.

I used FRAGSTATS 3.3 software (McGarigal *et al.* 2002) to calculate landscape metrics representing landscape composition and configuration. Composition metrics included percentage of landscape with corn and sunflower, other agricultural uses (including pastures, fallow and weedy fields), and native and introduced trees. Configuration metrics included the aggregation of susceptible crops and trees within each buffer (measured with a clumpiness index), mean nearest-neighbor distance among attractive crops and tree patches, considering all attractive crops or tree patches on the landscape, respectively, and patch shape complexity (measured with a shape index) of attractive crops and tree patches. Substantial correlations ($r \geq 0.60$) were found among some landscape metrics, particularly at higher extents (3000 and 5000 m, Table A-1, Appendix A) and only uncorrelated metrics ($r < 0.60$) were included in the same model. Because percentage of landscape with different land cover types could be important for explaining bird abundance on a site (Fahrig 2001; Renfrew and Ribic 2008; Hagy *et al.* 2008), for analyses I sought to include configuration metrics uncorrelated with percentage of landscape for the two primary cover classes (crops susceptible to damage and trees). In the case of susceptible crops, this was possible with the clumpiness index. However, in the case of tree patches, all configuration metrics were correlated with percentage of this cover type on the landscape. Percentage of the landscape with tree patches was correlated negatively with mean nearest neighbor distance and positively with patch shape complexity and clumpliness. Therefore, I only considered percentage of the landscape with trees for data analyses.

Finally, because percentage of landscape with crops susceptible to damage was negatively correlated with percentage of landscape with trees at higher buffer extents (3000 and 5000 m, Table A-1, Appendix A), I included only one of them at a time for model construction at those buffer extents.

Statistical Analyses

I modeled relative abundance of monk parakeets and monk parakeet damage in each crop field as a function of within-field, field and landscape variables at each buffer extent (1000, 3000 and 5000 m) separately. Additionally, I constructed a set of models combining within-field, field and landscape variables. The response variables (relative abundance of monk parakeets and damage) were examined for deviation from normality (Infostat, Di Rienzo *et al.* 2010, SAS v. 8.0; SAS Institute Inc., 2006). Because both variables were not normally distributed, nor were transformations of those variables (e.g., square root for abundance or cosine for proportion of damage) normally distributed, a generalized linear model framework (GLM) was selected for modeling purposes, with a negative binomial error structure for relative abundance of monk parakeet and a binomial error structure for proportion of crop damage. Because final sample sizes for model construction were relatively small for each crop (n=22 for corn and n= 27 for sunflower), each model was restricted to include between one and three variables. I ran models for all single variables, all sets of two variables and then all sets of 3 variables within each level (within-field, field and landscape, Table A-2, Appendix A). Then, for parakeet damage, I ran multi-level models that contained the strongest predictors from each of the three levels. I used the within-field variable with the minimum AICc value as the base model for adding the best performance field and landscape variables in the multi-level models (Fletcher and Koford 2002; Renfrew and Ribic 2008). Multi-level models were not run for parakeet abundance because I was not able to clearly identify predictors within each level.

I developed models for corn and sunflower separately, to be confident that responses at field or landscape levels were not driven by response to field quality (i.e., crop type). These crops differ in within-field variables (e.g., plant height, plant density, weed density, Oscar Valentinuz, pers.com.). Additionally, I expected the use, and potentially damage, of crop fields to differ based on differential preferences for these crops (Aramburú y Bucher 1999). All models were evaluated using SAS PROC GENMOD and maximum likelihood estimation. I used Akaike Information Criteria adjusted for small sample size (AICc) for comparing model performance, and I restricted Δ AICc scores to ≤ 2 for model retention (Burham and Anderson 2002). For evaluating individual variable performance at each level, I used model averaging and the sum of plausible models in which a variable was present ($\Sigma\omega_i$, Burham & Anderson 2002).

Results

Monk Parakeet Abundance and Damage in Crop Fields

Monk parakeets differentially used crop fields based on the crop type. Monk parakeets were significantly more abundant in sunflower than in corn fields ($\bar{x}$ =9.29 monk parakeet/point/field, SE=1.52, and $\bar{x}$ =5.27, SE=1.61, respectively, Wilcoxon test= 549.50, p=0.007), and no statistically significant differences occurred in abundance within each crop type between years (Wilcoxon test=171.00, p=0.11 for corn; Wilcoxon test= 205.50, p=0.22 for sunflower). Monk parakeets were observed in 29 of the 30 fields with sunflower (0-38 parakeets observed per point per field), and in 14 of the 24 corn fields (0-33 monk parakeets observed per point per field).

Similar to abundance, monk parakeet damage differed according to the crop type. Damage was significantly higher in sunflower than in corn fields ($\bar{x}$ =4.29 % damaged plants, SE=0.88; $\bar{x}$ =0.90, SE=0.46, respectively, Wilcoxon test= 455.00, p<0.0001), and no statistically significant differences occurred in damage to each crop type between years (Wilcoxon test= 166.50, p=0.17 for corn; Wilcoxon test= 175.00, p=0.97 for sunflower). Damage by monk parakeets was observed on 29 of the 30 sampled fields with sunflower (0-20 % of the plants damaged), and in 12 of the 24 corn fields (0 – 11% of plants damaged). Monk parakeet abundance was strongly correlated with damage in corn fields (R=0.75, p< 0.001), but not in sunflower fields (R=0.49, p= 0.01).

Monk Parakeet Abundance and Damage in Crop Fields in Relation to Within-field, Field and Landscape Variables

I did not detect any association of within-field, field or landscape characteristics with abundance of monk parakeets in corn and sunflower fields. Top performing models included only one variable at all levels, and all variables produced models with similar AICc values (Δ AICc $\leq$ 2 between the minimum and the maximum value for all univariate models, Table 2-1). Additionally, all 95% confident intervals (CI) for coefficients for each of the predictor variables included zero, indicating these factors probably had no effect on monk parakeet damage in corn or sunflower fields (Table 2-1). Given the lack of explanatory power of all variables, I did not explore multi-level models with abundance data.

In contrast to abundance, parakeet damage to crop fields clearly was associated with within-field, field, and landscape characteristics. Most variables representing within-field and field characteristics were included in the top performing models at each level for either corn or sunflower (Table 2-2). Similarly, most landscape variables were included in the top performing models at each buffer extent (1, 3 and 5-km, Table 2). However, differences emerged in the way explanatory variables were related to parakeet damage on corn and sunflower fields at each level.

***Within-field and field level variables*.** Monk parakeet damage to corn and sunflower fields increased as weed coverage increased, and damage decreased as plant density increased (Table 2-2). Also, monk parakeet damage to corn fields decreased as phenological stage of corn advanced (Table 2-2). Plant density and phenological stage were the most important variables for explaining monk parakeet damage to sunflower and corn fields, respectively, while weed coverage was less important for both crop types (Table 2-3).

At the field level, monk parakeet damage to corn fields decreased as the field shape become more irregular or different from a regular square (i.e., shape index increased). Monk parakeet damage to sunflower fields declined as field area increased (Table 2-2), and damage to sunflower fields increased as tree abundance on the field perimeter increased (Table 2-2). Field shape was the most important variable explaining monk parakeet damage to corn fields, and field area and tree abundance were the most important variables explaining monk parakeet damage to sunflower fields (Table 2-3).

***Landscape level variables*.** Monk parakeet damage to corn fields was related positively to the percentage of landscape with trees and pastures and other agricultural uses (including weedy and fallow fields) around the field at multiple buffer extents (Table 2-2). Additionally, monk parakeet damage to corn fields increased where crops susceptible to damage (corn and sunflower) by monk parakeets were more aggregated on the landscape. In sunflower fields, the relationship between monk parakeet damage and aggregation of crops susceptible to damage was less clear (Table 2-2). Parakeet damage to sunflower fields increased as distance to the nearest site including man-made structures and trees declined (Table 2-2). For both crop types, the percentage of landscape with trees consistently had the lowest AICc value and was among the most important variables explaining monk parakeet damage to crop fields at multiple buffer extents (Table 2-3).

The damage of monk parakeets to crop fields was better explained by models including variables at landscape level than for models describing the field characteristics or conditions within the field. Based on AICc values, single-level models with variables within 1-km and 3-km buffers performed better than any other single-level models for corn and sunflower fields, respectively (Table 2-2). For corn fields, the single-level model with variables within 1-km buffer performed even better than the multi-level model in explaining monk parakeet damage to crop fields (Table 2-2). However, for sunflower fields, the multi-level model, including a landscape variable in addition to within-field and field variables, performed better than any of the single-level models (Table 2-2).

Discussion

Factors Related with Monk Parakeet Abundance and Damage to Crop Fields

Monk parakeet abundance and damage were greater in sunflower than in corn fields. Although abundance and damage were correlated, I could explain monk parakeet damage based on within-field, field and landscape variables but I could not explain monk parakeet abundance in fields based on any variable that I measured. Probably, because bird damage is cumulative in time and bird abundance is not (Hone 1994), bird damage data allowed me to better capture differences among fields in relation to within-field, field and landscape variables than abundance data. Additional statistical analyses that I conducted with abundance data using Classification and Regression Trees (CART) showed relationships similar to these reported here for damage data for some variables, such as an increase in monk parakeet abundance in sunflower fields as plant density decreased or percentage of landscape comprised of tree patches around the field increased. However, the performance of models in explaining monk parakeet abundance was generally poor, based on the low percentage of variance explained by models at each level (usually between 30 and 50%).

Landscape variables were more important than local variables in explaining monk parakeet damage to corn and sunflower fields. Particularly, the distance to nearest sites with trees and percentage of the landscape with tree patches around the crop fields were consistently important for explaining monk parakeet damage to corn or sunflower fields. The increase in damage in sunflower fields proximate to sites with man-made structures and trees, and in corn or sunflower fields surrounded by abundant trees, may reflect lower energetic costs for monk parakeets traveling short distances from the nest or loafing areas to foraging sites. This pattern may indicate the importance of landscape processes, such as landscape complementation, for a central-place forager such as the monk parakeet. Landscape complementation refers to the occurrence of habitat patches containing non-substitutable resources for a species in close proximity (i.e., food and nesting sites, Dunning *et al.* 1992). Consequently, species abundance in a particular patch would be larger if the patch is located in a landscape in which both habitats are relatively common or in close proximity, rather than in a landscape in which one habitat is rare or both habitats are far apart (Dunning *et al.* 1992). Considering monk parakeets use nests all year around, both for breeding and roosting, and they travel limited distances each day from the nest to foraging sites (Spreyer and Bucher 1998), the abundance and/or proximity of tree patches with potential nesting sites could influence population size of parakeets and, consequently, damage on particular plots within those landscapes. This result supports the finding of a study of red-winged blackbirds in which the availability of roosts and loafing areas in proximity to sunflower fields (2.4 km) was important for explaining differences on bird damage among fields (Hagy *et al.* 2008).

The availability of alternative foraging sites for monk parakeets within the landscape also was important for explaining monk parakeet damage to corn and sunflower fields. Crop damage was positively associated with the degree of aggregation of fields containing preferred food crops in the landscape and with the percentage of the landscape with pastures and other agricultural uses that could provide weed seeds and other foods. This pattern may indicate that parakeets are spending more time foraging in fields where other foraging sites are easily available, or that populations are larger in areas with alternative foraging sites. This result may indicate the importance of another landscape process, landscape supplementation, for monk parakeets. Landscape supplementation occurs when patches with substitutable resources occur in proximity in the landscape and, therefore, sustain a larger population than does a landscape in which these habitats are far apart (Dunning *et al.* 1992). Considering monk parakeets have a generalist foraging behavior (Bucher *et al.* 1991; Hyman and Pruett-Jones 1995), we would expect the availability of alternative foods on the landscape to allow potentially higher populations in the area and, consequently, higher damage in particular plots within that area. However, this result differs from studies of other bird pest species in which the availability of alternative foraging sites around crop fields was negatively related to bird use or damage on those fields (Amano *et al.* 2004, 2008; Hagy *et al.* 2008). The high preference of monk parakeet for sunflower and, at lesser extent, corn compared to other seeds (Aramburú and Bucher 1999; Canavelli, unpublished) may explain damage in these fields, even when alternative seeds were available in the landscape.

Although landscape characteristics around the crop fields were important for predicting monk parakeet damage to crop fields, local variables (within-field and field level) also were important. For corn fields, the characteristics of the landscape within 1 km of the field were more important than any local characteristic for explaining parakeet damage. However, phenological stage of crop plants and field shape also were important at local levels, with greater monk parakeet damage in immature and regularly shaped corn fields. For sunflower fields, local characteristics of the field, such as plant density and field area, were as important as landscape variables. Small sunflower fields, with low plant density and high percentage of the field border with trees were more prone to monk parakeet damage than other fields. These results support the need to consider landscape-level variables and local-level variables for predicting bird damage to crop fields (Tourenq *et al.* 2001; Amano *et al.* 2008; Hagy *et al.* 2008).

Differences on the degree of importance of local variables compared to landscape variables for corn and sunflower could be explained by differences in structural characteristics of each crop on the ground. Corn is known to have less vegetative and reproductive plasticity than sunflower under different levels of plant density (Oscar

Valentinuz, pers.com.). Consequently, small variations in plant density have lower influence on the structure of individual plants in corn compared to sunflower (Oscar Valentinuz, pers.com.). As a result, corn fields usually are characterized by a more homogenous stand of plants compared to sunflower fields (i.e., individual plants in corn usually are more similar among each other compared to sunflower plants). The high variation in fine scale structure of sunflower fields could provide the basis for patch selection by birds at finer scales and could help to explain the higher importance of local variables for sunflower fields compared to corn fields.

The use of multiple buffer extents have been shown to improve the detection of birds responses to landscape context (e.g., Cooper and Walters 2002; Renfrew and Ribic 2008; Boscolo and Metzger 2009). In this study, models at the buffer width of 1 km for corn fields and 1 and 3 km for sunflower fields had better performance than models at the buffer width of 5 km. Assuming these buffer extents reflect the scale of the foraging process under study, the results are consistent with reduced mobility and small home range of monk parakeets during nesting season (Bucher 1985, 1992b) and may indicate that daily distances of travel between nest and foraging sites are even shorter than originally proposed (i.e., between 3 and 5 km, Spreyer and Bucher 1998). Short distances of travel could be related to reproductive characteristics of monk parakeets, considering most crop fields were sampled at the end of the reproductive season (January) and variables related to potential places for nesting, such as the distance from the crop fields to the nearest site with man-made structures and trees and the percentage of the landscape occupied by tree patches, were among the most important factors explaining monk parakeet damage at all buffer extents. However, the importance of variables within 1-3 km buffers around fields also may be related to the feeding characteristics of parakeets because, given their generalist and omnivorous diet, they could easily shift among food items within a relatively small area (Boscolo and Metzger 2009).

Management Implications

Monk parakeet damage to corn and sunflower fields is an important concern for agricultural producers in some areas of Argentina (Bucher 1984, 1992a, b; Bruggers y Zaccagnini 1994; Bruggers *et al.* 1998). Although damage values in this study were relatively low (< 5 % of damaged plants, corresponding to less than 3% of grain loss, Canavelli *et al.* 2008), farmers perceive a problem exists, and sometimes apply short-term control methods, such as toxic baits and nest poisoning with pesticides (De Grazio and Besser 1975; Aramburú 1991; Bucher 1992a,b). However, these management measures have low success to decrease damage on specific crop fields (Bruggers *et al.* 1998; Spreyer and Bucher 1998; Rodriguez and Zaccagnini 1998) and potentially have severe consequences for non-target wildlife species (Zaccagnini 2006). For this reason, objections to these types of control have occurred in the past and are currently increasing, and new methods are needed (Bucher 1992a,b; Bruggers *et al.* 1998; Canavelli and Aramburu, *in press*). In order to better plan integrated management schemes for preventing and/or decreasing monk parakeet damage, wildlife managers need information on the underlying factors that promote the damage of monk parakeets on specific crop fields.

Crop type and landscape context are very important for explaining monk parakeet damage to corn and sunflower fields. Monk parakeet damage was significantly more frequent and higher in magnitude in sunflower than in corn fields. Therefore, farmers planning to plant sunflower should be more aware of monk parakeet damage and, consequently, plan management alternatives to decrease monk parakeet damage more carefully than farmers planting corn. Also, in order to prevent monk parakeet damage, crop fields should be located at least 1 km from places with man-made structures and trees ("cascos") and other patches with trees, which could be particularly difficult in some areas without cutting down the trees. Additionally, farmers planting sunflower fields could reduce damage by increasing field area. Both eliminating trees and increasing field area, and consequently decreasing the availability of alternative non-crop habitats, such as arborous or weedy edges, would result in a simplified landscape, which could have important negative consequences not only for biodiversity but also for the regulation of other crop pests (Bianchi *et al.* 2006; Power 2010; Batáry *et al.* 2011). Therefore, when the magnitude of damage justifies applying management measures, these alternatives should be considered with caution and evaluated in relation to other strategies, such as crop protection, in the context of a regional management strategy. Finally, farmers may consider increasing plant density as a measure to prevent monk parakeet damage. In this case, farmers also should consider the tradeoff of this agronomical practice and the limits on plant density recommended for each crop in the area, in order to avoid other problems such as smaller plants and/or yields. Alternative feeding areas or lure crops probably would not be successful in decreasing damage by monk parakeets in particular crop fields. However, this management alternative needs more evaluation, particularly with sunflower as the attractive crop.

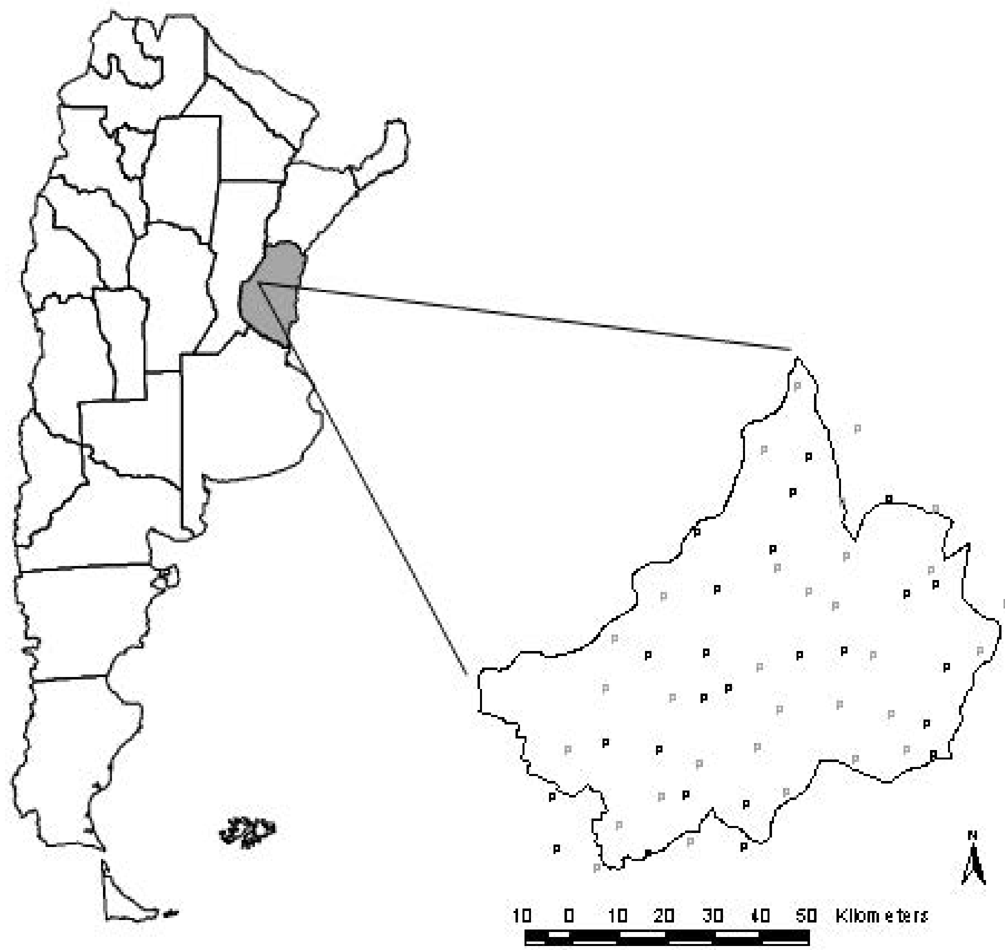

Figure 2-1. Map showing the location of Department of Paraná (Entre Ríos Province, Argentina) and the crop fields sampled in 2007 and 2008. Black dots indicate corn fields (n=25) and grey dots indicate sunflower fields (n=31).

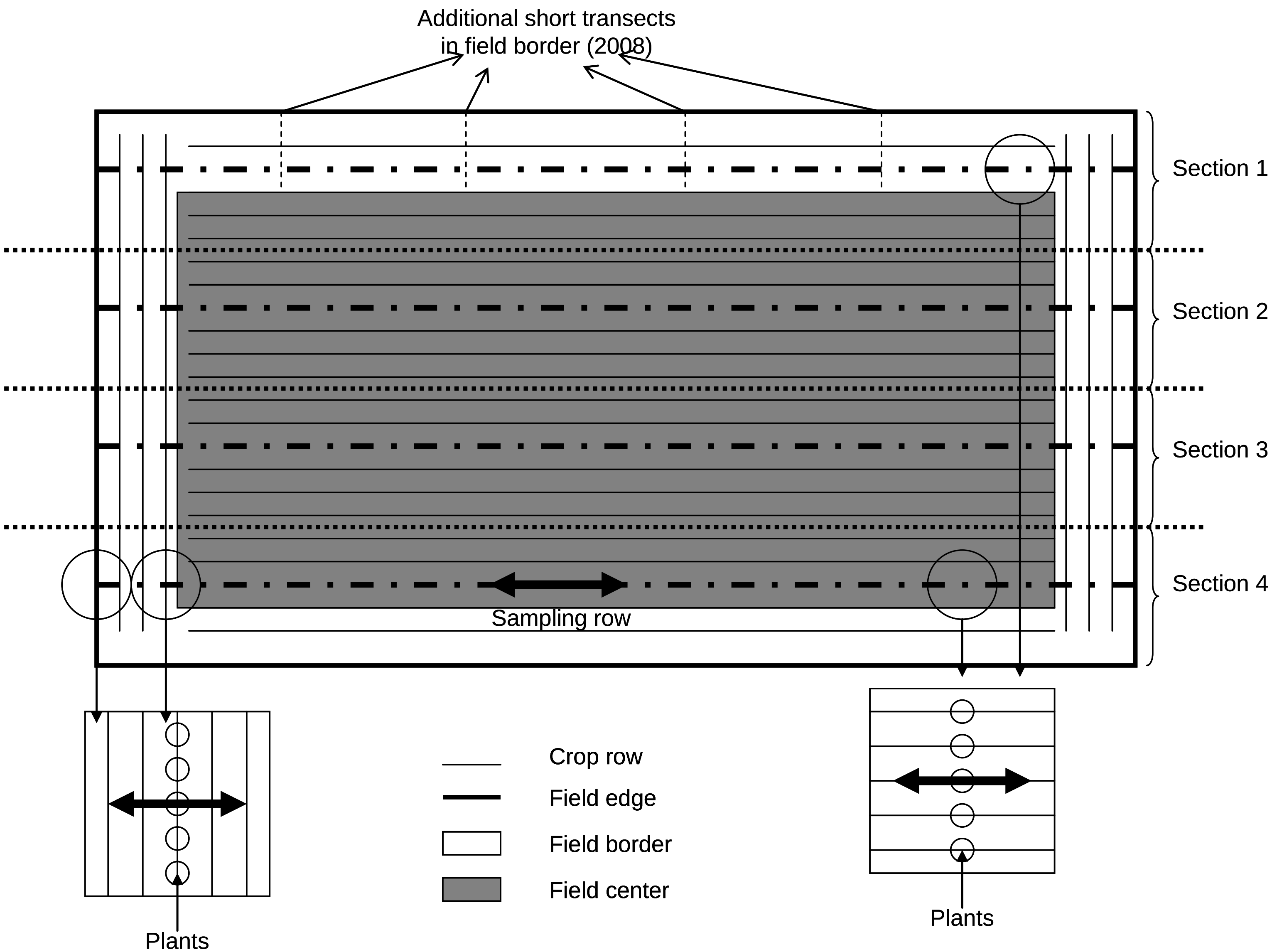

Figure 2-2. Sampling scheme for evaluating bird damage to crop fields.

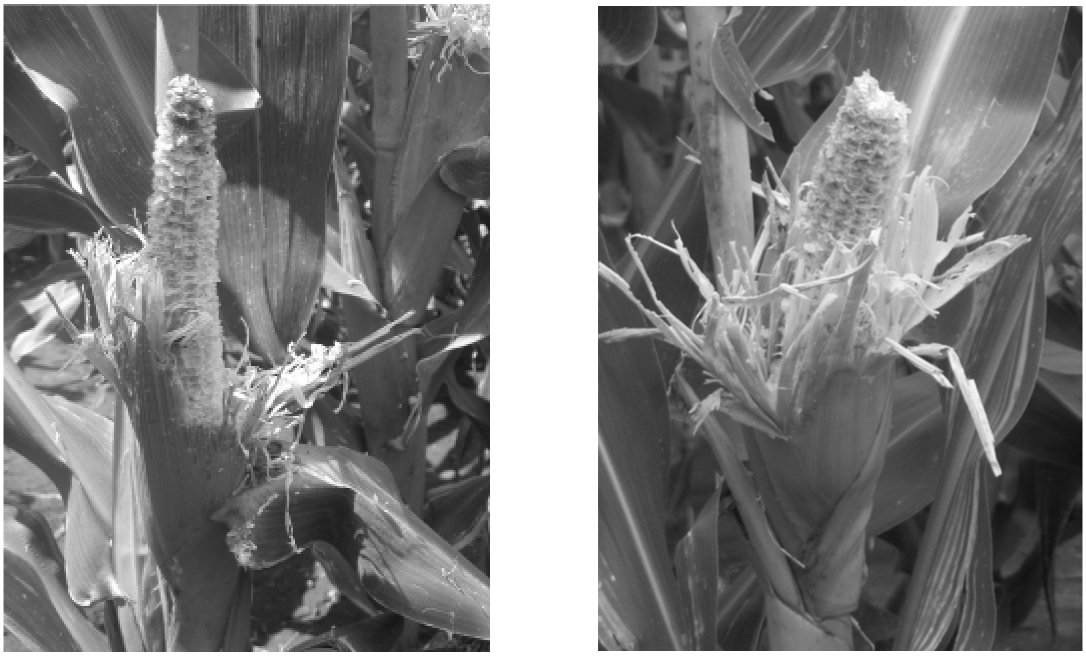

Figure 2-3. Monk parakeet damage to corn ears.

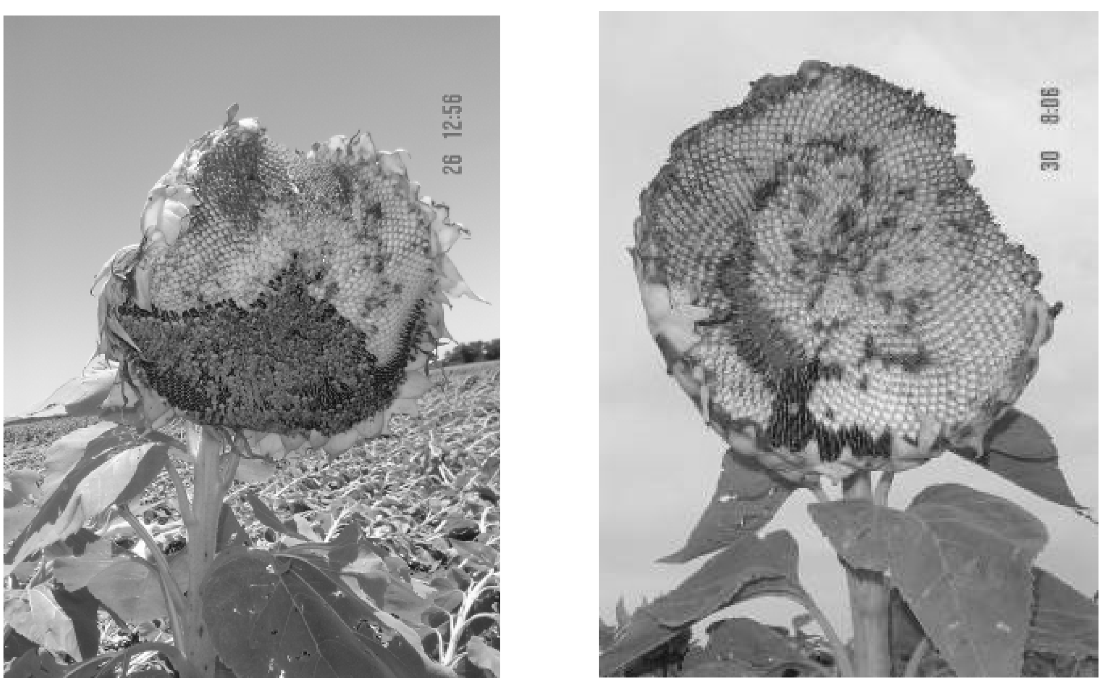

Figure 2-4. Monk parakeet damage to sunflower heads.

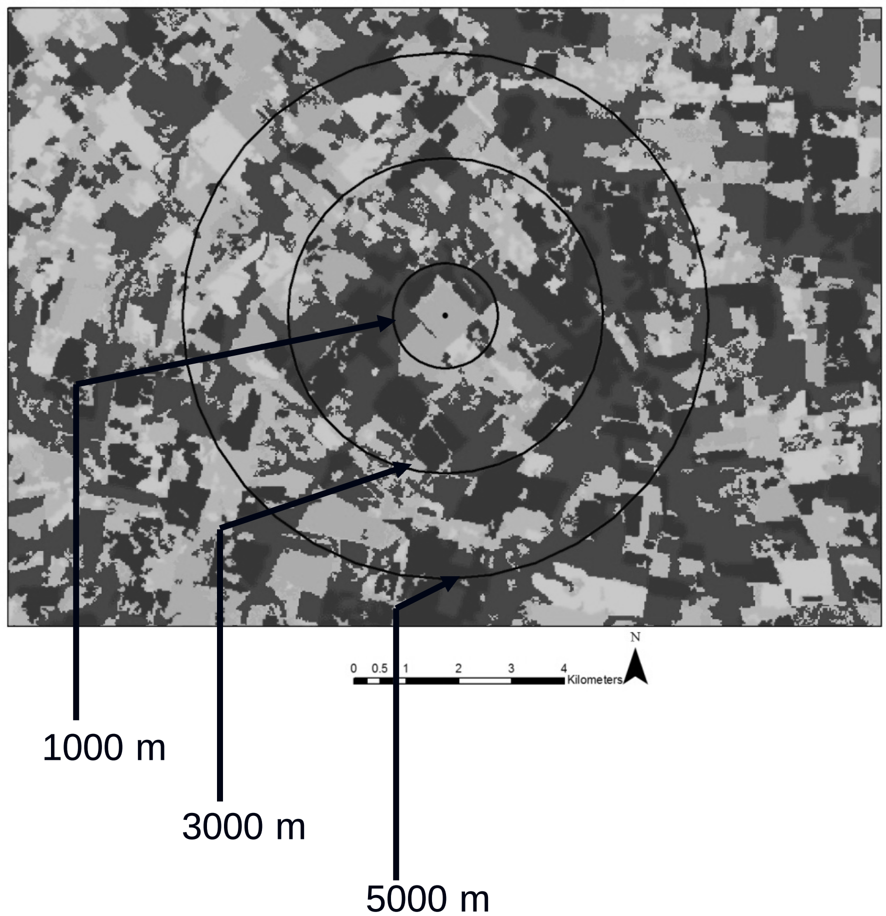

Figure 2-5. Buffer extents used for sampling landscape level variables from satellite images around each crop field (central point).

Table 2-1. Minimum AICc models and regression results for factors used in predicting monk parakeet abundance in crop fields in Paraná department (Entre Ríos, Argentina) in 2007 and 2008 summer seasons. All models are within ΔAICc ≤ 2 for each other. Multi-level models were not run because I could not clearly identify the most important variable within each level. Coefficients and associated standard errors for each predictor variable are derived from the univariate model and the Akaike weight (ω_i). In landscape models, numbers preceding the variable code indicate buffer sizes (in kilometers).

		Corn				Sunflower			
Spatial level	Variable[1]	AICc	Akaike weight (ω_i)	Coefficient	CI	AICc	Akaike weight (ω_i)	Coefficient	CI
Within-field	PLTDEN	25.27	0.27	0.15	0.60	35.63	0.27	-0.01	0.29
	PHENST	25.36	0.26	0.45	0.90	35.64	0.27	0.08	0.39
	WDCOV	25.36	0.26	0.96	2.06	35.65	0.27	0.43	1.27
Field	AREA	25.23	0.27	0.01	0.05	35.63	0.27	-0.003	0.02
	SHAPE	25.25	0.26	-1.79	2.08	35.63	0.26	-0.45	1.57
	TREES	25.33	0.25	0.62	1.47	35.66	0.26	0.05	0.40
Landscape -1 km	DISTCO	25.35	0.14	0.002	0.004	35.64	0.14	0.0002	0.002
	1CRPLAN	25.23	0.15	0.01	0.11	35.69	0.14	-0.02	0.03
	1CRCLUMP	25.24	0.15	1.94	5.73	35.66	0.14	1.21	3.87
	1TRPLAND	25.29	0.14	0.02	0.06	35.66	0.14	0.006	0.02
	1PSTPLAND	25.30	0.14	0.03	0.08	35.71	0.14	-0.02	0.04
Landscape -3 km	3CRPLAN	25.27	0.19	-0.03	0.13	35.81	0.17	-0.03	0.04
	3CRCLUMP	25.20	0.20	-3.40	7.67	35.58	0.19	0.90	3.35
	3TRPLAND	25.48	0.17	0.03	0.04	35.59	0.18	0.003	0.01
	3PSTPLAND	25.21	0.19	0.03	0.12	35.58	0.19	0.001	0.05
Landscape -5 km	5CRPLAN	25.26	0.19	-0.03	0.14	35.71	0.18	-0.02	0.04
	5CRCLUMP	25.13	0.20	-2.70	3.20	35.70	0.18	3.12	6.27
	5TRPLAND	25.53	0.16	0.03	0.04	35.64	0.18	0.002	0.01
	5PSTPLAND	25.24	0.19	0.16	0.06	35.64	0.18	0.01	0.05

[1] PLTDEN = Plant density, PHENST = Phenological stage, WDCOV = Weed coverage, AREA = Field area, SHAPE = Field shape index, TREES = Abundance of trees on border, DISTCO = Distance to the nearest site with man-made structures and trees, CRPLAND = Percentage of the landscape with crops susceptible to damage (corn and sunflower), CRCLUMP = Clumpiness index of crop patches susceptible to damage, TRPLAND = Percentage of the landscape with tree patches, PSTPLAND = Percentage of the landscape with pastures and other agricultural uses (including weedy and fallow fields).

Table 2-2. Minimum AICc models for monk parakeet damage to corn and sunflower fields in Entre Rios (Argentina) during 2007 and 2008 summer seasons. I used ΔAICc ≤ 2 for determining the subset of candidate models within each level. Models are ordered based on model performance within each level (lower AICc value indicating better model performance). Brackets indicate a negative relationship with bird abundance or damage. Variables are defined in Table 1. In landscape and multi-level models, numbers preceding the letters code indicate buffer sizes (in kilometers).

	Corn			Sunflower		
Spatial level	Model	AICc	Akaike weight (ω_i)	Model	AICc	Akaike weight (ω_i)
Within-field	(-PHENST)	63.90	0.24	(- PLTDEN) + WDCOV	306.40	0.46
	(-PHENST) + WDCOV	64.17	0.21	(- PLTDEN)	307.10	0.32
	(-PHENST) + (- PLTDEN)	64.26	0.20			
	(-PHENST) + (- PLTDEN)+ WDCOV	64.71	0.16			
	(- PLTDEN)+ WDCOV	65.85	0.09			
	(- PLTDEN)	65.88	0.09			
Field	(-SHAPE)	63.37	0.62	(-AREA)	315.59	0.63
				TREES	317.14	0.29
Landscape – 1 km	1TRPLAND + 1PSTPLAND +1CRCLUMP	22.70	0.91	(-DISTCO) + 1TRPLAND	281.48	0.44
				(-DISTCO) + 1TRPLAND + 1CRCLUMP	282.84	0.22
Landscape – 3 km	3TRPLAND + 3PSTPLAND + 3CRCLUMP	35.40	0.41	3TRPLAND + 3PSTPLAND	276.68	0.77
	3TRPLAND + 3CRCLUMP	35.95	0.31			
	3TRPLAND + 3PSTPLAND	36.47	0.24			
Landscape – 5 km	5TRPLAND + 5PSTPLAND + 5CRCLUMP	42.49	0.60	5TRPLAND + 5PSTPLAND	287.12	0.62
	5TRPLAND + 5PSTPLAND	43.79	0.31	5TRPLAND + 5PSTPLAND + (-5CRCLUMP)	288.13	0.38
Multi-level	(-PHENST) + (-SHAPE) + 1TRPLAND	38.93	0.96	(- PLTDEN) + (-AREA) + 1TRPLAND	249.34	0.99

Table 2-3. Regression results for factors considered in predicting monk parakeet damage to crop fields in Paraná department (Entre Ríos, Argentina) in 2007 and 2008 summer seasons. Coefficients and associated standard errors for each predictor variable are derived from multimodel inferences using all parameter subsets and Akaike weights (ω_i) at each level. $\Sigma\omega_i$ for each predictor variable shows the sums of Akaike weights for all possible models in which the predictor variable was incorporated at each level. The larger the Σωi, the more important a variable is relative to other variables.

		Corn				Sunflower			
Spatial level	Variable	AICc	Coefficient	CI	$\Sigma\omega_i$	AICc	Coefficient	CI	$\Sigma\omega_i$
Within-field	PLTDEN	65.88	-0.17	0.18	0.54	307.10	-0.27	0.10*	1.00
	PHENST	63.90	-0.51	0.40*	0.81	333.23	0.005	0.03	0.22
	WDCOV	69.52	0.27	0.31	0.47	331.50	0.17	0.19	0.44
Field	AREA	71.63	<0.001	<0.001	0.05	320.72	-0.01	0.008*	1.00
	SHAPE	63.37	-3.14	2.70*	0.83	328.79	0.11	0.20	0.32
	TREES	71.63	-0.008	0.09	0.18	329.86	0.17	0.12*	0.93
Landscape -1 km	DISTCO	70.40	<0.001	<0.001	0.01	326.83	(-) <0.001	<0.001*	0.66
	1CRPLAN	69.97	<0.001	<0.001	0.00	324.64	<0.001	<0.001	0.00
	1CRCLUMP	55.10	13.77	11.58*	0.97	325.50	0.27	0.51	0.31
	1TRPLAND	33.79	0.06	0.03*	1.00	283.58	0.02	0.006*	1.00
	1PSTPLAND	69.66	0.06	0.04*	0.93	325.90	-0.002	0.002	0.17
Landscape -3 km	3CRPLAN	48.54	-0.001	<0.001*	0.01	308.59	(-) <0.001	<0.001	0.00
	3CRCLUMP	56.13	9.73	9.89	0.73	304.19	-0.18	0.64	0.22
	3TRPLAND	40.72	0.05	0.02*	0.99	334.17	0.02	0.006*	1.00
	3PSTPLAND	71.66	0.06	0.06	0.65	323.65	0.04	0.01*	1.00
Landscape -5 km	5CRPLAN	52.31	-0.02	0.01*	0.07	319.06	(-) <0.001	<0.001*	0.00
	5CRCLUMP	70.83	12.61	15.58	0.64	332.13	-0.63	0.92	0.38
	5TRPLAND	51.24	0.06	0.02*	0.93	317.25	0.02	0.006*	1.00
	5PSTPLAND	71.59	0.14	0.08*	0.98	320.16	0.05	0.02*	1.00

[*] 95% confidence intervals for multimodel weighted coefficients for each of the predictor variables not including zero (i.e., these factors probably affected monk parakeet damage to corn or sunflower fields).

CHAPTER 3
DENSITY OF MONK PARAKEET NESTS IN SITES WITH EUCALYPTUS IN RELATION TO LOCAL AND LANDSCAPE VARIABLES

Background

The selection of nesting sites by birds is one of the most critical processes involved in species persistence, because of its direct influence on reproductive success and population growth (Walsberg 1981; Li y Martin 1991; White *et al.* 2006). Similar to other habitat selection processes, selection of nesting sites involves a hierarchy of decisions at multiple scales (Hildén 1965; Johnson 1980; Cody 1985; Wiens *et al.* 1987). Landscape characteristics may influence initial settlement in a site or patch (area of contiguous cover different from its surroundings, Forman and Godron 1986), and local characteristics of the site, such as vegetation structure, influence selection of a particular place for the nest (Hildén 1965; Bailey and Thompson 2007).

Multi-level studies, in which researchers evaluate the influence of local and landscape variables on animal abundance and distribution in particular patches (i.e., "focal patches", Brennan *et al.* 2002), have been used for understanding factors influencing nest site selection by birds (Donázar *et al.* 1993; Soh *et al.* 2002; Martinez *et al.* 2003; Bailey and Thompson 2007). Multi-level studies are common in landscape ecology and conservation biology (see reviews in Mazerolle and Villard 1999 and Thorton *et al.* 2010). Also, multi-level studies have been proposed as a very helpful tool for integrating multiple scales of observation about the behavior of birds involved in human-wildlife conflicts and designing management strategies (Clergeau 1995; Soh *et al.* 2002).

In this study, I applied a multi-level approach for analyzing local and landscape factors influencing density of monk parakeet nests in sites with eucalyptus trees in east central Argentina. The monk parakeet (*Myiopsitta monachus*) is a parrot species commonly involved in human-wildlife conflicts in its native range (South America) and non-native areas of distribution (North America and Europe, Spreyer and Bucher 1998). In Argentina and Uruguay, the monk parakeet is among the most important bird pest species causing damage to grain crops (Bucher and Bedano 1976; Bucher 1984, 1992a, b; Bruggers y Zaccagnini 1994; Bruggers *et al.* 1998). This species also causes damage in other settings (e.g., fruit crops and electric utility structures, Bucher 1992a; Bucher and Martin 1987). In North America and Europe, the monk parakeet primarily causes problems in urban settings related to location of nests, including damage to electric utility structures that lead to power outages (Avery *et al.* 2002) and disturbance to tranquility of human neighborhoods, due to the noise parakeets produce (Santos 2005; Burger and Gochfeld 2009). Currently, the monk parakeet is not a threat to agriculture production or native biota in non-native areas, but if its populations continue to expand, this species could cause more problems in the future (Sol *et al.* 1997; Domenech *et al.* 2003). Understanding habitat features influencing the selection of nesting sites by monk parakeets is important for managing conflicts with this species in its native and non-native areas of distribution.

Most studies on nesting habitats for monk parakeet have focused on describing substrates selected for nesting and characteristics of nests (Humphrey and Peterson 1978; Sol *et al.* 1997; Burger and Gochfeld 2000, 2005, 2009). Suitable nesting sites for monk parakeets are varied because, unlike other parrots, the monk parakeet does not nest in cavities but rather constructs nests with sticks on tall natural and artificial structures (Forshaw 1989; Spreyer and Bucher 1998). Natural structures include savanna trees (e.g., *Prosopis* sp. and *Acacia* sp.), willow (*Salix* sp.), palms (e.g. *Phoenix* sp.), and eucalyptus (*Eucalyptus* sp.), among others (Sol *et al.* 1997; Spreyer and Bucher 1998; Gochfer and Burger 2000, 2005, 2009). Artificial structures for nesting include silos, fire escapes, windmills, and utility poles (Spreyer and Bucher 1998).

In spite of the extensive information about the characteristics of substrates selected for nest placement, almost no information is available about the influence of local and landscape habitat features on the abundance of monk parakeet nests in a specific site or patch in its native range (but see Cavallero 2010). In Spain, selection of nesting patches by monk parakeets was explained by micro-habitat variables, particularly the type and height of the trees, and macro-habitat variables, such as abundance of palm trees, a preferred nesting substrate in that area (Sol *et al.* 1997). In the Pantanal of Brazil, selection of nesting patches with colonies of monk parakeets was influenced for pre-existing nests of jabiru stork (*Jabiru mycteria*) and the availability of large trees, usually planted in proximity to farm houses (Burger and Gochfeld 2005). In Argentina, the only study that has examined local and landscape variables that influence the abundance of monk parakeet nests was done in patches with native savanna trees, such as *Prosopis* sp. and *Acacia* sp. (Cavallero 2010). In that study, the relationships between abundance of monk parakeet nests and habitat characteristics of patches were found to be weak at both local and landscape levels, though local characteristics, such as tree density and cover, were slightly more important than landscape characteristics (Cavallero 2010).

In Argentina, monk parakeets apparently prefer introduced eucalyptus trees for nesting because they are taller than the surrounding native trees, which could reduce the incidence of nest failure from predation, particularly from humans (Humphrey and Peterson 1978; Navarro *et al.* 1992). In agricultural landscapes throughout central Argentina, eucalyptus trees are usually planted around man-made structures (e.g., houses and barns) for shade and windbreaks. These areas of human habitation with eucalyptus trees are predominantly common as nesting areas for monk parakeets in this highly modified landscape (Spreyer and Bucher 1998). Additionally, these areas of human habitation with eucalyptus trees are sites where monk parakeets potentially are subject to control measures. Therefore, I focused this study on these types of sites (referred to as farms hereafter). I hypothesized that the density of monk parakeet nests in a site would be related to two factors in the patch: 1) eucalyptus trees, specifically abundance and height of these trees, and 2) whether control measures for parakeets were applied in the patch. I also expected characteristics of landscape around the patch, such as the abundance of nesting and foraging habitats, to influence the density of monk parakeet nests in the patch. However, based on other studies of nests in native habitat, I expected landscape characteristics to be less important than local characteristics for explaining density of monk parakeet nests in the patch.

Methods

Study Area

The study was conducted in a 525,000-ha area comprising the Department of Paraná (Entre Ríos Province, Argentina). The area is characterized by diverse production activities, with predominance of crops, beef cattle, and milk production (Engler and Vicente 2009). Agricultural crops cover about 49% of the area, including in order of importance soybeans, wheat, corn, sunflower and sorghum (Engler and Vicente 2009). Mean annual temperature is 19ºC (12ºC in winter and 25ºC in summer) and mean rainfall is approximately 1000 mm.

A gradient in production activities, and therefore landscape pattern, occurs in the study area from north-east to south-west. The north-east mostly is devoted to a mixture of crops and cattle production, with high interspersion of woodlands, pastures and crops. The south-west is intensively agricultural, with a few patches of woodland interspersed with large plots of annual crops.

Sampling Scheme

I used a Geographic Information System (ArcGIS v.9.2) to place a 10x10-km grid over the Paraná Department and identified the most proximate site with eucalyptus trees to the center point in each grid. This site constituted the first sampling patch in each grid cell. A patch was defined as an area of at least 900 m^2 (30x30 m) including eucalyptus trees clearly differentiated from its surroundings and located at least 30 m from another patch. A second patch was selected in the field at least 2000 m from the previous sampling site, which represents the estimated maximum distance for dispersal by monk parakeets (Spreyer and Bucher 1998), to assure independence of birds among nesting sites. When eucalyptus trees were seen on the horizon from the first sampling patch, they were used as a reference for searching for the second sampling patch. Otherwise, the second sample was located by following available routes around the central point in the grid cell. Between September and December 2008, I identified 62 sites with eucalyptus trees around occupied human habitations and other man-made structures (e.g., barns, water tanks). I used these 62 sites for this study.

Nest Abundance Surveys

Monk parakeets build communal nests, comprising many nests in one nest structure, usually grouped in colonies with many nest structures in one area (Forshaw 1989; Bucher *et al.* 1991; Eberhard 1998; Burger and Gochfeld 2005, 2009). For the purpose of this study, a nest was defined as a distinct and compact collection of twigs with one or more nest cavities or chambers. Nest size as well as distance between nests in a colony is highly variable. For example, nest size can range between < 0.80 m to > 1.5 m in diameter (Spreyer and Bucher 1998), and distance to the nearest nest can range from 8.54 to 60.20 m (Burger and Gochfeld 2000). However, because nests are very compact, separate nests are easy to distinguish (Forshaw 1989; Spreyer and Bucher 1998; Burger and Gochfeld. 2009). Additionally, nests usually are placed on the uppermost branches of tree (Forshaw 1989; Eberhard 1998; Spreyer and Bucher 1998- although see Burger and Gochfeld 2005), which makes them easy to detect from the ground. All nests in a patch were considered part of the same colony.

Two observers systematically surveyed each patch by walking along lines with eucalyptus trees, one to each side of the tree line, counting all parakeet nests seen in the trees. When isolated trees were found, the tree was circled and all nests observed in the tree were recorded. Nests in introduced tree species other than eucalyptus (2 cases) and human-made structures (1 case) only were observed on abandoned farms, and therefore were not included in the study. In addition to the number of nests, the number of nest cavities or chambers per nest also was recorded. However, because of the difficulties of accurately determining the number of nest cavities in each nest from the ground, and the high correlation between abundance of nests and nest cavities in nesting patches (r=0.92), I considered only the abundance of nests in this study.

Local-Level Variables

Local data for each farm included three measures of eucalyptus trees: 1) height of trees, taken as the mean of the tallest and shortest tree in the patch, 2) canopy area, and 3) proportion of the patch area occupied by eucalyptus canopy. Canopy area was estimated by projecting the outer edge of the canopy to the ground and then measuring the area of the polygon delimited by the outer edge in the field (Hays *et al.* 1981). In the case of individual eucalyptus trees, the canopy diameter was measured with a measuring tape and the area of the polygon was estimated based on a circle area. When eucalyptus trees were in a line, the area of the polygon was estimated by measuring the length and width of the polygon with a tape and assuming the polygon was a rectangle. Additionally, I recorded presence/absence of control measures applied in the site against monk parakeets and the type of control being applied by interviewing the landowner. Finally, I recorded the geographic coordinates of patch borders in the field.

Once in the lab, all patches were digitized using Google Earth and the geographic coordinates of patch borders. Polygons were then converted to a vector file and imported in ArcGIS (v 9.2) and the patch area was estimated using Patch Analyst extension for ArcGIS (Rempel 2010). Because substantial correlation (r=0.70) occurred between patch area and canopy area of eucalyptus in the patch and only uncorrelated metrics were included in the same statistical model, I used canopy area of eucalyptus for modeling purposes (Statistical analysis), based on its significance as a nesting substrate for monk parakeets.

Landscape-Scale Variables

I evaluated landscape context around each nesting patch within circular buffers of 3 extents (1000, 2000 and 3000 m) from the center of each patch (Figure 3-1). The upper buffer limit of 3000 m was greater than the documented maximum dispersal distance for monk parakeets (2000 m, Speyer and Bucher 1998). In some cases, 3-km buffers of contiguous nesting patches exhibited > 50% overlap and, in these cases, I selected one of the patches for statistical analysis based on its proximity to the central point on the original 10x10 grid. I did not use buffers smaller than 1000 m because of problems with artificial borders and estimation of landscape indices.

Buffers for nesting patches were obtained from a Landsat TM image classified by Noelia Calamari (INTA, EEA Paraná). The Landsat image was classified using supervised classification with ECHO (Extraction and Classification of Homogeneous Objects) in MultiSpect Application v3.1 (2007). Ten land cover types were identified: water, corn, sunflower, soybeans, sorghum, pastures and other agricultural uses (e.g., fallow and weedy fields), built-up areas, plowed and some fallow fields, which could not be clearly distinguished, introduced trees, native trees, and riparian vegetation. Results from the classification were validated with 100 points per land cover type randomly selected using Quickbird images (available in GoogleEarthTM, http://earth.google.com) and ground sampling. Overall classification accuracy was 82 % (range for cover types: 54% for corn and 96% for water). Finally, to clearly distinguish among different land cover types and decrease the problem of artificial borders with raster images, I re-grouped the land cover types into 7 classes: water, preferred food crops for monk parakeets (corn and sunflower), un-used crops (soybean and sorghum, immature at the time the image was obtained), pastures and other agricultural uses (e.g. fallow and weedy fields), built-up areas, plowed and fallow fields, and tree patches including predominantly native and, at much lesser extent, introduced trees. In this analysis, I used only availability of three land cover classes: 1) preferred food crops (corn and sunflower), 2) tree patches (all patches on the landscape with native or introduced trees), potentially used as primary sites for perching, nesting or daily loafing, and 3) pastures and other agricultural uses (e.g., fallow and weedy fields), which can include food items for monk parakeets such as flowers and seeds.

I used FRAGSTATS 3.3 software (McGarigal *et al.* 2002) to calculate landscape metrics representing landscape composition and configuration. Composition metrics included percentage of landscape with corn and sunflower, other agricultural uses (including pastures, fallow and weedy fields), and tree patches. Configuration metrics were estimated for tree patches and included patch density, edge density for tree/non-tree patches, mean nearest-neighbor distance among tree patches, and aggregation of tree patches (measured with a clumpiness index). Shape complexity was measured using a shape index, estimated as the patch perimeter (m) divided by the square root of patch area (m^2), adjusted by a constant to adjust for a circular standard (McGarigal *et al.* 2002). Substantial correlations ($r \geq 0.60$, independently of the p-value) were found among some landscape metrics, particularly at higher extents (2000 and 3000 m, Table A-3, Appendix A) and only uncorrelated metrics ($r < 0.60$) were included in the same statistical model. Because patch density was the only configuration metric representing fragmentation of tree patches that was uncorrelated with percentage of landscape with trees, and percentage of landscape with trees could be important for explaining bird abundance at a site (Fahrig 2001, 2003; Renfrew and Ribic 2008; Hagy *et al.* 2008), I only included patch density as a configuration metric in statistical models. Percentage of landscape with pastures and other agricultural uses was negatively correlated with percentage of landscape with tree patches, particularly at higher extents (2000 and 3000 m, Table A-3, Appendix A). Because tree patches represent alternative nesting sites and pastures and other agricultural uses represent potential foraging sites, I retained both variables but included only one of them at a time for model construction.

Statistical Analyses

I modeled density of monk parakeet nests in nesting patch as a function of local and landscape variables at each buffer extent (1000, 2000 and 3000 m). Additionally, I constructed a set of models combining local and landscape variables. The response variable (density of monk parakeet nests) was examined for deviation from normality and transformed to the decimal logarithm to meet normality and improve linearity (Infostat, Di Rienzo *et al*. 2010; SAS v. 8.0, SAS Institute Inc., 2006). Data from one nesting patch was consistently outside the distribution range of values for all independent variables and was eliminated from the pool of data, as well as five patches with missing values for at least one variable at the local level. Additionally, twenty patches were eliminated for the landscape analysis, because of overlapping buffers. Therefore, final sample size for modeling purposes was 35 nesting patches, though descriptive statistics are presented for all patches (Table 3-1).

All models were developed using a generalized linear model framework (GLM) with a normal error structure. Because final sample size for model construction was relatively small (n=35), each model was restricted to include between one and three variables. I ran models for all single variables, all sets of two variables and then all sets of 3 variables within each level (local and landscape). Then, I ran multi-level models that contained the strongest predictor from local and landscape levels. For multi-level models, I used the local variable with the minimum AICc value as the base model and then added the landscape variable with the best performance at each buffer extent (Fletcher and Koford 2002, Renfrew and Ribic 2008).

All models were evaluated using SAS PROC GENMOD and maximum likelihood estimation. I used Akaike Information Criteria adjusted for small sample size (AICc) for comparing model performance, and I restricted Δ AICc scores to ≤ 4 for model retention (Burham and Anderson 2002). For evaluating individual variable performance at each level, I used model averaging and the sum of plausible models in which a variable was present ($\Sigma\omega_i$, Burham & Anderson 2002).

Results

Density of Parakeet Nests and Characteristics of Nest Patches and Landscapes

Most surveyed patches (85%) had monk parakeet nests in the eucalyptus trees. However, density of nests among patches varied widely (range: 1-222 nests/ha, mean= 27 nests/ha ± 5.56 SE). Area covered by canopy of eucalyptus trees in a patch generally was small (< 1 ha), occupying on average about a quarter of the patch area (Table 3-1). Mean height of eucalyptus trees was relatively uniform among patches (CV= 19%, Table 3-1). At most sites (63%), people had not applied control measures against monk parakeets in the last 2 years. At patches where control measures occurred (n=23), most people applied lethal control by shooting, either as the only control measure (52%) or combined with removing (9%) or burning (17%) nests. Non-lethal measures included removing nests (4%), burning nests (9%), or capturing nestlings alive for pet trade (9%). Trees occupied on average a quarter of the landscapes surrounding nest patches, although a wide range of variation was observed (Table 3-1). Preferred food crops for monk parakeets (corn and sunflower) and pastures and other agricultural uses were less abundant, although these habitats together could occupy more than a quarter of the landscape (Table 3-1).

Density of Monk Parakeet Nests in Relation to Local and Landscape Variables

All local variables were included in the top performing model explaining density of monk parakeet nests at specific patches (Table 3-2, local level). The density of nests was positively related to area of eucalyptus canopy, proportion of the patch area covered by eucalyptus canopy, height of the trees, and presence of control measures for monk parakeets (Table 3-2). In the latter case, landowners were more likely to control parakeets when they were very abundant. However, the proportion of patch area with canopy of eucalyptus trees was the only important variable for explaining density of monk parakeet nests at this level as indicated by the 95% confidence intervals for multimodel weighted coefficients for the predictor variables (Table 3-3).

Similarly, all landscape variables were included in the top performing model explaining density of monk parakeet nests at specific patches (Table 3-2, landscape level at 1km, 2km and 3km). Density of nests usually increased as the percentage of the landscape with trees increased, density of tree patches in the landscape decreased (i.e., patches were more dispersed), percentage of the landscape with preferred food crops increased, and percentage of landscape with pastures and other agricultural uses decreased (Table 3-2 and 3-3). At landscape level, the percentage of landscape with trees was the most important variable for predicting density of monk parakeet nests at all spatial extents (Table 3-3).

Models generally had poor performance, with no model clearly the best for explaining variation in nest density among nesting patches at any level (Table 3-2). Models at single level that included the proportion of patch area with eucalyptus or the percentage of landscape with trees 1 km around the nesting patch had the lowest AICc values (Table 3-2). The best multilevel models at all spatial extents included these two variables and had lower AICc values than landscape level models, but not than local level models (Table 3-2). However, the degree of uncertainty about a best model for explaining density of monk parakeet nests in farms with eucalyptus was high, because none of these models had a model weight greater than 0.36 (Table 3-2).

Discussion

Factors Related with Density of Monk Parakeet Nests

The density of monk parakeet nests in inhabited farms with eucalyptus trees was not clearly explained by any variable or combination of variables evaluated in this study, either at local or landscape level. Although all variables were involved in the subset of top performing models, models performed poorly in explaining density of monk parakeet nests. These results are similar to results of a previous study conducted in the same region (Paraná department and surroundings, Entre Ríos, Argentina), in which the abundance of monk parakeet nests in patches with native trees was weakly related to local and landscape variables within 2.5 km of the nesting patch (Cavallero 2010). However, as in that study, some variables emerged as slightly more important at each level in this study, with local variables being comparatively more important than landscape variables.

The proportion of the patch area covered by eucalyptus canopy was the most important variable at the local level explaining abundance of nests. Additionally, this local variable had a better performance than any other variable at landscape scale (lower AICc value). The canopy area of eucalyptus trees likely is an indicator of the availability of nesting sites for monk parakeets in a patch. Because monk parakeets are colonial birds (Spreyer and Bucher 1998) and they prefer eucalyptus trees for nesting (Bucher and Martin 1987; Navarro *et al.* 1992), nest density would be expected to increase as the proportion of the patch occupied by eucalyptus increased.

At landscape level, the importance of percentage of landscape with trees around nesting patches in explaining the density of parakeet nests compared to other variables could be related to a variety of factors. For example, as the percentage of landscape with native tree patches increases, the abundance of monk parakeets may increase because of the large amount of nesting habitat or because patches of native trees contain some other resource that increases parakeet abundance (e.g., food). A relationship between the abundance of nests in nesting patches and the abundance of trees around the patches, particularly preferred trees for nesting, also was found in previous studies with monk parakeets, both in its native and non-native areas (Sol *et al.* 1997; Cavallero 2010).

The poor performance of local and landscape variables in explaining density of monk parakeet nests also could be related to several factors. Some important variables may not have been measured or the way the variables were measured may not have been optimal for capturing the influence of those variables. For example, the type and structure of eucalyptus trees in each nesting patch, which I did not measure, may explain differences in density of monk parakeet nests among patches. Tree type and structure have been found to be important in explaining monk parakeet selection of tree species for nesting (Sol *et al.* 1997; Burger and Gochfeld 2005, 2009). Although all parakeet nests in this study were in eucalyptus trees, both personal observations and a previous work (Volpe and Aramburú 2010) indicate that nests are usually placed in eucalyptus trees with stout trunks and open crowns that offered large and robust surfaces for nest construction. All these are characteristics of red eucalyptus (*Eucalyptus camaldulensis* or *E.tereticornis* , Duke 1983), the predominant type of eucalyptus tree I observed in the farms. However, other species of Eucalyptus trees frequently were available, including white eucalyptus, such as *E.grandis or E. duniis,* and *E.cinerea*. The structure of the eucalyptus trees also may be more influenced by the arrangement and management of trees (isolated trees, trees in a line, or trees in small groups) than by the tree species (D.Diaz, pers.com.).

Another issue may be that buffer extents used in this study were not large enough to capture habitat features related to nest settlement, such as availability of foraging sites. I used the maximum dispersal distance to define the largest buffer extent, but monk parakeets are known to travel up to 8 km for daily foraging when breeding and 24 km when not breeding (Hyman and Pruett-Jones 1995; Spreyer and Bucher 1998). Also, other landscape cover types, such as urban habitats, could be important for monk parakeets, but no data are available regarding this.

Alternatively, factors related to the behavior of monk parakeets could influence nest density more than habitat variables at local and landscape levels. Monk parakeets select a nesting site for the first nest, and then they continue adding nests to the colony, building new nest chambers in the same nest or new nests in the proximity of the previous nest (Sol *et al.* 1997; Burger y Gochfeld 2000). For colonial and philopatric birds, such as monk parakeets, the influence of landscape scale variables in nest site selectivity could be expected to be lower than for birds with no natal philopatry and high rate of colonization of new nest locations (Katie Sieving, pers.com.). Therefore, nest density may be related to differences in time of colonization of specific patches instead of differences in habitat characteristics of the patches (Cavallero 2010). If this is case, the number or density of nests in nesting patch would be more dependent on the time the first nest appeared (longer ago, more nests) than to the characteristics of the patch. However, if the best nest sites are chosen first, colony age and habitat quality could be linked. No information is available to elucidate this issue.

The generalist foraging behavior of monk parakeets (Freeland 1973; Bucher *et al.* 1991; Hyman and Pruett-Jones 1995; Spreyer and Bucher 1998), plus the abundance of food in the area from crops and other agricultural uses as well as weedy fields, may explain why the percentage of landscape with preferred food crops, pastures and other agricultural uses contributed little to explaining density of monk parakeet nests. Density of monk parakeet nests in parks in Spain was higher in parks offering more plants for foraging, but the relationship between nest density and food plants was weak and less important than the abundance of nesting sites (Sol *et al.* 1997). Also, the abundance of monk parakeet nests in patches with native trees in Entre Ríos was more strongly related to the abundance of preferred nesting sites than foraging sites around the nesting patches (Cavallero 2010).

Predation is a factor that has been proposed as influencing selection of nesting sites by monk parakeets, because predation of eggs and chicks in nests could be an important cause of mortality at nests (Navarro *et al.* 1992; Sol *et al.* 1997; Burger and

Gochfeld 2005, 2009; Spreyer and Bucher 1998). In this study, all nests were in eucalyptus trees around farm houses and man-made structures inhabited by people, where the abundance of predators of monk parakeet nests is probably low (Burgess and Gochfeld 2009), but human disturbance may have influenced nest density in ways that we did not detected. Presence or absence of human control was not important for explaining density of monk parakeet nests in nesting patches, implying that control measures were not effective in decreasing density of monk parakeet nests. In fact, the relationship between control and density of parakeet nests was positive rather than negative. However, a few farmers in sites with nest density equal to zero indicated that they destroyed all parakeet nests and killed or harassed the monk parakeets, and did not let them return again. If control measures had been recorded in a way that measured efficacy, rather than presence/absence of control, this variable may have contributed more to explaining nest density.

Management Implications

The number of monk parakeet nests in a farm could be reduced by limiting the available nest sites by removing eucalyptus trees. Potentially, trees with lower height and poor structure to hold nests, such as native trees of genus *Acacia* or *Prosopis*, could be used to replace some benefits of eucalyptus (e.g., shade and wind break) without providing attractive nesting sites for monk parakeets. The replacement of introduced eucalyptus trees by native trees also could favor an increase of local biodiversity, with additional values for ecosystem services (Butterfield 1995; Haggara *et al.* 1998; Burghardt *et al.* 2008). Alternatively, the structure of the eucalyptus trees could be changed so that they do not support nests (Volpe and Aramburú 2011). However, the efficacy of these strategies to decrease density of monk parakeet nests in a farm is unknown.

The lack of significance of landscape variables in explaining density of monk parakeet nests in farms with eucalyptus, limits the possibilities of recommending management measures at this level. The only management measurement that emerges from results of this study would be to decrease the amount of tree patches around the farms. However, eliminating trees would result in a more simplified landscape, which could have important consequences for biodiversity and ecosystem services provided by trees (Power 2010; Batáry *et al.* 2011). Also, the benefits probably would be low, considering the low weight of this variable for explaining density of monk parakeet nests in the farms. Therefore, based on this study, I would not recommend management measures at landscape level for decreasing density of monk parakeet nests in farms with eucalyptus.

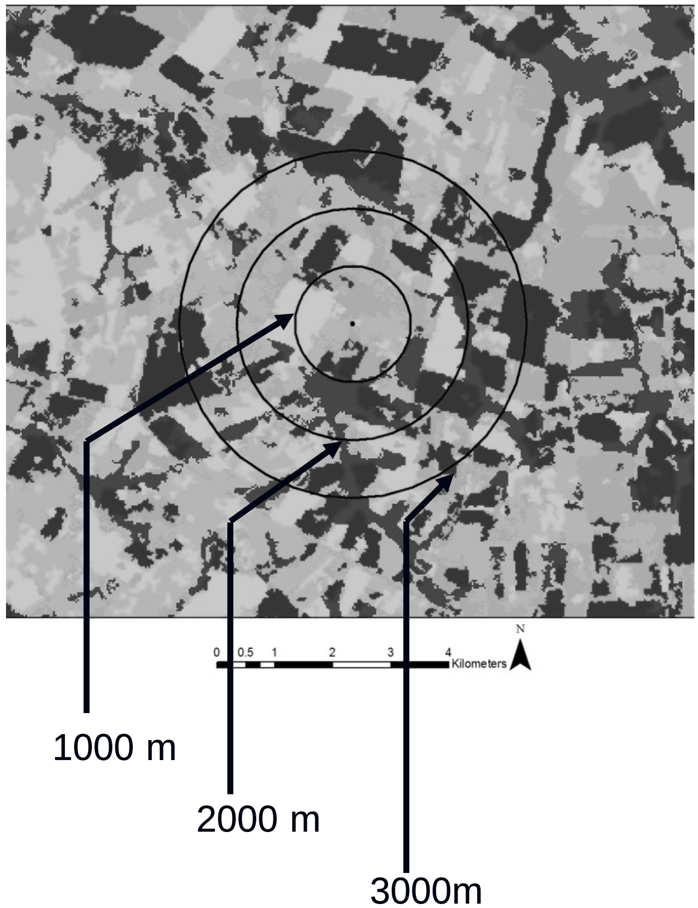

Figure 3-1. Buffer extents used for sampling landscape level variables from satellite images around each nesting patch (central point).

Table 3-1. Summary of vegetation structure and landscape metrics included in models of monk parakeet nest density in inhabited farms with eucalyptus in east central Argentina. n=62 nesting patches for local level, n=42 nesting patches for landscape level.

Variable	Description	Mean	SE	Range
Local level				
EUHGT	Mean height of eucalyptus trees at each site (m)	25.28	0.62	15.32-38.13
EUAREA	Area of patch covered by eucalyptus canopy (ha)	0.27	0.04	0.04-1.12
EUPROP	Proportion of patch area covered by eucalyptus canopy	0.24	0.02	0.03-0.78
CONTROL	Application of control measures on each site to decrease monk parakeet nesting (presence/absence)	NA	NA	NA
Landscape level*				
CRPLAND	Percentage of the landscape with preferred food crops (corn and sunflower)	12.11	0.67	4.14-24.12
PSTPLAND	Percentage of the landscape with pastures and other agricultural uses potentially available to monk parakeets for foraging (including weedy and fallow fields)	17.73	1.09	2.48-32.54
TRPLAND	Percentage of the landscape with trees (either native or introduced)	25.18	3.22	0.96-79.59
TRPD	Density of patches with trees on the landscape (#/km^2)	1.07	0.07	0.28-2.40

* These variables were estimated at three buffer extents (1000, 2000 and 3000 m) around each nesting site. Values are given for the 3000 m buffer. Different buffers have different values for metrics, but the relationships among variables were qualitatively similar.

Table 3-2. Minimum AICc models for density of monk parakeet nests in inhabited farms with eucalyptus trees in east central Argentina (n=35). Models were developed with: 1) local variables only, 2) landscape variables at 3 spatial extents, and 3) local and landscape variables in the same models (muti-level models). All models with ΔAICc ≤ 4 within a level are presented. Models are ordered based on model performance within each level (lower AICc value indicating better model performance).

Level	Model	AICc	Akaike weight (ω_i)
Local	EUPROP	16.49	0.33
	EUPROP + CONTROL	18.30	0.13
	EUPROP + EUHGT	18.61	0.11
	EUPROP + EUAREA	18.71	0.11
	EUAREA	20.47	0.04
Landscape – 1 km	1TRPLAND	18.15	0.36
	1TRPLAND + (-1TRPD)	20.33	0.12
	1CRPLAND + 1TRPLAND	20.47	0.11
	(-1TRPD)	20.72	0.10
	(-1PSTPLAND)	21.03	0.08
	(-1CRPLAND)	21.17	0.08
Landscape – 2 km	2TRPLAND	18.91	0.29
	2CRPLAND + 2TRPLAND	20.38	0.14
	(-2PSTPLAND)	20.63	0.12
	2TRPLAND + 2TRPD	21.20	0.09
	(-2TRPD)	21.26	0.09
	2CRPLAND	21.31	0.09
	2CRPLAND + 2TRPLAND + 2TRPD	22.83	0.04
	2CRPLAND + (-2PSTPLAND)	22.87	0.04
Landscape – 3 km	3TRPLAND	19.25	0.23
	(-3PSTPLAND)	19.72	0.19
	3CRPLAND + 3TRPLAND	20.56	0.12
	(-3TRPD)	21.25	0.09
	3CRPLAND	21.26	0.09
	3TRPLAND + 3TRPD	21.50	0.08
	3CRPLAND + (-3PSTPLAND)	21.86	0.06
	(-3PSTPLAND) + 3TRPD	22.04	0.06
	3CRPLAND + (-3TRPD)	22.98	0.04
	3CRPLAND + 3TRPLAND + (-3TRPD)	23.00	0.04
Multi-level	EUPROP + 2TRPLAND	16.62	0.34
	EUPROP + 3TRPLAND	16.62	0.34
	EUPROP + 1TRPLAND	16.70	0.32

Brackets indicate a negative relationship with nest density.

Table 3-3. Regression results for factors considered for predicting density of monk parakeet nests in inhabited farms with eucalyptus trees in east central Argentina. Coefficients and associated standard errors for each predictor variable are derived from multimodel inferences using all parameter subsets and Akaike weights (ω_i). $\Sigma\omega_i$ for each predictor variable shows the sums of Akaike weights for all possible models in which the predictor variable was incorporated at each level. The larger the $\Sigma\omega_i$, the more important a variable is relative to other variables. Variables are ordered within each level based on the importance value ($\Sigma\omega_i$).

Level	Variable	Coefficient	CI	$\Sigma\omega_i$
Local	Proportion Eucalyptus area (EUPROP)	1.58	0.84*	0.72
	Human control (CONTROL)	0.04	0.06	0.13
	Tree area(EUAREA)	0.04	0.10	0.11
	Tree height (EUHGT)	0.002	0.004	0.11
Landscape -1 km	Percentage of landscape with tree patches (1TRPLAND)	0.010	0.007*	0.59
	Density of tree patches (1TRPD)	-0.03	0.07	0.22
	Percentage of landscape with preferred food crops (1CRPLAND)	<0.001	0.005	0.19
	Percentage of landscape with pastures (1PSTPLAND)	-0.001	0.002	0.08
Landscape -2 km	Percentage of landscape with tree patches (2TRPLAND)	0.008	0.006*	0.57
	Percentage of landscape with preferred food crops (2CRPLAND)	0.006	0.01	0.31
	Density of tree patches (2TRPD)	-0.008	0.10	0.23
	Percentage of landscape with pastures (2PSTPLAND)	-0.004	0.005	0.17
Landscape -3 km	Percentage of landscape with tree patches (3TRPLAND)	0.006	0.005*	0.47
	Percentage of landscape with preferred food crops (3CRPLAND)	0.01	0.02	0.34
	Percentage of landscape with pastures (3PSTPLAND)	-0.01	0.01	0.31
	Density of tree patches (3TRPD)	-0.02	0.14	0.29

* 95% confidence intervals for multimodel weighted coefficients for each of these predictor variables did not include zero, indicating that these factors probably affected abundance of monk parakeet nests.

CHAPTER 4
INFLUENCE OF SOCIO-PSYCHOLOGICAL AND SOCIO-DEMOGRAPHIC FACTORS ON FARMERS PREFERENCES FOR MANAGEMENT STRATEGIES TO DECREASE MONK PARAKEET DAMAGE TO CROPS

Background

Granivorous bird species associated with agroecosystems cause damage to crops, feedlots and stored grains world-wide (Pinowski and Kendeigh 1977; De Grazio 1978; Feare 1993; Bruggers and Zaccagnini 1994). The number of species causing this damage is relatively small, but their impacts often are significant (Pinowski and Kendeigh 1977; De Grazio 1978; Feare 1993; Bruggers *et al.* 1998). Some species, such as red-winged blackbirds (*Agelaius phoeniceus*) in North America, eared doves (*Zenaida auriculata*) in South America and red-billed quelea (*Quelea quelea*) in Africa, comprise flocks and communal roosts of thousands of individuals and perform wide movements (Beletsky 1996; Bucher 1992a; and Bruggers and Elliot 1989, respectively). Other species that cause damage, including the rose-ringed (*Psittacula krameri*) and the monk parakeets (*Myopsitta monachus*), although less numerous and more resident, are also very social and visible (Spreyer and Bucher 1998; Kahn 2003). The conspicuousness of these birds and the damage they cause, plus the high variability in damage, make objective estimation of damage by farmers difficult (Conover 2002) and contribute to a tendency to overestimate losses (Dyer and Ward 1977; Bucher 1992a, 1998). Consequently, farmers often apply management measures to decrease bird damage that are not economically effective or are contrary to research findings (Bomford and Sinclair 2002; Tracey *et al.* 2007).

The tolerance threshold to bird damage and, consequently, the point at which a farmer decides to apply control measures, are likely to vary depending on psychological and economic factors (Avery 2002). Although no studies have been conducted comparing the influence of psychological and economic factors on management decisions about bird pests, studies of insect pest management in crops have shown that socio-psychological factors, such as perceptions of pest status and attitudes toward control, can influence farmers´ decisions about pest management more than economics, particularly when farmers tend to overestimate crop losses (Mumford and Norton 1984; Heong and Escalada 1994; Heong and Escalada 1999; Heong *et al.* 2002). Similarly, studies of other types of human-wildlife conflict have shown that socio-psychological factors influence people's decisions about management strategies to these conflicts (Pierce *et al.* 2001). Usually, people with negative attitudes toward wildlife species tend to prefer more invasive control methods to resolve human-wildlife conflicts (Locker *et al.* 1999; Coluccy *et al.* 2001; Don Carlos *et al.* 2009; Loyd and Miller 2010). Also, perceptions of problems with wildlife species, previous knowledge about a management method, and the perception of efficacy of the management method influence preferences for management actions to decrease human-wildlife conflicts (Stout *et al.* 1993, 1997; Locker *et al.* 1999; Zinn and Andelt 1999; Jonker *et al.* 2004).

In spite of the potential importance of socio-psychological factors for explaining management decisions to reduce wildlife damage to crops, research in this area is relatively scarce, particularly when related to bird damage (Timm 1991 in Clergeau 1995). Studies evaluating the influence of socio-psychological factors on tolerance levels of farmers to wildlife damage or decisions about management measures to decrease it have focused mostly in conflicts involving mammals, generally deer (Decker and Brown 1982; Messmer and Shroeder 1996; Campa *et al.* 1997; West and Parkhurst

2002). In addition, no studies have looked at the relationship of socio-psychological factors, such as subjective norms (i.e., the perception of social pressure to perform a particular behavior, Fishbein & Ajzen 1975; Ajzen 1985, 1991) or perceived behavioral control (i.e., the perception of ability to perform a particular behavior, Ajzen 1985, 1991) on management decisions to decrease wildlife damage to crops. Previous studies have shown a relationship between one or both factors with decisions about insect pest management (Heong and Escalada 1999; Heong *et al.* 2002) and wildlife-related activities, such as hunting (Rossi and Armstrong 1999; Hrubes *et al.* 2001) and the use of devices to decrease human-bear conflicts (Martin and McCurdy 2009). Finally, socio-demographic factors that influence preferences for management alternatives to decrease human-wildlife conflicts, such as age and education (Bjerke *et al.* 1998; Koval and Mertig 2004; Loyd and Miller 2010), have not been studied in relation to farmers´ preferences for management strategies to decrease bird damage to crops. Research on factors underlying farmers´ preferences for alternative management measures to decrease bird damage to crops is needed to develop effective extension programs and improve management of bird damage to crops (Bomford and Sinclair 2002; Tracey *et al.* 2007).

In this study, I applied a behavioral decision approach to determine farmers' preferences for management strategies to decrease damage from monk parakeets (*Myiopsitta monachus*) to crops in Argentina and to evaluate socio-psychological factors and socio-demographic factors that influenced those preferences. In South America, particularly in Argentina, the monk parakeet is considered one of the most important bird pest species causing damage to grain crops (Bucher and Bedano 1976; Bucher 1992a, 1992b; Bruggers *et al.* 1998). Damage involves principally sunflower, corn, and sorghum, with occasional damage to wheat and rice (Bucher y Bedano 1976; Bucher 1984, 1992 a; Bruggers y Zaccagnini 1994). Quantification of damage to crops by monk parakeets is very scarce, but indicates low (< 5%) to moderate (up to 20%) crop loss (De Grazio y Besser 1975; De Grazio 1985; Canavelli *et al.* 2008).

Traditionally, lethal control has been applied by government agencies, agricultural professionals and farmers as the most effective method for decreasing monk parakeet-damage to crops in Argentina (Bucher 1984, 1992 a,b). Several methods have been used, including nest burning or destruction, shooting, payment of bounties, trapping, netting, toxic baits, spraying of nests with insecticides. Since the 1980s, the primary lethal control method has been insecticides mixed with grease and applied on nest openings to produce intoxication and potentially death of birds entering the nest (Aramburú 1991). However, objections to this method are increasing and new methods are required (Canavelli and Zaccagnini 2007; Canavelli and Aramburu, *in press*). Additionally, monk parakeets represent conflicting values for different groups of people because, although they are considered a pest species, this species also is valued as a domestic pet (Moschione and Banchs 2006). Understanding the bases of farmers' preferences for management strategies to decrease monk parakeet damage to crops is crucial for managing conflicts between monk parakeets and crop production (Canavelli and Zaccagnini 2007).

Based on the historical context of bird damage management in Argentina, I expected farmers to highly favor population control methods, such as lethal and reproductive control, to decrease monk parakeet damage to crops. Additionally, I expected preferences of farmers for specific management strategies to be related to attitudes toward monk parakeets, perceptions of expectations from other people about damage management (subjective norms), and perceived behavioral control about pest management. Finally, I also expected other socio-psychological factors, such as perceptions of problems with monk parakeets, knowledge about control strategies and beliefs about the efficacy of management strategies, and socio-demographic factors, such as age and education, to be related to preferences.

Methods

Study Area

The study was conducted in Paraná Department (Entre Ríos Province, Argentina), where cattle, milk and crops are the major production activities (Engler and Vicente 2009). Within the department, about 49% of area is devoted to agricultural crops, including in order of importance soybean, wheat, corn, sorghum and sunflower. This area represents approximately 15% of the total agriculture in the province (Engler and Vicente 2009). Annual mean temperature is 19ºC and mean rainfall is 1000 mm per year.

Paraná Department contains 2,314 farms, totaling 488,558 ha (National Agricultural Survey database, INDEC 2002). Most farms (58%) are smaller than 100 ha, following in frequency 100 - 300 ha (25%), 300-500 ha (7%), 500-1000 (5%) and > 1000 ha (4%). Farm size is correlated with area devoted to crops within the farm, and commonly is related to socio-demographic variables, such as land ownership and social organization of work (Engler and Vicente 2009).

Sampling Scheme and Questionnaire Design

I applied a cross-sectional study design (de Vaus 2001) based on personal interviews to obtain an instantaneous picture of farmers' attitudes, perceptions and preferences for alternative management strategies. From the target population of farms in Paraná department, I selected 115 farmers for face-to-face questionnaires. Twenty-four farmers were randomly selected among all farmers producing corn and/or sunflower in the 2007 crop season, because these crops are very susceptible to monk parakeet damage (Bucher y Bedano 1976; Bucher 1984, 1992 a; Bruggers y Zaccagnini 1994). The other 95 farmers were randomly selected from the INDEC 2002 database after stratifying by the area devoted to crops within each farm into four categories: 0.5-20 has, 20-80 ha, 80-300 ha, and > 300 ha. To select farmers within each stratum, I ranked farmers based on the area of the farm devoted to crops. Afterwards, I selected individual farmers using systematic sampling with a random start, in order to cover the size distribution of crop area within each stratum. The number of farmers selected in each stratum was proportional to the total number of farmers in the stratum.

The questionnaire for the interview was organized in five main sections: 1) farmers´ perceptions of bird abundance and damage; 2) farmers knowledge and attitudes toward monk parakeets; 3) farmers knowledge and preferences for management strategies to decrease or prevent monk parakeet damage to crops, 4) personal and external influences on the application of management strategies, and 5) socio-demographic information (Appendixes B and C). Most questions in each section were closed and/or structured questions that were completed with the help of the farmer. Opinion responses were categorized with a symmetric scale with a central neutral category (agree, neutral, disagree) and options for undecided and not answering (Reiter *et al.* 1999; Jacobson *et al.* 2003).

Prior to implementation, questionnaires were reviewed by extension agents and agronomists at the Paraná Experimental Station at the National Institute of Agricultural Technology (INTA) to determine the clarity of questions, completion time, and other aspects of survey completion (Reiter *et al.* 1999). The questionnaire also was pre-tested with a sample of seven farmers closely related to the station and adjusted subsequently. A summary of the questionnaire structure and content is included in Appendix B and the final questionnaire in Spanish is included in Appendix C.

Variable Measurement

Preference for management strategies

For evaluating farmers´ preferences for management strategies to decrease monk parakeet damage to crops, I employed the method of paired comparisons, a widely used method to evaluate preference dimensions in psychology, marketing, policy and economics, based on offering the respondent items from a choice set in pairs (Burgess *et al.* 2002; Brown and Peterson 2003). For each pair of options, the respondent is requested to choose the superior item. Each choice is assumed to be independent of all other choices (Brown and Peterson 2003).

I evaluated preference of farmers for each of seven management strategies for decreasing monk parakeet damage to crops: 1) lethal control by shooting, trapping, or poisoning, 2) crop protection with physical or chemical deterrents, 3) agricultural practices, such as early planting, high crop density, etc., 4) habitat management by modifying tree structure, using decoy plots, etc., 5) reproductive control by removing or burning nests, egg oiling, etc., 6) capture of birds and relocation, and 7) integrated pest management (IPM), defined for the purpose of this study as the integration of several control tactics to reduce the status of the pest (Kogan 1998). Based on these seven strategies, I had a set of 21 pairs of strategies, and respondents were forced to choose one of the two options in each pair. As a short-term measure of reliability of the answers, I had two repeated pairs of choices with reverse order of items. These two pairs were randomly selected from the full set of pairs. I randomly sorted the 23 pairs, made ten versions of the questionnaire that differed only in the order of the presentation of pairs, and randomly choose the version to use in a given interview. Altering the order of presentation of pairs has been suggested as a way of decreasing bias on stated preferences due to the order in which pairs are presented and, consequently, increasing reliability in the answers (Brown and Peterson 2003).

Socio-psychological factors

Perceptions of problems with monk parakeets. Perceptions of problems with monk parakeets included questions about monk parakeet damage, population abundance, and trends in damage and abundance in the three years prior to the interview (Appendixes B and C). Because measures of perceptions of monk parakeet abundance were significantly related with perceptions of monk parakeet damage (Fisher Exact Test $p=0.025$), and perception of population trends of parakeets were significantly related with perceptions of trends in damage (Fisher Exact Test $p< 0.0001$), I focused the analysis on perception of damage. Also, I asked farmers about their tolerance to monk parakeet damage on crops. For each crop, I asked if the farmer usually produced the crop in the farm and, if so, whether parakeet damage usually occurred on the crop. In the case of a positive answer about damage, I asked if he/she considered damage as tolerable (2) or intolerable (3). For statistical analyses, I combined answers for the three crops most attractive to monk parakeets (corn, sunflower and sorghum) for each farmer, because most farmers (≥ 80%) growing these crops had experienced damage by monk parakeets. To obtain an index of tolerance of damage for each farmer, I averaged tolerance levels among the crops for which farmers reported damage. Index of tolerance varied between 2 (tolerable) and 3 (intolerable). Finally, I asked farmers about their perception of the importance of losses by monk parakeets compared with losses caused by other factors, such as climate, insects, weed, diseases and harvesting machinery. Importance of monk parakeet losses compared to other crop loss causes was captured in three categories (1=less important, 2=equally important, 3=more important). In order to have a single value of relative importance of monk parakeet damage compared to other crop losses for each farmer for statistical analyses, I added the importance value of monk parakeet damage compared to all other factors (climate, insects, weed, diseases, harvesting machinery) for each farmer (index range: 5- monk parakeet damage considered lower in importance to 15-monk parakeet damage considered higher in importance).

Knowledge about management strategies and beliefs about their effectiveness. All farmers interviewed knew about monk parakeets and the damage they cause on food crops. Previous knowledge of farmers about management strategies was evaluated in general and for each of seven management strategies: lethal control, crop protection, agricultural practices, habitat management, reproductive control, capture of birds and relocation, and integrated pest management. On each case, knowledge was recorded as a binary variable (1=yes, 2=no). Based on the strategies previously known by each farmer, I also determined the perceived effectiveness for each strategy separately as well as which strategy farmers considered the most effective. A first question asked about the perceived effectiveness of each previously known strategy (1=no effective, 2=slightly effective, 3=very effective), and a second question asked farmers to rank the management strategies based on their effectiveness (first, second and third most effective strategies).

Attitudes toward monk parakeets and management of monk parakeet damage to crops. Attitudes toward monk parakeets were measured using a Likert scale index based on 14 belief items that were successful in separating opinions from different groups of farmers. A Likert scale is an instrument widely used to measure levels of theoretical constructs, such as opinions, attitudes or beliefs, not readily observed by direct means (DeVellis 2003). It includes a set of items that are combined into a composite score (De Vellis 2003). Originally, I evaluated a pool of 40 items developed following DeVellis guidelines (2003, pgs. 60-101) for assessing attitudes toward monk parakeets and another pool for assessing attitudes toward management of monk parakeet damage to crops. However, after evaluation of item performance with a sample of 12 farmers, I developed a 14-item Likert scale only for evaluating attitudes toward monk parakeets, because items for evaluating beliefs about management of parakeet damage to crops were not good at separating opinions from different groups of farmers (conservationists vs. productionists). Attitudes ranged from 14, indicating farmers had a less favorable or “negative” attitude toward monk parakeets, to 42, indicating farmers had a more favorable or “positive” attitude toward monk parakeets.

Subjective norms about monk parakeet damage management. To determine subjective norms, I asked farmers to state what they thought specific reference groups expected the farmer to do about monk parakeet control (norm belief) and how much farmers cared about expectations of each reference group (motivation to comply, Heong and Escalada 1999). The six reference groups were neighbors, spouse, extension agents from 1) a cooperative, 2) the national government and 3) the state government, and sales agents from chemical companies. Norm belief was scored for each reference group asking the farmer to state if each group expected the farmer to never control monk parakeets (score=1), occasionally (once every 2 years, score=2), frequently (at least once a year, score=3) or very frequently (every season, score=4). Motivation to comply was scored for each reference group asking the farmer to state how much he/she cares about the opinion of each group (1=does not care, 2=cares moderately, 3=cares a great deal). For statistical analyses, a composite measure of subjective norm was estimated for each farmer as the product of norm belief and motivation to comply for each reference group, added for all groups (Heong and Escalada 1999; Heong *et al.* 2002). When a reference group did not apply for a farmer (e.g., spouse) or the farmer was not decided about the answer for a specific reference group, a score equal to 0 was used so the group did not counted in the overall sum. Composite scores of subjective norms ranged from 1, indicating farmers experience no social pressure to control monk parakeets, to 61, indicating farmers experienced strong social pressure to control monk parakeets.

Perceived behavioral control about bird pest management. Perceived behavioral control about bird pest management was evaluated as the perceived confidence of farmers in their own abilities to apply management strategies to decrease bird damage to crops (internal factors) and the influence of external factors limiting these abilities (e.g., limited access to control devices, high complexity of the current techniques, elevated cost of actual techniques, etc., Appendix C). Confidence was captured in three categories (1=insecure, 2=moderately secure, 3=very secure) and a composite measure of confidence for each farmer was estimated as the sum of all values for all abilities for each farmer. Similarly, the influence of external factors was also measured in three categories (1=not limiting, 2=moderately limiting, and 3= highly limiting). The overall value of perception of limiting factors for each farmer was estimated as the sum of the individual values for each item. Finally, for statistical analyses, a composite measure of perceived behavioral control was estimated as the product of perceived confidence and limiting factors.

Socio-demographic factors

Socio-demographic factors also were evaluated for each farmer, including age, educational level, area of the farm, area of farm devoted to crops, and social participation. Social participation was evaluated as the affiliation with one or more farmers´ organization (0=no affiliation, 1= 1 organization, 2= 2-3 organizations, 3=4-5 organizations, 4= > 5 organizations) and the degree of participation to farmers meetings (0=no participation, 1=less than one every 2 months, 2= monthly or bi-monthly, 3= > once a month). In order to have a single value for each farmer representing social participation, a composite index was built by adding the affiliation with farmers´ organizations and the degree of participation on farmers meeting (range:0-7). Other socio-demographic factors, such as property ownership, income from crops, and sources of information about pest management strategies were included on the questionnaire for general description of the population but were not used for relating to preferences for management strategies because of incomplete information for all farmers (property ownership and income from crops) or unclear expected relationship with preferences (sources of information).

Statistical Analyses

Preference scores and reliability

With data from all respondents, I estimated scale values of preference for each management strategy, developed a scale of preferences, and estimated individual respondent reliability for the answers. I constructed *preference matrices* for each farmer with the full set of choices (i.e., 7 management strategies, 21 pairs). Each matrix had seven rows and seven columns, one for each management strategy, and each cell represented the preference of one strategy compared to another (0= not preferred, 1=preferred). Based on the preference matrix for each farmer, I estimated a *preference score* for each strategy, representing the number of times a strategy was preferred to all other strategies in the set of choices (Brown and Peterson 2003). Finally, I estimated a *scale value* of preference for each management strategy and its associated standard error by applying the Bradley-Terry (BT) model for pair-comparison data to the *aggregated preference matrix* for the sample of farmers. The BT model was run in R with the BradleyTerry2 add-on package (version 0.9-2, 2010, Turner and Firth 2011). As a measure of reliability of the responses, I calculated the *coefficient of consistency* for each respondent using the number of circular triads (i.e., the number of intransitive responses) for each individual (Burgess *et al.* 2002; Brown and Peterson 2003). The coefficient of consistency varies between 1 (no circular triads) and 0 (maximum possible number of triads, Brown and Peterson 2003).

Assessment of the relationship between preferences for management strategies and socio-psychological and socio-demographic factors

Preference scores for each management strategy were re-categorized as: 1=low preference (preference scores 0, 1 and 2); 2=medium preference (preference scores 3 and 4); and 3=high preference (preferences scores 5 and 6). Also, because of the large number of categories for many variables relative to the sample size (n=111), I re-categorized independent variables with more than four levels and/or uneven distribution of cases among categories to variables with three or four levels using probabilistic methods based on frequency distribution (e.g., quartiles) and/or social-based criteria (e.g., grouping of age-< 40, 40-49, 50-59, ≥60 yrs old- or education- incomplete primary school, primary school, secondary school and university instruction - levels). As all variables were categorical, I compared each socio-psychological and socio-demographic factor with preferences for each management strategy using bivariate Chi-square analyses. For cell counts of expected values below five, I used Fisher's exact test (Agresti 2002) to evaluate statistical significance. Additionally, I used proportional odds logistic-regression models in SAS (v.8, 2006) to determine which socio-psychological and socio-demographic factors were most strongly related with preferences for each management strategy (Agresti 2002). The relative importance of each variable for predicting preferences for each management strategy was evaluated by considering the Akaike's Information Criterion (AIC, Burnham and Anderson 2002) by ranking the variables in order of lowest AIC value (the best performing independent variable) to the highest (the worst performing independent variable, Hagy *et al.* 2008). Models with Δ AIC scores of ≤ 2 were considered competitive models (Burham and Anderson 2002). Additionally, I used percent concordance, a measure of association of predicted probabilities and observed responses, as a complementary measure of model fit. I modeled each management strategy separately because evaluation of all strategies simultaneously was too complex. Finally, I explored the correlation between behavioral factors (attitudes, subjective norms and perceived control) and other independent variables using Chi-square tests. For graphical representation of contingency tables, I used mosaic displays when two or three variables were involved (Friendly 2000). When more than three variables were related simultaneously, I used multiple correspondence analyses (MCA) to graphically represent the relationships.

Results

Preferences for Bird Pest Management Strategies

Strategies for monk parakeet population control, such as reproductive and lethal control, were most preferred by farmers, followed by integrated pest management, crop protection, agricultural practices, and habitat management (Figure 4-1). Preferences for different strategies were related. For instance, when farmers highly preferred reproductive control, they also preferred lethal control and had low preferences for other alternatives, such as crop protection, integrated pest management or agricultural practices (group A in Figure 4-2). Conversely, when alternative strategies to population control were preferred, such as crop protection or agricultural practices, farmers had low preferences for all population control strategies (lethal and reproductive control, group B in Figure 4-2).

Reliability of preference scale values. Farmers averaged 1.26 (± 0.16 SE) circular triads of a possible maximum of 14. Average coefficient of consistency for preferences was 0.91 (± 0.01 SE). Forty-seven percent of farmers (n=52) had no circular triads (i.e., inconsistencies on his/her choices), 40% of farmers had three or less triads, and 13% had four or more.

Factors Related to Preferences for Management Strategies

Socio-psychological factors

Perceptions of problems with monk parakeets. Most farmers (68%) had experienced damage by monk parakeets on their crops on the last three years. For these farmers (n=75), damage was generally insignificant (32% of farmers) or moderate (49% of farmers). Only 19% of these farmers (equivalent to 13% of all farmers) considered damage intense. Damage for the 2006-2007 crop season was reported as less than 5% crop loss by 32 farmers (29% of all farmers), between 5 and 10% crop loss by 26 farmers (23%), between 10 and 25% by 9 farmers (8%) and greater than 25% by 8 farmers (7% of all farmers). Most farmers reported an increasing trend in damage, with damage equal or greater in the last season compared to the average annual damage over the last three years (43% and 41% of farmers, respectively).

Most farmers (67%) growing attractive crops for monk parakeets (corn, sunflower or sorghum) experienced damage by monk parakeets on at least one of the crops. However, when damage was observed, most farmers considered the damage as tolerable (76%). Farmers growing other crops (e.g., soybean, alfalfa, millet and flax) mostly reported no damage by monk parakeets, with exception of wheat, where half of farmers growing this crop (n=33) reported some damage by monk parakeets. In this case, most farmers that reported damage by monk parakeets (88%) also considered damage as tolerable.

Most farmers (> 60%) considered crop losses caused by monk parakeet damage to be more important than losses by weeds, diseases, and harvesting machinery. In contrast, most farmers (> 60%) considered crop losses caused by adverse climate and pest insects equally or more important than damage by monk parakeets. During the interviews, some farmers mentioned losses by weeds and diseases also could be more important than damage by monk parakeets, but these two problems could be managed well, so that losses were lower. The mean and median score of perception of importance of monk parakeet were identical (11; range= 5-15), suggesting farmers perceived losses by monk parakeets to be relatively important compared to other causes of crop loss.

Preferences of farmers for management strategies generally were not associated with perceptions of damage by monk parakeets to crops (Table 4-1). The only statistically significant relationship was that farmers who perceived monk parakeet damage as more important than other crop losses highly preferred lethal control as a management strategy to decrease damage (Table 4-1). No variable representing perception of problems with monk parakeets was included among the most important variables explaining preferences for any management alternative (Table 4-2).

Knowledge about management strategies and beliefs about their effectiveness. Most farmers (88%) knew some control strategies for decreasing monk parakeet damage before they were interviewed, some of them did not (12%). Lethal control, reproductive control and agricultural practices were commonly known by farmers (Figure 4-3). Integrated pest management (IPM) and capture and relocation of birds were the least known alternatives by farmers (Figure 4-3). Lethal and reproductive controls also were considered the most effective strategies by most farmers, while agricultural practices and integrated pest management followed those in order of importance (Figure 4-4).

Preferences of farmers for management strategies were clearly associated with previous knowledge about the strategy and its perceived efficacy, with farmers generally preferring strategies known to them or perceived as effective before the interview. For instance, farmers who knew about reproductive control, lethal control, integrated pest management, and capture and relocation before the interview highly preferred these management strategies (Table 4-1). Similarly, farmers who perceived these strategies, as well as crop protection and agricultural practices, very effective also preferred them (Table 4-1). However, these relationships were not observed for habitat management.

Both previous knowledge and perceived efficacy of the method were important variables explaining preferences for integrated pest management (Table 4-2). Previous knowledge also was one of the two most important variables explaining preferences for capture and relocation (Table 4-2). Previous knowledge about a strategy was a pre-requisite for farmers to respond to questions about perceived efficacy. Therefore, these variables were related.

Attitudes toward monk parakeets. Attitude scores indicated that farmers predominantly feel a “negative” attitude toward monk parakeets (mean score=24, median score=22, range=14-42). Most of farmers (> 60%) disagreed with all positive statements about monk parakeets. In contrast, opinions were more closely split between agreed and disagree for negative statements about parakeets, with the exception of two statements. Most farmers agreed with the following statements: “Monk parakeets only make me lose money" (65% of farmers) and "Monk parakeets bothered me because they decrease my crop production" (83% of farmers).

Attitude was the most important factor explaining monk parakeet preferences for management strategies to decrease monk parakeet damage to crops for four of the seven strategies evaluated: reproductive control, lethal control, crop protection and agricultural practices (Table 4-2). Farmers with negative attitudes toward monk parakeets highly preferred population control strategies (reproductive and lethal control, Table 4-1). In contrast, farmers with positive attitudes toward monk parakeets highly preferred alternative management strategies, such as crop protection and agricultural practices (Table 4-1). Also, attitude was one of the two most important factors for preferences for capture and relocation (Table 4-2). Attitude was not important for explaining preferences for integrated pest management (Table 4-2).

Subjective norms about monk parakeet control. Farmers recognized external influences from different groups of people (spouse, neighbors, extension agents from cooperatives, government and agrochemical companies) on what it is expected for them to do about monk parakeet control. However, the influence of these groups usually was considered unimportant in their decision about control. More than 60% of the farmers thought that all groups would expect them to control monk parakeets frequently (at least once a year) or very frequently (once every season). However, the opinion of these groups of people did not concern farmers very much, especially if coming from neighbors or commercial agents from agrochemical companies. Usually, between 40 and 50% of farmers did not care about the opinion of each reference group, and more than 60% of farmers did not care about the opinion of neighbors or commercial agents from agrochemical companies. Farmers experienced only moderate social pressure regarding the management of monk parakeet problems (mean score of subjective norms=29.33, median=28, range=1-61).

Similar to attitudes, farmers who perceived strong social pressure to control monk parakeets highly preferred population control strategies (reproductive and lethal control) as well as habitat management (Table 4-1). No-statistically significant relationships were found with preferences for other management strategies (Table 4-1). Also, subjective norms were non-included among the most important factors explaining preferences for any management strategy (Table 4-2).

Perceived behavioral control about bird pest management. Most farmers (88%) were confident in identifying pest bird species, but fewer (<60%) were confident about knowing multiple alternatives for bird pest management, the biology of these birds, existing regulation of bird pest management, or methods for capturing bird pests, among other abilities. All external factors presented to farmers as limiting their abilities for applying bird pest management were recognized by most of farmers (>60%) as moderately or highly limiting, including limited access to information and/or limited available information, high complexity of current techniques, and difficulties with cost-benefit evaluations. Farmers´ answers were divided only when we asked about community opinion regarding certain management strategies (e.g., lethal control), because half of farmers did not consider community opinion as a limiting factor for the application of those strategies. When farmers´ confidence and the influence of limiting factors were integrated, median score of the composite measure of perceived behavioral control was 153 and mean score was 162.45 (range: 42-336), suggesting that farmers feel moderate control in applying management strategies to decrease bird damage, probably as a consequences of relatively low-moderate internal control and high limitation of external factors.

The perception of behavioral control was related only to preferences for integrated pest management (Table 4-1). Farmers who perceived high control in applying management strategies to decrease bird damage highly preferred integrated pest management, an alternative and more complex strategy to population control. Similar to subjective norms, perceived behavioral control was not included among the most important factors explaining preferences for any management strategy (Table 4-2).

Socio-demographic factors

Most of interviewed farmers (n=111) were male (97%). All of them were 18 years old and older, most of them between 30 and 59 yrs old (71% of total). Most farmers had finished primary school (54%) but fewer finished secondary school (16%) or university (17%). The area under management by each farmer varied between 16 and 3200 ha, with most of farmers (60%) making decisions for 300 ha or less. About half of farmers (n=49) conducted production activities on their own property and a similar number (n=44) rented land for production.

Only 49% of the farmers had greater than 25% of the farm area in crops. However, income from crops was important (50% or more of the total income for the farm) for many farmers (n=33) who answered the question (n=87). Most farmers (82%) conducted production activities on the farms besides crops (cows, milk production, etc.).

Most farmers (60%) did not belong to any farmer organization. The ones who did (n=44), mostly were associated with one organization (59%). None of the interviewed farmers belonged to a conservation organization. Most farmers (80%) participated in farmers´ meetings and conferences, usually once every two months or less.

Preferences for management strategies to decrease monk parakeet damage were generally less related to socio-demographic factors than socio-psychological factors. However, young farmers (< 40 yrs old) with high levels of formal education (university instruction) had lower preference for population control methods (reproductive and lethal control) compared to older farmers with less formal education, and the reverse occurred for agricultural practices (Table 4-1). Farm area, percentage of area devoted to crops, and social participation were each related to preferences for reproductive control. Farmers with small farms, a smaller amount of area devoted to crops, and elevated social participation, highly preferred this management strategy (Table 4-1). Also, small farmers had low to moderate preference for habitat management (Table 4-1). No socio-demographic factor was included among the most important variables explaining preferences for any management alternative (Table 4-2).

Relationships among Socio-psychological and Socio-demographic Factors

Attitudes were related with socio-demographic factors, such as age and education (Table 4-3). Most farmers with negative attitudes toward monk parakeets were ≥ 60 yrs old and relatively less educated farmers (incomplete primary school, Figure D-1, Appendix D). Similarly, attitudes were related to socio-psychological factors, specifically beliefs about the effectiveness of management strategies. Most farmers with negative attitudes toward monk parakeets considered lethal and reproductive control as the most effective strategies (Figure D-2, Appendix D). Beliefs about the effectiveness of management strategies also were related with subjective norms about monk parakeet control, with most farmers considering population control strategies (lethal and reproductive control) as the most effective strategies perceiving moderate to high social pressure (Figure D-3, Appendix D). Perceived control regarding bird pest management was not related with any other socio-demographic or socio-psychological factor (Table 4-3).

Results Summary

In summary, socio-psychological factors, such as attitudes toward monk parakeets, previous knowledge of each strategy and beliefs about effectiveness of each strategy, were strongly related to preferences for management strategies (Tables 4-1 and 4-2). Other socio-psychological factors, such as subjective norms about monk parakeet control and perceived control about bird pest management were related to preferences for management strategies to a much lesser extent. Finally, perceptions of problems with monk parakeets were not related to preferences for management strategies, with the exception of the perception of importance of monk parakeet damage compared to other loss causes, which was strongly related to preferences for lethal control (Table 4-1).

Socio-demographic factors were less related to preferences for management strategies than were socio-psychological factors. Only age and level of formal education were related to preferences for population control methods (reproductive and lethal) and agricultural practices (Table 4-1). Other socio-demographic factors (farm area, percentage area devoted to crops and social participation) were related only to preferences for reproductive control (Table 4-1).

The most preferred strategies, reproductive and lethal control, were related to the greatest amount of factors evaluated in this study (n= 9 and 7, respectively, Table 4-1). However, some of these factors were related among each other (Table 4-3). Attitudes were related with socio-demographic factors, such as age and education and to socio-psychological factors, specifically beliefs about the effectiveness of management strategies (Table 4-3). Also, beliefs about the effectiveness of management strategies were related with subjective norms about monk parakeet control (Table 4-3).

Discussion

Preferences of Farmers for Management Strategies and Factors Related with those Preferences

Population control strategies, such as nest destruction and killing of birds, were perceived by farmers as the most effective strategies for decreasing monk parakeet damage to crops and also were the most preferred strategies. The use of these strategies is historical in Argentina (Bucher and Bedano 1976; Bucher 1984; Aramburú 1991; Bucher 1992 a and b; Bruggers *et al.* 1998), including in the region of this study (Zaccagnini and Bucher 1983; Giménez and Salomón 2000). Although the effectiveness of these strategies to decrease damage to crops by monk parakeets has not been evaluated, intense campaigns of population control, where monk parakeets are killed on the nests with pesticide can produce considerable reductions in monk parakeet populations (Bucher 1985, 1992b). The reduction in populations produced by lethal control or nest destruction, together with a perception of a positive relationship between the application of these control measures and a decrease on monk parakeet damage to crops (Bucher and Bedano 1976; Zaccagnini and Bucher 1983), could explain the perceptions of effectiveness and preference for both methods by farmers. However, other studies suggest that neither of these strategies alone would be cost-effective for decreasing monk parakeet damage to crops because of the difficulties of producing a large enough decrease in the population (Canavelli 2003) with a cost lower than the damage (Bucher 1992b). Also, these methods are not environmentally safe, either for monk parakeets or other species (Keith 1991; Bucher 1992b; Zaccagnini 2006). Therefore, the use of lethal or reproductive control as the main strategies for decreasing monk parakeet damage to crops is at least questionable, not only by wildlife biologists but also by some farmers and the general public, who have shown strong opposition to population control of monk parakeets in some cases (Canavelli and Aramburú, *in press*).

Preferences of farmers for management strategies were more strongly related to attitudes toward monk parakeets than to any other socio-psychological or socio-demographic factor. Similar to what has been found in previous studies looking at the influence of attitudes on preferences for management actions involving wildlife species (e.g., Bjerke *et al.* 1998; Stout *et al.* 1997; Don Carlos *et al.* 2009; Loyd and Miller 2010), most farmers with negative attitudes toward monk parakeet preferred invasive population control methods, such as lethal and reproductive control, and farmers with positive attitudes toward monk parakeets preferred non-lethal strategies, such as crop protection and agricultural practices. Given crop damage from monk parakeets was considered tolerable in this study, the predominantly negative attitudes toward monk parakeets may be related to past problems more than the perception of actual damage (Zinn and Andelt 1999). This particularly would be the case if those problems contributed to building strongly held attitudes that are relatively stable and difficult to change (Pierce *et al.* 2001). This proposition may be supported by the relationship of attitudes toward monk parakeets with age, with older farmers having predominantly negative attitudes compared to younger farmers.

Preferences of farmers for management strategies also were strongly associated with perceived efficacy of management strategies and, to a lesser extent, to previous knowledge about those strategies. Farmers who were familiar with a management alternative to decrease monk parakeet damage to crops, and perceived the management strategy to be effective also preferred this strategy. However, some disparities were observed in the relationships between preferences and knowledge or perceived efficacy. For example, although integrated pest management was the least known management strategy (< 20% of farmers knew about it), this strategy ranked third in preference, following reproductive and lethal control strategies in the general scale of preferences/ranking. Similarly, many farmers preferred integrated pest management although this strategy was not perceived to be among the most effective ones. In addition, some farmers perceived strategies such as agricultural practices as very effective, but they were not highly preferred. Consequently, although knowledge and perception of efficacy were important predictors of preferences for some management strategies, they were less directly related to preferences than attitudes.

Other socio-psychological factors, such as subjective norms and perceived control, were related to preferences of farmers for management strategies but to a lesser degree than attitudes, perceived efficacy of management strategies or previous knowledge about those strategies. Subjective norms and perceived control also have been found to predict human behavior regarding other types of human-wildlife interactions (e.g., hunting), although usually to a lesser degree than attitudes (Rossi and Armstrong 1999; Hrubes *et al.* 2001; Martin and McCurdy 2009). Finally, socio-demographic variables, such as age and education, also had little influence on preferences of farmers for management strategies. However, some disparities occurred depending on the management strategy. For example, age and education were significantly related with preferences for population control methods, particularly lethal control. Similarly, other studies have found a relationship between supporting the extirpation of wolves and age and educational level (Bjerke *et al.* 1998), or educational level, but not age, and preference for lethal control of feral cats (Loyd and Miller 2010). Given attitudes toward wildlife generally are related to educational level and age (Kellert 1980; Kellert and Berry 1987 in Loyd and Miller 2010), the relationship between preferences for management strategies to decrease monk parakeet damage to crops and age and education is probably mediated through a direct relationship of age and education with attitudes and an indirect relationship with preference for a strategy, as has been proposed for behavioral intentions in general (Fishbein and Ajzen 1975; Ajzen 1991).

Contrary to what I expected, preferences for management strategies, including lethal or reproductive control, were not related with perceptions of magnitude of damage by monk parakeets. Previous studies have found a direct relationship between perception of damage and decisions in pest management (e.g., Savary 1993; Heong and Escalada 1999, 2002) and perceptions of risks and preference for wildlife management techniques (e.g., Stout *et al.* 1997; Coluccy *et al.* 2001). In this study, the proportion of interviewed farmers reporting damage by monk parakeets was substantial (68%), indicating wide-spread consumption of crops by monk parakeets in the region. However, the reported magnitudes of damages were relatively low (< 10% of crop loss), in agreement with previous studies of damage perception (Zaccagnini and Bucher 1983; Giménez and Salomon 1999, 2000) and quantitative evaluations of damage in the region (Zaccagnini y Cassani 1985; Zaccagnini y Tate 1991, 1992; Giménez and Salomón 1999; Canavelli *et al.* 2008). Additionally, most farmers were tolerant of monk parakeet damage, even in very susceptible crops, such as corn, sunflower or sorghum. The perception of low magnitude of damage by monk parakeets to crops and this tolerance to damage may explain the lack of significant relationships between these factors and preferences for management alternatives. Nevertheless, some farmers still perceived monk parakeet damage as an important cause of crop loss, and even more important than other sources. Beliefs about the importance of damage by monk parakeets compared to other crop losses was the only factor that was significantly related with preferences for lethal control, suggesting that when damage from parakeets is considered greater than other causes of crop loss, farmers prefer a management strategy that produces a decrease in the bird population. Previous studies also have found that people are more willing to accept more invasive population control methods, particularly lethal control, when the severity of incidents with wildlife increases (e.g., Bjerke 1998; Zinn *et al.* 1998; Locker *et al.* 1999; Don Carlos *et al.* 2009).

Management Implications

The monk parakeet is considered one of the most important bird pest species causing damage to grain crops in Argentina (Bucher and Bedano 1976; Bucher 1992a, 1992b; Bruggers *et al.* 1998). Currently, the main management strategies are population control methods such as lethal control with insecticides mixed with grease and applied on nest openings or capturing parakeets and destroying the nests. In this study, farmers preferred reproductive control more than lethal control as a management strategy to decrease monk parakeet damage to crops. However, it is possible that reproductive control masked some ways of lethal control in the nests, such as burning nests with nestlings inside. Objections to these methods are increasing by some farmers and the general public, who have shown strong opposition to lethal control of monk parakeets in some cases (Canavelli and Aramburu, *in press*). Consequently, new methods are required (Canavelli and Zaccagnini 2007; Canavelli and Aramburu, *in press*).

Several management strategies other than lethal or reproductive control are currently available to prevent monk parakeet damage to crop fields or protect those fields from damage, including agricultural practices, such as increasing crop density and sowing deterrent crops, or using bio repellents (Canavelli and Aramburú, *in press*). Unfortunately, no evaluations have been made of the efficacy of these management strategies to decrease monk parakeet damage to crops. In order to shape farmers' opinions and management decisions about strategies other than lethal or reproductive control, evaluations of the efficacy of these strategies are needed in the regions where conflicts with monk parakeets are important.

Given current uncertainties in the outcome of management actions to decrease monk parakeet damage to crops, it would be useful to adopt an adaptive management approach (Holling 1978; Walters 1997; Shea *et al.* 2002; Parkes *et al.* 2006) in which multiple land owners are involved and experiments with different management options are conducted in the region (Canavelli and Zaccagnini 2007; Canavelli and Aramburú, *in press*). Involving stakeholders, farmers in this case, in management actions and management decisions in the field would increase ownership of stakeholders in the results and enhance credibility of management agencies coordinating the activities (Messmer *et al.* 1997). Additionally, field projects demonstrating effectiveness of different practices to decrease monk parakeet damage to crops likely would stimulate opinion changes about management and/or encourage adoption of new practices (Stout *et al.* 1997; Tracey *et al.* 2007).

Extension actions within a management program would have to integrate people with different points of view, in order to avoid public controversies about management, particularly in regional management programs and/or programs based on controversial management strategies, such as lethal or reproductive control. In this study, attitude was the main driver of preferences for management strategies. Additionally, a diversity of attitudes toward monk parakeets was observed among farmers. Although farmers with a “negative” attitude predominated, about 45% of the farmers had a moderate or positive attitude toward monk parakeets. The observed diversity of attitudes toward monk parakeets is similar to attitudes of farmers toward other wildlife species (wolves, deer, prairie dogs, etc) that damage properties (Bjerke *et al.* 1998; Loker *et al.* 1999; Zinn and Andelt 1999; Jonker *et al.* 2004).

Attitudes could be based on ethical issues, involving the prioritization of different values (Stout *et al.* 1997) as well as previous experiences and/or worries about possible damage in the future instead of the real experiences (Brown *et al.* 1978). Results from this study reinforce the importance of understanding the underlying factors supporting farmers´ attitudes as well as addressing heterogeneity in farmers´ attitudes toward monk parakeets in extension activities oriented to increase farmers´ preferences for management strategies other than population control. Additionally, extension activities would have to focus on changing attitudes, as a prerequisite of changing behavior, more than increasing knowledge about management practices, determining and communicating levels of damage or showing the efficacy of alternative management strategies.

Finally, research and extension actions also need would need to be proactive, so that intolerable losses are anticipated and avoided instead of trying to eliminate a situation once it has occurred (Fritzell *et al.* 1997). In this study, an increasing preference for lethal control was observed as perception of damage intensity increased compared to other crop losses. This relationship may indicate that, if problems increase in the future and farmers´ tolerance of damage decreases, farmers may be more likely to support lethal methods to resolve these problems (Fritzell *et al.* 1997; Loker *et al.* 1999). Therefore, it would be worthwhile to conduct research and extension activities focused on monitoring the intensity of damage and abundance of monk parakeets and communicating the results to the general public. Although these activities probably would not influence farmers´ preferences for management strategies, at least with the current perception of low levels of damage, they would be useful in anticipating intolerable levels of damage and reducing application of lethal strategies to decrease this damage.

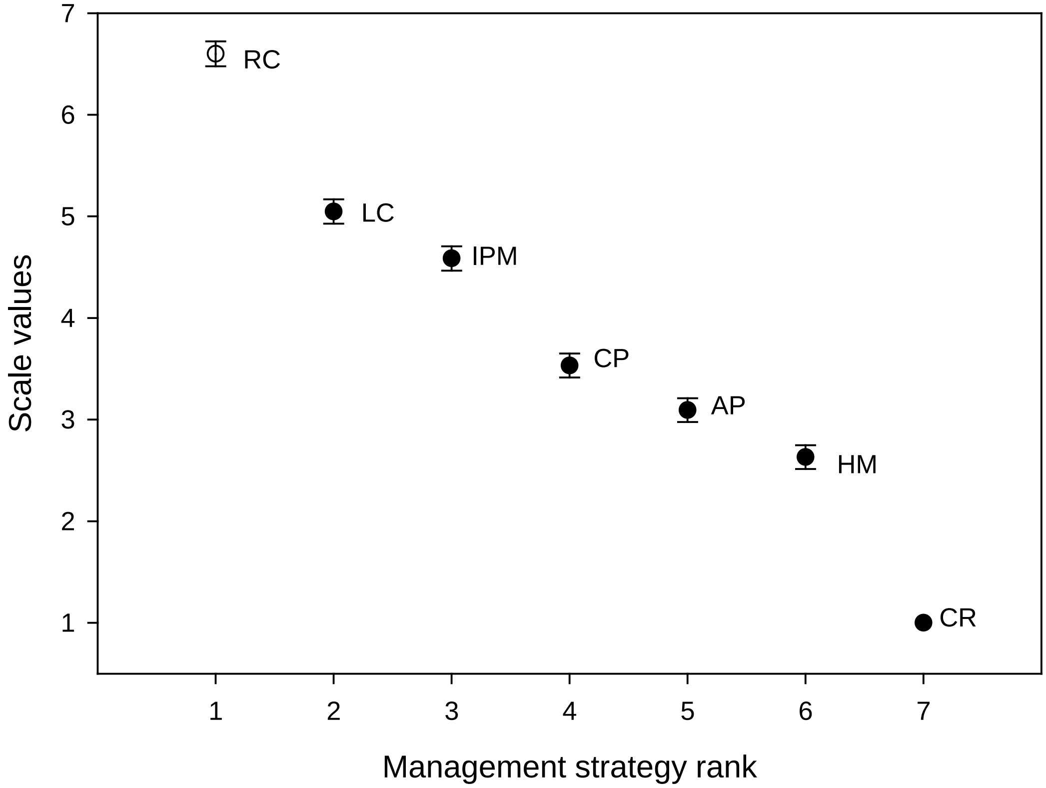

Figure 4-1. Ranking of preference for management alternatives (± s.e.) by farmers (n=111). Scale values on the graph were estimated with the Bradley-Terry model. RC= reproductive control, LC= Lethal control, IPM= Integrated pest management, CP= Crop protection, AP= Agricultural practices, HM= Habitat management, CR= Capture and relocation.

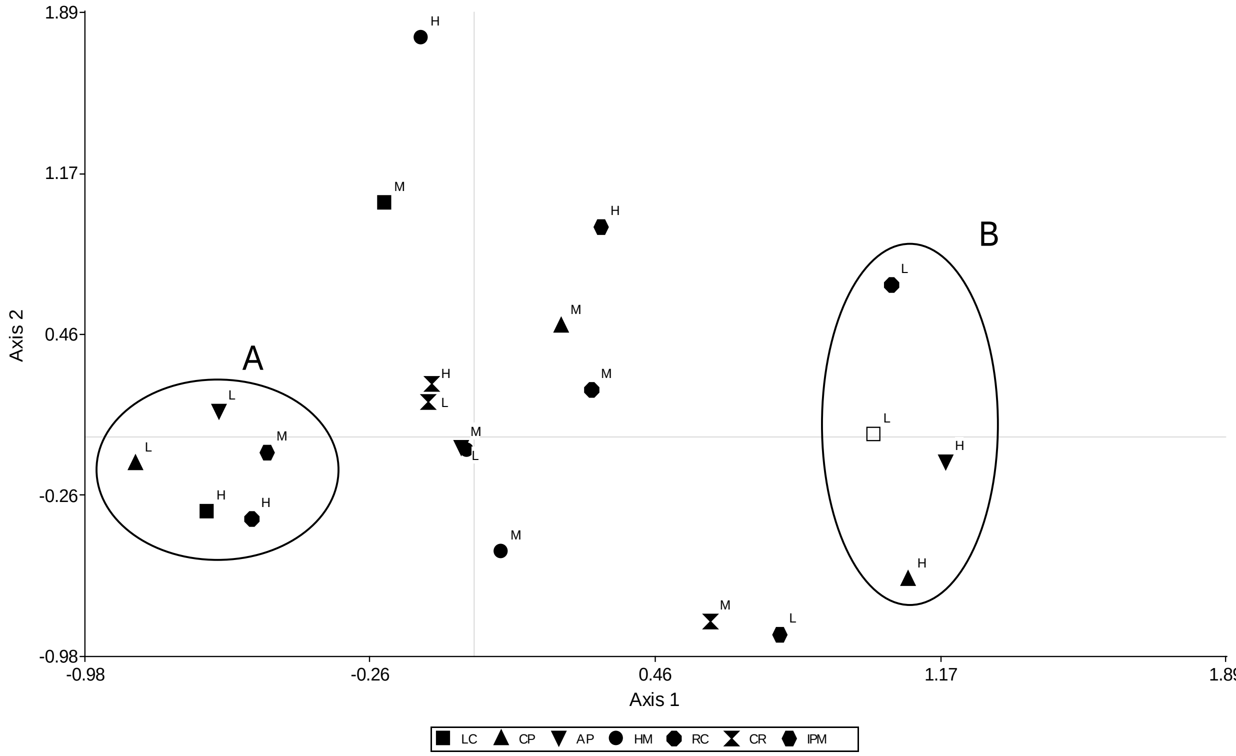

Figure 4-2. Distribution of the levels of preferences for each management strategy based on a multiple correspondence analysis (MCA). LC= lethal control, CP= crop protection, AP= agricultural practices, HM= habitat management, RC= reproductive control, CR= capture and release, IPM= integrated pest management. Levels of preference: L= low, M= medium, H= high. Group A represents high level of preference for population control methods (lethal and reproductive control) and low preferentes for crop protection and agricultural practices. Group B represents the reverse.

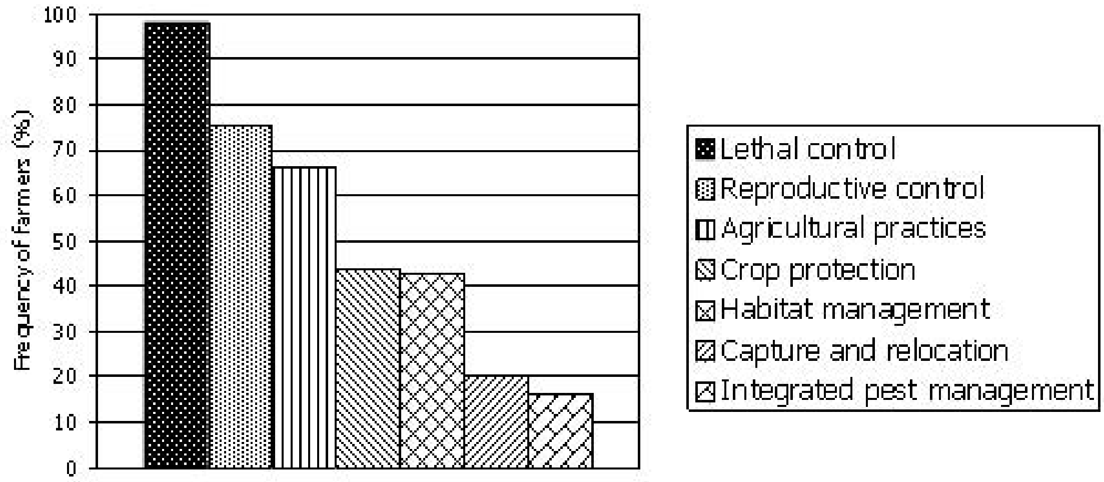

Figure 4-3. Frequency of farmers knowing about management alternatives for decreasing monk parakeet damage before the interviews.

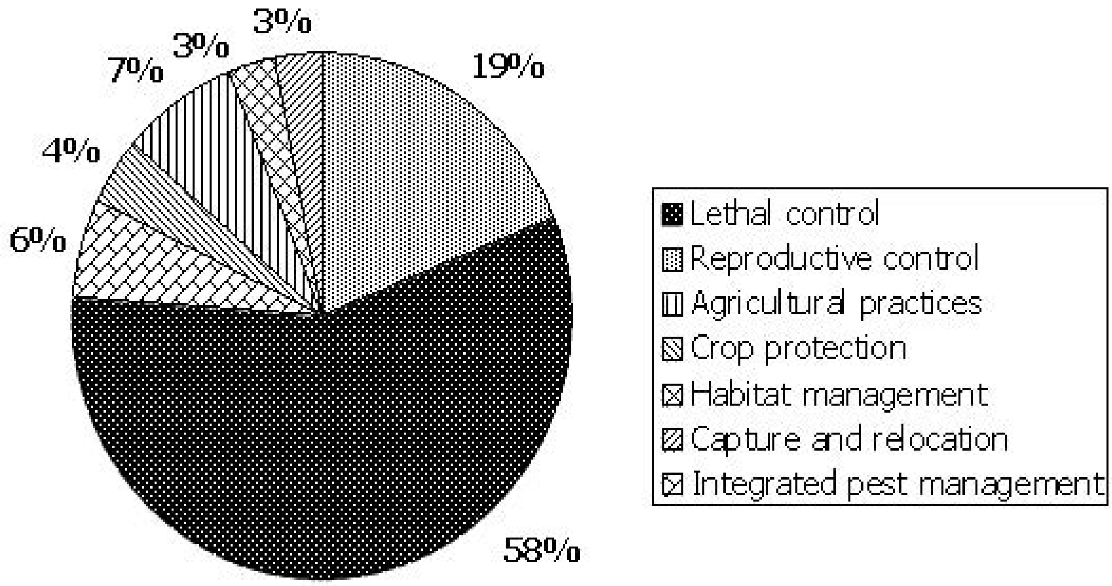

Figure 4-4. Frequency of farmers reporting management alternatives for decreasing monk parakeet damage as the most effective one among all known alternatives.

Table 4-1. Summary of regression results for socio-psychological and socio-demographic variables and preferences for management strategies. Values for each variable correspond to the β-regression coefficient and their respective standard error (in parenthesis). The table includes only variables with statistically significant relationships with preferences, either in the bivariate Chi-square tests or the regression models. Significance was set as p= 0.05 for both tests. Management strategies are ordered based on farmers´ preferences. Management strategies: RC= reproductive control, LC= lethal control, IPM= integrated pest management, CP= crop protection, AP= agricultural practices, HM= habitat management, CR= capture and relocation.

Variable name	RC	LC	IPM	CP	AP	HM	CR
Socio-psychological factors							
Perception of problems with monk parakeet							
- Perception of damage in the last 3 yrs							
- Perception of damage trend							
- Tolerance to damage							
- Importance of monk parakeet damage		0.38 (0.16)					
Previous knowledge of each strategy	0.94 (0.38)	1.13 (0.55)**	1.33 (0.53)				1.35 (0.52)
Beliefs about effectiveness of each strategy	0.44 (0.16)	0.71 (0.20)	0.50 (0.23)**	0.01 (0.20)	0.18 (0.26)		0.58 (0.25)**
Attitudes toward monk parakeets	-1.26 (0.25)	-1.53 (0.29)		1.07 (0.24)	0.96 (0.24)		0.80 (0.28)
Subjective norms about monk parakeet control	0.57 (0.23)	0.01 (0.01)*				0.45 (0.23)**	
Perceived control of bird pest management			0.33 (0.23)*				
Socio-demographic factors							
Age	0.34 (0.17)**	0.34 (0.17)			-0.41 (0.16)**		
Education	-0.56 (0.20)	-0.44 (0.20)**			0.41 (0.20)**		
Farm area	-0.31 (0.23)*					0.29 (0.23)*	
Percentage area devoted to crops	-0.18 (0.22)*						
Social participation	0.57 (0.24)*						

* Statistically significant relationship in the bivariate Chi-square test but not in the regression model.
** Statistically significant relationship in the regression model but not in the Chi-square test.

Table 4-2. Top performing variables related to preferences of farmers for management strategies to decrease monk parakeet damage to crops based on the AIC value and percent concordance, which represents the association of predicted probabilities and observed responses. Models with ΔAICc ≤ 2 are considered competitive models and are presented here. Management strategies are ordered based on farmers´preference. AIC values are not comparable among strategies, because they correspond to different data sets (one for each management strategy).

Method	Variable name	AIC	Percent concordant
Reproductive control (RC)	Attitudes toward monk parakeets	203.93	54.40
Lethal control (LC)	Attitudes toward monk parakeets	192.81	59.20
Integrated Pest Management (IPM)	Previous knowledge of each strategy	229.41	20.00
	Beliefs about effectiveness of each strategy	230.67	20.30
Crop protection (CP)	Attitudes toward monk parakeets	222.77	49.70
Agricultural practices (AP)	Attitudes toward monk parakeets	226.58	48.30
Habitat management (HM)	Perception of damage trend	218.37	45.70
	Subjective norms about monk parakeet control	218.97	42.90
	Tolerance to damage	220.17	37.90
Capture and relocation (CR)	Attitudes toward monk parakeets	140.55	48.70
	Previous knowledge of each strategy	142.36	32.10

Table 4-3. Results from bivariate Chi-square test evaluating the correlation between independent variables. Values correspond to the Chi-square test statistic and the corresponding p-value in parenthesis. In cases where only one value is reported, it corresponds to the p-value of the Fisher test.

	Attitudes toward monk parakeets	Subjective norms about monk parakeet control	Perceived control regarding bird pest management
Socio-psychological factors			
Perception of problems with monk parakeet			
- Perception of damage on the last 3 yrs	0.42	2.45 (0.87)	6.16 (0.41)
- Perception of damage trend	0.28	5.63 (0.69)	9.68 (0.29)
- Tolerance to damage	0.41	1.32 (0.86)	5.62 (0.23)
- Importance of monk parakeet damage (loss)	7.68 (0.26)	2.00 (0.92)	6.24 (0.40)
Previous knowledge of each strategy	0.62	0.21	0.54
Beliefs about effectiveness of each strategy	0.04 *	0.03 *	0.57
Socio-demographic factors			
Age	11.91 (0.06)	6.38 (0.38)	7.06 (0.31)
Education	< 0.001 *	0.32	2.38 (0.88)
Farm area	1.88 (0.76)	4.74 (0.31)	6.49 (0.16)
Percentage area devoted to crops	5.59 (0.23)	5.75 (0.22)	3.09 (0.54)
Social participation	2.35 (0.31)	0.51 (0.77)	0.38 (0.83)

* Indicates statistically significant relationships at p= 0.05.

CHAPTER 5
CONCLUSIONS

Influence of Local and Landscape Variables on Monk Parakeet Abundance or Damage in Crop Fields and Nesting Sites

Agricultural landscapes are a mixture of cultivated and uncultivated patches (fields), varying in composition (i.e., amount of land cover types in the landscape) and configuration (i.e., spatial arrangement of patches within the landscape) at multiple spatial and temporal scales (Forman and Godron 1986; Burel and Baudry 1995; Holt *et al.* 1995; Landis and Marino 1999). Mobile species using these landscapes, including bird species causing damage to crops, often use cultivated and non-cultivated patches in their life cycles. The abundance and distribution of these cultivated and non-cultivated patches in the agricultural landscape may influence both the abundance and damage of a bird species on a particular patch or crop field (Otis and Kilburn 1987; Tourenq *et al.* 2001; Amano *et al.* 2004, 2008; Hagy *et al.* 2008). Similarly, the abundance and distribution of these cultivated and non-cultivated patches may influence the abundance of birds in nesting sites within the agricultural landscape (Bruun and Smith 2003; Surmacki 2005).

Monk parakeet abundance and damage varied in this study with the type of the crop in the field, being greater in sunflower than in corn fields (Chapter 2). Although monk parakeet abundance and damage were correlated, particularly in corn fields, I was able to explain damage to crops by monk parakeets better than monk parakeet abundance. Probably, because damage is cumulative and abundance data represent an “instantaneous picture”, relationships of damage to within-field, field and landscape variables emerged more clearly than with abundance data.

Landscape characteristics around crop fields were consistently more important than local characteristics of the crop field for explaining monk parakeet damage in a field (Chapter 2). This result may indicate the importance of landscape processes, such as landscape complementation and supplementation, for a central-place forager such as the monk parakeet. Monk parakeets use nests all year around, both for breeding and roosting, and they travel limited distances each day from the nest to foraging sites (Spreyer and Bucher 1998). The increase in damage in sunflower fields proximate to sites with man-made structures and trees, and in corn or sunflower fields surrounded by abundant trees, may reflect lower energetic costs for monk parakeets traveling short distances from the nest or loafing areas to foraging sites. The proximity of foraging and nesting sites may result in larger numbers of parakeets aggregating at those sites or the lower energetic cost may favor an increase in population size of parakeets and, consequently, damage on particular plots within those landscapes. Additionally, the increase in damage in crop fields with greater availability of alternative foraging sites for monk parakeets on the landscape around the crop fields may be related to the generalist foraging behavior of monk parakeets (Bucher *et al.* 1991; Hyman and Pruett-Jones 1995), which may allow potentially higher populations in the area and, consequently, higher damage in particular fields within that area.

Local characteristics of the field, although less important than landscape characteristics, also favored monk parakeet damage to crop fields, particularly on sunflower fields. Fields with small area, low plant density and high percentage of patches with trees around the field usually were more prone to damage by monk parakeets than other sunflower fields. These results support the need of considering local and landscape-level variables for predicting and managing bird damage to crop fields (Clergeau 1995; Tourenq *et al.* 2001; Amano *et al.* 2008; Hagy *et al.* 2008).

In contrast to damage, the density of monk parakeet nests in inhabited farms with eucalyptus trees was not clearly explained by any variable or combination of variables modeled in this study, either at local or landscape level (Chapter 3). The proportion of eucalyptus canopy area in the nesting patch, a local variable, was more important than any other variable at local and landscape level, but this variable had low explanatory capability. Several factors could explain the poor performance of local and landscape variables in explaining density of monk parakeet nests. Some important variables may not have been measured or the way the variables were measured may not have been optimal for capturing the influence of those variables. For example, buffer extents used in this study may have been not large enough to capture habitat features related to nest settlement, such as availability of foraging sites. Finally, factors related to the behavior of monk parakeets could have influenced nest density more than habitat variables at local and landscape levels, including colonial habits, natal philopatry, or generalist foraging behavior of monk parakeets.

The importance of landscape variables for explaining monk parakeet damage in foraging sites (crop fields) compared to monk parakeet abundance in nesting sites (sites with eucalyptus trees) may be explained by the range of movements associated with each process. The scale of response to the environment by mobile species depends on the ecological process under consideration and the movement ranges of these species (Addicott *et al.* 1987; Wiens 1989; Holland *et al.* 2004). Daily movements of monk parakeets from the nest to feeding area are generally between 3 and 5 km while breeding, but can reach 24 km outside the reproductive season (Spreyer and Bucher 1998). Dispersal distances from natal nest to first breeding site usually ranges between 0.3 to 2 km, and when changing nests from one year to another, mean distance of movement is 0.5 km (maximum= 2.5 km, Martin and Bucher 1993; Spreyer and Bucher 1998). Therefore, daily foraging activities of monk parakeets comprise a bigger area than annual reproductive activities. Consequently, landscape scale variables may influence foraging activities more than reproductive activities.

Human Dimensions of Conflicts between Monk Parakeets and Crop Production

Population control strategies, such as nest destruction and killing of birds, were perceived by farmers as the most effective strategies for decreasing monk parakeet damage to crops and also were the most preferred (Chapter 4). The use of these strategies is historical in Argentina (Bucher and Bedano 1976; Bucher 1984; Aramburú 1991; Bucher 1992 a and b; Bruggers *et al.* 1998), including the region of this study (Zaccagnini and Bucher 1983; Giménez and Salomón 2000). The stated preferences were consistent with field observations from my assessment of factors influencing the distribution of parakeet nests. In farms where farmers used control methods against monk parakeets, the most common methods were centered on population control, applying lethal control by shooting, either as the only control measure or combined with removing or burning nests. Non-lethal population control measures were centered in reproductive control, including removing nests, burning nests, or capturing nestlings alive for pet trade.

Preferences of farmers for management strategies were related more strongly to attitudes toward monk parakeets than to any other socio-psychological or socio-demographic factor. Similar to what has been found in previous studies looking at the influence of attitudes on preferences for management actions involving wildlife species (e.g., Bjerke *et al.* 1998; Stout *et al.* 1997; Don Carlos *et al.* 2009; Loyd and Miller 2010), most farmers with negative attitudes toward monk parakeet preferred invasive population control methods, such as lethal and reproductive control, and farmers with positive attitudes toward monk parakeets preferred non-lethal strategies, such as crop protection and agricultural practices. Given crop damage from monk parakeets was considered tolerable, the predominantly negative attitudes toward monk parakeets could be related to past problems more than the perception of actual damage (Zinn and Andelt 1999). This proposition may be supported by the relationship of attitudes toward monk parakeets with age, with older farmers having predominantly negative attitudes compared to younger farmers.

Preferences of farmers for management strategies also were strongly associated with perceived efficacy of management strategies and, to a lesser extent, to previous knowledge about those strategies. Other socio-psychological factors, such as subjective norms and perceived control, were related to preferences of farmers for management strategies but to lesser degree than attitudes. Finally, preferences for management strategies, including lethal or reproductive control, generally were not related to perceptions of magnitude of damage by monk parakeets or socio-demographic variables, such as age and education, although there were some disparities depending on the management strategy under consideration.

The prediction of behavior or intention to act is a complex process based on multiple factors (Fishbein and Ajzen 1975; Hines *et al.* 1986; Ajzen 1991; Norton and Mumford 1993). Socio-psychological variables, such as attitudes, perception of efficacy, economic orientation, etc., and cognitive variables, such as knowledge of environmental problems and how to take action, are known to influence the intention to act (or verbal commitment) in responsible environmental behaviors more than socio-demographic factors, such as age, income, education and gender (Hines *et al.* 1986). Results from this study generally were consistent with previous studies looking at human dimensions of human-wildlife conflicts (e.g., Bjerke *et al.* 1998; Stout *et al.* 1997; Don Carlos *et al.* 2009; Loyd and Miller 2010) and form a basis to understand farmers´ preferences for current population control measures.

Management Implications

Monk parakeet damage to corn and sunflower fields has been documented as an important concern for agricultural producers in some areas of Argentina (Bucher 1984, 1992a, b; Bruggers y Zaccagnini 1994; Bruggers *et al.* 1998). In my study, farmers perceived a problem exists and indicated a preference for population control methods, either lethal (e.g., toxic baits, nest poisoning with pesticides) or reproductive (e.g., nest removal, burning, etc.), to reduce monk parakeet damage to crops. However, damage in corn and sunflower fields evaluated in this study was relatively low (< 5 % of damaged plants, corresponding to less than 3% of grain loss, Canavelli *et al.* 2008), and damages were perceived as low to moderate but tolerable by most farmers. Additionally, no control measures against monk parakeet damage were observed on any of the surveyed crop fields in this study, and people did not apply any control measures against monk parakeets at most farms with eucalyptus trees surveyed in this study. Therefore, there is little evidence from this study for the need of controlling monk parakeets, at least in the region where the study was conducted.

Based on this study, when management measures are needed, managers should consider local factors, such crop type, field area and plant density, when planning management measures to prevent monk parakeet damage to crop fields, particularly to sunflower fields. Also, managers trying to reduce the number of monk parakeet nests in inhabited farms with eucalyptus trees would have to consider limiting the available nest sites at local scales. This could be done by removing eucalyptus trees or by modifying the structure of the eucalyptus trees. Potentially, the removed eucalyptus trees could be replaced by other trees not adequate for nesting. However, none of these management strategies has been evaluated.

The only management technique at the landscape scale that emerged from this study that might decrease damage to crops fields by monk parakeets and abundance of nests in farms would be to decrease the amount of tree patches around crop fields or farms. For example, farmers could try to locate crop fields at least 1 km from places with man-made structures and trees ("cascos" or farms) and other patches with trees in order to prevent monk parakeet damage. However, decreasing the amount of tree patches around the crop fields or the farms will be difficult without cutting down the trees. Eliminating trees, either for decreasing monk parakeet damage to crops or nest abundance in inhabited farms, would result in a more simplified landscape, which could have important consequences for biodiversity and ecosystem services provided by biodiversity, including the regulation of other crop pests (Bianchi *et al.* 2006; Power 2010; Batáry *et al.* 2011). Detailed information about the cost of control, not only economical but also environmental, compared to economic loss from damage would be particularly useful to put the problem of damage to crops by monk parakeets in perspective for farmers and to select management measures that are socially optimal (i.e., with more benefits for the whole society than for individual landowners, Tisdell 1982).

Several management strategies are currently available at field level that may reduce monk parakeet damage to crop fields or protect those fields from damage, including altering agricultural practices and crop protection measures, such as increasing crop density and sowing deterrent crops, or using biorepellents (Canavelli and Aramburú, *in press*). Unfortunately, no evaluations have been made of the efficacy of these management strategies to decrease monk parakeet damage to crops or the cost-benefit ratio of applying these techniques. Additionally, this study indicated that these management strategies currently are not among the most preferred by farmers.

Considering reproductive control was the most preferred management strategy by farmers in this study, a population control that could be promissory for the future is chemical contraception. Current research indicates the effectiveness of Diazacon as a chemical inhibitor of reproduction for monk parakeets (Avery *et al.* 2008). However, at the moment there is not a registered product for reducing fertility of monk parakeets in any country worldwide. In addition, multiple aspects related to the use of chemical contraceptives, such as biological feasibility, economic practicality and health and safety issues, including impact on non-target species (Avery *et al. 2008*; Fagerstone *et al.* 2010), would have to be addressed before a product is available for reproductive control of monk parakeets in Argentina.

In order to shape farmers' opinions and management decisions about strategies other than lethal or reproductive control in the way they are currently applied, it is necessary to evaluate the efficacy of alternative strategies, both at local and landscape levels, in those regions where conflicts with monk parakeets are important. Given the current uncertainties in the outcome of management actions to decrease monk parakeet damage to crops, an adaptive management approach, in which multiple land owners are involved and experiments with different management options are conducted in the region (Holling 1978; Walters 1997; Shea *et al.* 2002; Parkes *et al.* 2006) is appropriate (Canavelli and Zaccagnini 2007; Canavelli and Aramburú, *in press*). Extension actions within a management program also would have to integrate people with different points of view, in order to avoid public controversies about management. Finally, research and extension actions should be proactive, so that intolerable losses are anticipated and avoided instead of trying to eliminate a situation once it has occurred.

APPENDIX A
COMPLEMENTARY RESULTS FROM CHAPTERS 2 AND 3

Table A-1. Correlations between landscape metrics used to quantify landscape composition and configuration around focal fields. Values are given for the 3000-m buffer for sunflower fields. Different buffer widths for different crops (corn or sunflower) have different values for the correlation coefficients, but the relationships between variables are qualitatively similar.

	CRPLAND*	CRSHAPE	CRMNN	CRCLUMP	TRPLAND	TRSHAPE	TRMNN	TRCLUMP	PSTPLAND
CRPLAND	1.00	0.63	-0.71	-0.38	-0.61	-0.52	0.52	0.22	0.26
CRSHAPE		1.00	-0.63	-0.65	-0.47	-0.27	0.45	-0.32	0.41
CRMNN			1.00	0.79	0.41	0.32	-0.26	0.19	-0.41
CRCLUMP				1.00	0.39	0.32	-0.26	0.30	-0.45
TRPLAND					1.00	0.89	-0.70	0.64	-0.34
TRSHAPE						1.00	-0.65	0.54	-0.39
TRMNN							1.00	-0.25	0.14
TRCLUMP								1.00	-0.03
PSTPLAND									1.00

* CRPLAND = Percentage of landscape comprised by crops susceptible to damage (corn and sunflower), CRSHAPE = Mean shape of crop patches susceptible to damage in the landscape, CRMNN = Mean nearest neighbor distance among crop patches susceptible to damage, considering all patches on the landscape, CRCLUMP = Clumpiness index of crop patches susceptible to damage, TRPLAND = Percentage of landscape comprised by tree patches, TRSHAPE = Mean shape of tree patches in the landscape, TRMNN = Mean nearest neighbor among tree patches, considering all tree patches on the landscape, TRCLUMP = Clumpiness index of tree patches, PSTPLAND = Percentage of landscape comprised by pastures and other agricultural uses (including weedy and fallow fields).

Table A-2. Suite of models used to describe the relative abundance and damage of monk parakeet to crop fields at within-field, field and landscape levels in Paraná (Entre Ríos, Argentina), 2007-2008. Models were run for corn and sunflower separately.

	Within-field			Field			Landscape[2]			
Within-field	PLTDEN	PHENST	WDCOV	AREA	SHAPE	TREES	CRPLAN	CRCLUMP	TRPLAND	PSTPLAND
1	x									
2		x								
3			x							
4		x	x							
5	x	x								
6	x		x							
7	x	x	x							
Field										
1				x						
2					x					
3						x				
4				x		x				
5					x	x				
6				x	x					
7				x	x	x				
Landscape[2]										
1										
2							x			
3								x		
4									x	
5										x
6								x	x	
7							x	x		
8							x			x
9									x	x
10								x	x	x
11							x	x		x

Table A-2. Continued

	Within-field			Field			Landscape[2]			
Multi-level[3]	PLTDEN	PHENST	WDCOV	AREA	SHAPE	TREES	CRPLAN	CRCLUMP	TRPLAND	PSTPLAND
Sunflower										
1	x			x					1x	
2	x			x					3x	
3	x			x					5x	
Corn										
1		x			x				1x	
2		x			x				3x	
3		x			x				5x	

[1] PLTDEN= Plant density, PHENST= Phenological stage, WDCOV= Weed coverage, AREA= Field area, SHAPE = field shape index, TREES= Abundance of trees on border, CRPLAND = Percentage of crops susceptible to damage (corn and sunflower), CRCLUMP = Clumpiness index of crop patches susceptible to damage, TRPLAND = Percentage of tree patches, PSTPLAND = Percentage of pastures and other agricultural uses (including weedy and fallow fields). [2] Models at this level were estimated at three buffer extents (1, 3 and 5 km) around each crop field. Models at 1 km-buffer extent included an additional variable (DISTCO= distance to the nearest site with man-made structures and trees). [3] Multi-level models were estimated only for damage. Numbers preceding the letter code “x” for landscape variables indicate buffer sizes (in kilometers).

Table A-3. Correlations between landscape metrics used to quantify landscape composition and configuration around nesting patches. Values are given for the 3000 m buffer. Different buffers had different values for the correlation coefficients, but the relationships between variables were qualitatively similar.

	CRPLAND	PSTPLAND	TRPLAND	TRPD	TRED	TRMNN	TRCLUMP	TRSHAPE
CRPLAND	1.00	0.13	-0.35	0.54	-0.10	0.28	-0.37	-0.39
PSTPLAND		1.00	-0.59	0.42	-0.46	0.51	-0.53	-0.53
TRPLAND			1.00	-0.25	0.87	-0.93	0.68	0.86
TRPD				1.00	0.07	0.18	-0.25	-0.32
TRED					1.00	-0.89	0.44	0.82
TRMNN						1.00	-0.59	-0.87
TRCLUMP							1.00	0.54
TRSHAPE								1.00

CRPLAND= Percentage of landscape with preferred food crops, PSTPLAND= Percentage of landscape with pastures and other agricultural uses (including weedy and fallow fields), TRPLAND= Percentage of landscape with trees (either native or introduced) in the landscape, TRPD= Density of patches with trees on the landscape (#/km^2) ,TRED= Edge density of tree patches, TRMNN = Mean nearest neighbor among all tree patches in the landscape, TRCLUMP = Clumpiness index of tree patches, TRSHAPE = Shape index for tree patches.

APPENDIX B
QUESTIONNAIRE STRUCTURE AND CONTENT

A.1. Farmer and farm identification

The first page of the questionnaire served to obtain personal information about the farmer (name, address, phone number, etc.) and the farm to which the farmer was referring the answers, including its geographical reference.

A.2. Farmers´ perceptions and beliefs about monk parakeet damage to crops

a. Perception of damage on the last three years, the last crop season (August 2006-May 2007) and its trend on the last 3 years.
b. Tolerance to damage on specific crops: corn, sunflower, soybean, wheat, sorghum, alfalfa, foxtail and cattail millet.
c. Importance of monk parakeet damage compared to other crop loss causes, including insects, weeds, diseases and weather.
d. Factors farmers consider could favor monk parakeet damage to crops, including proximity to woodland, utility tower, agricultural practices, etc.

A.3. Farmers´ perceptions and attitudes toward monk parakeets

a. Perception of monk parakeet abundance and its trend on the last 3 years.
b. Attitudes toward monk parakeets (Likert scale).
c. Opinion of farmers about different types of woodlands as refuge for monk parakeets.

A.4. Farmers knowledge and preferences for management strategies to decrease monk parakeet damage to crops

a. Knowledge of at least one management strategy.
b. Knowledge about particular management strategies (7 options).

c. Beliefs about effectiveness of particular management strategies.
d. Preferences for management strategies (paired comparisons).
e. Willingness to try new management alternatives.
f. External factors influencing the decision to use a particular management strategy, including economic cost, toxicity and available information.

A.5. Personal and external influences on the application of management strategies

a. Personal confidence about particular techniques.
b. External factors limiting the application of these techniques.
c. Farmers' opinion on what they suppose other people expect for them to do in relation to monk parakeet control.
d. Influence of other peoples´ opinion on farmers' management decisions.

A.6. Socio-demographic information

Socio-demographic variables, including age, educational level, operated area, area of farm devoted to crops and other productive activities, percentage of income from crops and other productive activities, affiliation of a farmer to a farming or a conservation organization, participation in farmers´ meetings, and information sources about pest management.

For a copy of the questionnaire in Spanish, see Appendix C.

APPENDIX C
QUESTIONNAIRE IN SPANISH

EVALUACIÓN DE PROBLEMAS OCASIONADOS POR COTORRAS EN CULTIVOS

DEPARTAMENTO PARANÁ

Cuestionario para entrevistas personales a productores

Fecha: ____ / ____ / ____ (día/mes/año)

1. IDENTIFICACIÓN DEL PRODUCTOR

1.1. Apellido y nombre del productor

____

1.2. Domicilio

Calle/Ruta, Nº/km (solo si difiere de la dirección de la explotación)

____

Código Postal: ____________________

Localidad o paraje más cercano: ____

Teléfono: _______________________ Celular: _________________________

Correo electrónico: ____

2. IDENTIFICACIÓN DE LA EXPLOTACIÓN AGROPECUARIA

2.1. Nombre:____

2.2. Ubicación:

Departamento: Paraná ____ Otro________________________

Calle/Ruta, Nº/km (Nomenclatura catastral)

____

Código Postal: ____________________

Localidad o paraje más cercano: ____

Ubicación respecto al mismo (km, orientación):_______________________________________

____

Coordenadas geográficas:

Latitud: __________________ º S Longitud: _________________ º W

3. INFORMACION SOBRE DAÑO POR COTORRAS

Q1 **Ha experimentado daño por cotorras en cultivos de su producción en los últimos 3 años** (PERIODO DE REFERENCIA: MAYO 2004-MAYO 2007), **si o no?**

NO………..	1	→ IR A Q8
SI…….…...	2	
NO CONTESTA….	9	

Q2 **El daño de cotorras ha sido insignificante, moderado, intenso o total en estos 3 años?**

INSIGNIFICANTE	1
MODERADO	2
INTENSO	3
TOTAL	4
INDECISO	7
NO CONTESTA	9

Q3 **Si tuviera que asignar un porcentaje al daño total por cotorras en esta última campaña** (2006-7 – PERÍODO DE REFERENCIA: 1 AGOSTO 2006- 31 MAYO 2007)**, cuánto estimaría que fue el mismo?**

< 5%	1
5-10%	2
10-25%	3
25-50%	4
50-75%	5
75-100%	6
INDECISO	7
NO CONTESTA	9

Q4 **Este porcentaje sería menor, igual o mayor al daño promedio de los últimos 3 años?**

MENOR	1
IGUAL	2
MAYOR	3
INDECISO	7
NO CONTESTA	9

Q5 **En base a su experiencia, consideraría el daño por cotorras tolerable o intolerable en los siguientes cultivos?**

		NO HACE EL CULTIVO	**HACE -CULTIVO**			**INDECISO**
ID	**CULTIVO**		**NO DAÑO**	**DAÑO TOLERABLE**	**DAÑO INTOLERABLE**	
1	**MAÍZ**	0	1	2	3	7
2	**GIRASOL**	0	1	2	3	7
3	**SOJA**	0	1	2	3	7
4	**TRIGO**	0	1	2	3	7
5	**SORGO**	0	1	2	3	7
6	**ALFALFA**	0	1	2	3	7
7	**MOHA**	0	1	2	3	7
8	**MIJO**	0	1	2	3	7
9	**OTRO (ESPECIFICAR)** ____________________	0	1	2	3	7
	NO CONTESTA		9			

Q6 **Las pérdidas ocasionadas por cotorras serían menor, igual o mayor que la producidas por insectos, malezas, enfermedades, clima, cosechadora, u otras causas?**

ID		MENOR	IGUAL	MAYOR	INDECISO	NO CONTESTA
1	INSECTOS	1	2	3	7	9
2	MALEZAS	1	2	3	7	9
3	ENFERMEDADES	1	2	3	7	9
4	CLIMA	1	2	3	7	9
5	COSECHADORA	1	2	3	7	9
6	OTRAS(MENCIONAR) ________________	1	2	3	7	9

Q7 **A continuación, voy a mencionarle factores que podrían favorecer el daño por cotorras a sus cultivos. En su opinión, cuáles serían factores importantes en su explotación?**

		No importante	**Algo importante**	**Muy importante**	INDECISO	NO CONTESTA
1	**ABUNDANCIA DE COTORRAS**	0	1	2	7	9
2	**PROXIMIDAD A MONTES**	0	1	2	7	9
3	**PROXIMIDAD A TORRES DE ALTA TENSIÓN**	0	1	2	7	9
4	**PRÁCTICAS AGRÍCOLAS** *(SIEMBRA, COSECHA, ETC.)*	0	1	2	7	9
5	**ALIMENTO DISPONIBLE DURANTE EL INVIERNO** *(FEEDLOTS, RASTROJO, ETC)*	0	1	2	7	9
6	**OTROS (ESPECIFICAR)** ____	0	1	2	7	9

4. INFORMACIÓN SOBRE COTORRAS

Q8 **Piensa Ud. que en su explotación hay pocas cotorras, algunas, o muchas?**

POCAS	1
ALGUNAS	2
MUCHAS	3
INDECISO	7
NO CONTESTA	9

Q9 **Si compara este número con el número promedio de cotorras en los últimos 3 años, pensaría que es menor, igual o mayor?**

MENOR	1
IGUAL	2
MAYOR	3
INDECISO	7
NO CONTESTA	9

Q10 **A continuación, nos gustaría conocer su opinión acerca de las cotorras** *(en este momento y en general, no necesariamente asociado al momento en que hacen o no hacen daño)*. **Por favor, le agradecería nos indique cuánto está en acuerdo o desacuerdo con las frases siguientes:**

		En desacuerdo	De acuerdo	Indeciso	No contesta
1	**Las cotorras nos alegran con su presencia.**	1	2	7	9
2	**Afortunadamente, podemos convivir con las cotorras.**	1	2	7	9
3	**Las cotorras son criaturas que deben ser protegidas.**	1	2	7	9
4	**Me molestan las cotorras porque disminuyen mi producción.**	1	2	7	9
5	**Las cotorras me imposibilitan la siembra de girasol o maíz.**	1	2	7	9
6	**Detesto el parloteo de las cotorras.**	1	2	7	9
7	**Las cotorras no sirven para nada.**	1	2	7	9
8	**Me gustan las cotorras.**	1	2	7	9
9	**Me molestan las personas que protegen a las cotorras.**	1	2	7	9
10	**Me gusta observar a las cotorras en el campo.**	1	2	7	9
11	**Me duele ver como se persigue a las cotorras.**	1	2	7	9
12	**Valoro mucho a las cotorras.**	1	2	7	9
13	**Las cotorras solo me hacen perder dinero.**	1	2	7	9
14	**Odio a las cotorras.**	1	2	7	9

Q11 **A continuación, voy a mencionarle distintos tipos de monte que podrían actuar como refugio para las cotorras. Por favor, podría indicarme en cada caso si Ud. considera que los mismos actúan como un refugio para las cotorras o no?**

		REFUGIO?		
ID	TIPO DE MONTE	NO	SI	INDECISO
1	**Nativo**	1	2	7
2	**De eucaliptus**	1	2	7
3	**Introducido distinto de eucaliptus**	1	2	7
4	**Mixto con eucaliptus**	1	2	7
5	**Mixto sin eucaliptus**	1	2	7
	NO CONTESTA	9		

5. INFORMACIÓN SOBRE MANEJO DEL DAÑO POR COTORRAS

Q12 **Conoce algún método para disminuir el daño por cotorras, si o no?**

NO……….. 1 → IR A Q19
SI……........ 2
NO CONTESTA…. 9

Q13 **A continuación, voy a leerle un listado de 7 métodos que son comúnmente utilizados en el manejo de aves perjudiciales. Para cada uno, podría por favor indicarme si lo conoce o no, y por qué medio lo conoce (experiencia propia, experiencia de los vecinos, u otros medios)?**

	METODO	CONOCE NO	SI	MEDIO Experiencia propia ·	Vecinos	Otros (especificar)
1	**Control letal** *(como trampas, veneno en los nidos, cebos tóxicos, disparos de escopeta)*	1	2	**3**	4	5 ____________
2	**Protección del cultivo** *(como repelentes químicos, auditivos- cañones de explosión, disparos de escopeta-, visuales)*	1	2	**3**	4	5 ____________
3	**Prácticas agrícolas** *(siembra profunda, cosecha anticipada)*	1	2	**3**	4	5 ____________
4	**Manejo del ambiente** *(poda o eliminación de árboles, siembra de cultivos trampa)*	1	2	**3**	4	5 ____________
5	**Control de reproducción** *(como volteo y /o quema de nidos, aceite en los huevos, sustancias químicas que evitan la reproducción)*	1	2	**3**	4	5 ____________
6	**Trampeo** *(captura viva)* **y/o reubicación**	1	2	**3**	4	5 ____________
7	**Manejo Integrado de Aves Plaga** *(MIP)*	1	2	**3**	4	5 ____________

Q14 **Para cada uno de los métodos conocidos por Ud., ya sea por experiencia propia o por otros medios, podría indicarme por favor si considera que no es efectivo o es efectivo (algo o muy efectivo)?. A continuación, voy a leerle la lista nuevamente.**

	METODO	NO EFECTIVO	ALGO EFECTIVO	MUY EFECTIVO	SIN OPINIÓN
1	CONTROL LETAL	1	2	3	0
2	PROTECCIÓN DEL CULTIVO	1	2	3	0
3	PRÁCTICAS AGRÍCOLAS	1	2	3	0
4	MANEJO DEL AMBIENTE	1	2	3	0
5	CONTROL DE REPRODUCCION	1	2	3	0
6	TRAMPEO Y/O REUBICACION	1	2	3	0
7	MANEJO INTEGRADO DE PLAGAS	1	2	3	0

Q15 **Ahora, en base a la efectividad que acabamos de mencionar, cuál piensa que es el más efectivo?. Si lo desea, con gusto puedo leerle la lista nuevamente.**

☐ 1.MAS EFECTIVO ☐ 2. SEGUNDO MAS EFECTIVO ☐ 3.TERCERO MAS EFECTIVO

Q16 **A continuación, vamos a presentarle pares de alternativas para disminuir el daño por cotorras. Para cada par, le agradeceríamos nos indique cuál de las 2 alternativas prefería aplicar, asumiendo fuera necesario disminuir el daño por cotorras a sus cultivos (por ejemplo, en la próxima campaña).**

ID#	Id1	Alternativa 1	Id2	Alternativa 2
1	1	Control letal	2	Protección del cultivo
2	3	Prácticas agrícolas	1	Control letal
3	1	Control letal	4	Manejo del ambiente
4	5	Control de reproducción	1	Control letal
5	1	Control letal	6	Captura viva
6	7	Manejo Integrado de Plagas	1	Control letal
7	2	Protección del cultivo	3	Prácticas agrícolas
8	4	Manejo del ambiente	2	Protección del cultivo
9	2	Protección del cultivo	5	Control de reproducción
10	6	Captura viva	2	Protección del cultivo
11	2	Protección del cultivo	7	Manejo Integrado de Plagas
12	4	Manejo del ambiente	3	Prácticas agrícolas
13	3	Prácticas agrícolas	5	Control de reproducción
14	6	Captura viva	3	Prácticas agrícolas
15	3	Prácticas agrícolas	7	Manejo Integrado de Plagas
16	4	Manejo del ambiente	5	Control de reproducción
17	6	Captura viva	4	Manejo del ambiente
18	4	Manejo del ambiente	7	Manejo Integrado de Plagas
19	5	Control de reproducción	6	Captura viva
20	7	Manejo Integrado de Plagas	5	Control de reproducción
21	6	Captura viva	7	Manejo Integrado de Plagas
22	5	Control de reproducción	2	Protección del cultivo
23	3	Prácticas agrícolas	4	Manejo del ambiente

Q17 **Nuevamente, asumiendo que fuera necesario para Ud. disminuir el daño por cotorras a sus cultivos (en la próxima campaña, por ejemplo), estaría o no dispuesto a probar técnicas de manejo diferentes a las que conoce?**

NO……….. 1 → IR A Q21
SI…….…..... 2
NO CONTESTA…. 9

Q18 **De ser así, cuáles alternativas estaría dispuesto o no estaría dispuesto a probar?**

	METODO	NO DISPUESTO	DISPUESTO	INDECISO	NO CONTESTA
1	CONTROL LETAL	1	2	7	9
2	PROTECCIÓN DEL CULTIVO	1	2	7	9
3	PRÁCTICAS AGRÍCOLAS	1	2	7	9
4	MANEJO DEL AMBIENTE	1	2	7	9
5	CONTROL DE REPRODUCCION	1	2	7	9
6	TRAMPEO Y/O REUBICACION	1	2	7	9
7	MANEJO INTEGRADO DE PLAGAS	1	2	7	9

IR A Q23

Q19 **En este caso, le gustaría conocer o no alternativas de manejo para disminuir el daño por cotorras a sus cultivos?**

NO……….. 1 → IR A Q21
SI…….…..... 2
NO CONTESTA…. 9

Q20 **A continuación, le voy a mencionar alternativas de manejo que son comúnmente utilizadas para disminuir los daños por aves perjudiciales. Las voy a mencionar en pares (es decir, de a dos) y, para cada par, le agradecería me indique cuál de los 2 alternativas desearía conocer primero. Si el método no es totalmente claro, con gusto puedo brindarle mayores detalles.**

ID#	Id1	Alternativa 1	Id2	Alternativa 2
1	1	Control letal	2	Protección del cultivo
2	3	Prácticas agrícolas	1	Control letal
3	1	Control letal	4	Manejo del ambiente
4	5	Control de reproducción	1	Control letal
5	1	Control letal	6	Captura viva
6	7	Manejo Integrado de Plagas	1	Control letal
7	2	Protección del cultivo	3	Prácticas agrícolas
8	4	Manejo del ambiente	2	Protección del cultivo
9	2	Protección del cultivo	5	Control de reproducción
10	6	Captura viva	2	Protección del cultivo
11	2	Protección del cultivo	7	Manejo Integrado de Plagas
12	4	Manejo del ambiente	3	Prácticas agrícolas
13	3	Prácticas agrícolas	5	Control de reproducción
14	6	Captura viva	3	Prácticas agrícolas
15	3	Prácticas agrícolas	7	Manejo Integrado de Plagas
16	4	Manejo del ambiente	5	Control de reproducción
17	6	Captura viva	4	Manejo del ambiente
18	4	Manejo del ambiente	7	Manejo Integrado de Plagas
19	5	Control de reproducción	6	Captura viva
20	7	Manejo Integrado de Plagas	5	Control de reproducción
21	6	Captura viva	7	Manejo Integrado de Plagas
22	5	Control de reproducción	2	Protección del cultivo
23	3	Prácticas agrícolas	4	Manejo del ambiente

IR A Q23

Q21 **Por favor, sería tan amable de indicarme al menos una razón de su negativa?**

NO CONTESTA 99

Q22 **Asumiendo que en la próxima campaña observa daños por cotorras en alguno de sus cultivos, podría indicarme cuál de los siguientes métodos probablemente aplicaría?. Si el método no es totalmente claro, con gusto puedo brindarle mayores detalles.**

		APLICARIA?			
	METODO	NO	SI	INDECISO	NO CONTESTA
1	**Control letal** *(como trampas, veneno en los nidos, cebos tóxicos, disparos de escopeta)*	1	2	7	9
2	**Protección del cultivo** *(como repelentes químicos, auditivos- cañones de explosión, disparos de escopeta-, visuales)*	1	2	7	9
3	**Prácticas agrícolas** *(siembra profunda, cosecha anticipada)*	1	2	7	9
4	**Manejo del ambiente** *(poda o eliminación de árboles, siembra de cultivos trampa)*	1	2	7	9
5	**Control de reproducción** *(como volteo y /o quema de nidos, aceite en los huevos, sustancias químicas que evitan la reproducción)*	1	2	7	9
6	**Trampeo** *(captura viva)* **y/o reubicación**	1	2	7	9
7	**Manejo Integrado de Aves Plaga** *(MIP)*	1	2	7	9

CONTINUAR CON Q23

==

Q23 **A continuación, le voy a leer un listado de 9 factores que podrían influir en su decisión de aplicar una alternativa de manejo del daño por cotorras. Para cada uno, podría por favor indicarme cuánto influye el factor (nada, algo o mucho) en su decisión?**

	FACTOR	**NADA**	**ALGO**	**MUCHO**	INDECISO	NO CONTESTA
1	**Costo económico**	1	2	3	7	9
2	**Costo de esfuerzo**	1	2	3	7	9
3	**Toxicidad**	1	2	3	7	9
4	**Efectividad esperada**	1	2	3	7	9
5	**Impacto en especies distintas a las cotorras**	1	2	3	7	9
6	**Requerimiento de colaboración con vecinos**	1	2	3	7	9
7	**Información disponible**	1	2	3	7	9
8	**Disponibilidad en el mercado de productos**	1	2	3	7	9
9	**Experiencia personal o de vecinos**	1	2	3	7	9

6. INFORMACIÓN SOBRE HABILIDADES PARA APLICAR TECNICAS DE MANEJO

Q24 **En las siguientes preguntas, imagine que se le presenta la posibilidad de aplicar una técnica de manejo para disminuir el daño por cotorras. No interesa lo que la técnica hace en sí misma, sólo que su objetivo es disminuir el daño, y es la primera vez que la utiliza. A continuación, le mencionaré una serie de habilidades necesarias para aplicar técnicas de manejo de conflictos con aves. Para cada una, le agradecería me indique si se siente inseguro, algo o muy seguro de poder aplicar esta nueva técnica de manejo en función de la habilidad mencionada.**

	HABILIDAD	**INSEGURO**	**ALGO SEGURO**	**MUY SEGURO**	INDECISO	NO CONTESTA
1	**Leer, comprender y seguir instrucciones de guías de uso.**	1	2	3	7	9
2	**Seguir estrictamente procedimientos de seguridad.**	1	2	3	7	9
3	**Controlar maquinaria.**	1	2	3	7	9
4	**Seleccionar la clase de herramientas para hacer el trabajo.**	1	2	3	7	9

	HABILIDAD	INSEGURO	ALGO SEGURO	MUY SEGURO	INDECISO	NO CONTESTA
5	**Considerar los costos y beneficios relativos de posibles acciones.**	1	2	3	7	9
6	**Tomar decisiones en base a información técnica.**	1	2	3	7	9
7	**Estar informado sobre técnicas de control de aves más allá de las químicas.**	1	2	3	7	9
8	**Saber identificar las aves involucradas en el daño.**	1	2	3	7	9
9	**Conocer el comportamiento de las aves involucradas en el daño.**	1	2	3	7	9
10	**Integrar información de los alrededores del campo en el análisis del problema.**	1	2	3	7	9
11	**Conocer las regulaciones vigentes sobre manejo de aves silvestres.**	1	2	3	7	9
12	**Conocer métodos de captura de aves (como trampas).**	1	2	3	7	9
13	**Conocer los plaguicidas y sus efectos más allá de la plaga.**	1	2	3	7	9
14	**Aplicar agroquímicos de acuerdo a las regulaciones vigentes.**	1	2	3	7	9
15	**Conocer propiedades de los agroquímicos.**	1	2	3	7	9
16	**Ejecutar acciones de seguimiento (monitoreo) de las técnicas aplicadas.**	1	2	3	7	9

Q25 **La habilidades antes mencionadas están condicionadas, en algunos casos, por limitantes que impiden su aplicación. A continuación, voy a leer una serie de limitantes que, en ciertos casos, podrían afectar su habilidad para aplicar medidas de manejo de aves perjudiciales. Por favor, le agradecería me indique en cada caso, si considera que las siguientes limitantes no limitan o limitan (algo o mucho) dicha habilidad.**

	LIMITANTES	NO LIMITAN	LIMITAN ALGO	LIMITAN MUCHO	INDECISO	NO CONTESTA
1	**Acceso restringido a información técnica.**	1	2	3	7	9
2	**Alta complejidad de las técnicas actuales.**	1	2	3	7	9
3	**Prejuicios en la comunidad sobre control letal.**	1	2	3	7	9
4	**Cuantificación dificultosa de los costos y beneficios de la aplicación de una técnica.**	1	2	3	7	9
5	**Acceso restringido a maquinarias o instrumentos para el control.**	1	2	3	7	9
6	**Condiciones ambientales adversas.**	1	2	3	7	9
7	**Información escasa sobre manejo de agroquímicos.**	1	2	3	7	9
8	**Alto costo de las técnicas actuales.**	1	2	3	7	9

7. INFORMACIÓN SOBRE INFLUENCIAS EXTERNAS

Q26 **A continuación, voy a mencionarle personas o grupos de personas que pueden influir en las decisiones de manejo de plagas. En cada caso, le agradecería me indique cuál sería su opinión sobre lo que cada persona o grupo de persona espera que Ud. haga para el manejo de las cotorras?**

		No controlar nunca	**Controlar ocasionalmente** *(una vez cada 2 años)*	**Controlar frecuentemente** *(al menos 1 vez al año)*	**Controlar muy frecuentemente** *(en cada estación)*	INDECISO	NO CONTESTA/ NO APLICA
1	**Vecinos**	0	1	2	3	7	9
2	**Esposa/o** *(de tenerla/o)*	0	1	2	3	7	9
3	**Extensionistas de una cooperativa**	0	1	2	3	7	9
4	**Agentes del gobierno nacional**	0	1	2	3	7	9
5	**Agentes de venta de las agroquímicas**	0	1	2	3	7	9
6	**Agentes del gobierno provincial**	0	1	2	3	7	9

Q27 **Cuánto le preocupa (nada, algo o mucho) lo que cada persona o grupo piense sobre lo que Ud. tendría que hacer para manejar los problemas con las cotorras?**

		No me preocupa	Me preocupa algo	Me preocupa mucho	INDECISO	NO CONTESTA/ NO APLICA
1	**Vecinos**	0	1	2	7	9
2	**Esposa/o** *(de tenerla/o)*	0	1	2	7	9
3	**Extensionistas de una cooperativa**	0	1	2	7	9
4	**Agentes del gobierno nacional**	0	1	2	7	9
5	**Agentes de venta de las agroquímicas**	0	1	2	7	9
6	**Agentes del gobierno provincial**	0	1	2	7	9

8. INFORMACIÓN SOBRE OBJETIVOS DE PRODUCCION

Q28 **Como productor, asumimos tiene determinados objetivos en su producción. En su opinión, cuáles de los siguientes objetivos serían importantes, desde el más al menos importante?**

OBJETIVO	**CODIGO**
Minimizar riesgos	1
Minimizar costos por unidad de producción	2
Maximizar la producción	3
Minimizar el impacto ambiental	4

☐ 1. MAS IMPORTANTE

☐ 2. SEGUNDO

☐ 3. TERCERO

9. INFORMACIÓN SOCIO-ECONOMICA

Q29 **A continuación, necesitaríamos contar con información personal adicional. Por favor, podría indicarnos su género y su edad?**

1.GENERO	
FEMENINO	1
MASCULINO	2

2. EDAD	
<18	1
18-29	2
30-39	3
40-49	4
50-59	5
59-65	6
>65	7
NO CONTESTA	9

Q30 **Cuál es el grado más alto que completó en sus estudios?**

PRIMARIA	1
SECUNDARIA	2
TERCIARIA *(2-3 años)*	3
UNIVERSITARIA *(4 o más años)*	4
POSGRADO *(Maestría y/o Doctorado)*	5
NO CONTESTA	9

Q31 **Por favor, podría indicarme cuál es la superficie, en hectáreas, de la explotación agropecuaria de referencia de la presente entrevista** *(incluye tierras propias y arrendadas, actividades agrícolas y otras)***?**

_________________________ **has**

EN HAS	
< 50	1
50-99	2
100-299	3
300-499	4
500-999	5
≥1000	6

Q32 **Podría indicarme, a continuación, cuántas hectáreas (o porcentaje aproximado del total) destinó, en esta última campaña** (2006-7 – CORTE: 31 MAYO 2007), **a la producción de cultivos?**

_________________________ **has**

NO CONTESTA 9

EN HAS	
< 50	1
50-99	2
100-299	3
300-499	4
500-999	5
≥1000	6

EN %	
< 5	1
5-10	2
10-25	3
25-50	4
50-75	5
75-100	6

Q33 **Podría mencionarme qué cultivos sembró esta última campaña** (2006-7 – PERÍODO DE REFERENCIA: 1 AGOSTO 2006- 31 MAYO 2007) **y cuánta superficie de los mismos (en has o en % de superficie total de la explotación)?**

ID	CULTIVO	EN HAS	EN %
1	MAÍZ		
2	GIRASOL		
3	SOJA		
4	TRIGO		
5	SORGO		
6	ALFALFA		
7	MOHA		
8	MIJO		
9	OTRO (ESPECIFICAR) ___________________		
	NO CONTESTA		9

Q34 **Sería tan amable de indicarnos, por favor, el porcentaje aproximados de sus ingresos anuales que proviene de la agricultura?**

NO CONTESTA 9

EN %	
< 5	1
5-10	2
10-25	3
25-50	4
50-75	5
75-100	6

Q35 **Realiza otras actividades productivas, si o no** *(ganadería, avicultura, tambo, etc.)***?**

NO……….. 1 → IR A Q38
SI……....... 2
NO CONTESTA…. 9

Q36 **Podría indicarme, a continuación, cuántas hectáreas (o porcentaje aproximado del total) destinó, en esta última campaña** (PERÍODO DE REFERENCIA: 1 AGOSTO 2006- 31 MAYO 2007), **a estas otras actividades productivas?**

________________________ **has**

NO CONTESTA 9

EN HAS	
< 50	1
50-99	2
100-299	3
300-499	4
500-999	5
≥1000	6

EN %	
< 5	1
5-10	2
10-25	3
25-50	4
50-75	5
75-100	6

Q37 **Sería tan amable de indicarnos, por favor, el porcentaje aproximados de sus ingresos anuales que proviene de estas otras actividades productivas?**

NO CONTESTA 9

EN %	
< 5	1
5-10	2
10-25	3
25-50	4
50-75	5
75-100	6

Q38 **Si le parece, hablemos ahora de montes en su explotación. Tiene sitios con monte en su explotación, si o no?**

NO……….. 1 → IR A Q42
SI……........ 2
NO CONTESTA…. 9

Q39 **Podría indicarme si los sitios corresponden a monte nativo, introducido (distinto que eucaliptus), eucaliptus, o mixto?**

NO CONTESTA 9

	TIPO DE MONTE	NO	SI
1	NATIVO	1	2
2	DE EUCALIPTUS	1	2
3	INTRODUCIDO DISTINTO DE EUCALIPTUS	1	2
4	MIXTO CON EUCALIPTUS	1	2
5	MIXTO SIN EUCALIPTUS	1	2

Q40 **Cuánto ocuparían, en hectáreas o porcentaje aproximado, los sitios de monte de la superficie total de su explotación?**

________________________ **has**

NO CONTESTA 9

EN HAS	
< 50	1
50-99	2
100-299	3
300-499	4
500-999	5
≥1000	6

EN %	
< 5	1
5-10	2
10-25	3
25-50	4
50-75	5
75-100	6

Q41 **Cuál de las siguientes opciones es la más probable respecto a los sitios de monte que tiene actualmente: que mantenga los sitios tal como están, que aumente los sitios con monte, o desmonte (parte o todo)?**

ID	ACCION	MONTE NATIVO	MONTE INTRODUCIDO	MONTE MIXTO
1	DESMONTAR TODO	1	2	3
2	MANTENER LOS SITIOS COMO ESTAN	1	2	3
3	AUMENTAR	1	2	3
4	NO CONTESTA	9		

Q42 **A continuación, y ya para ir cerrando la entrevista, vamos a realizar algunas preguntas sobre su participación en actividades sociales relacionadas con el agro. Por favor, podría indicarnos si pertenece o no a una organización de productores o relacionada con la agricultura?**

NO……….. 1 → IR A Q44
SI……........ 2
NO CONTESTA…. 9

Q43 **A cuántas organizaciones?**

1	1
2-3	2
3-5	3
>5	4
NO CONTESTA	9

Q44 **Participa usualmente en jornadas o reuniones agrícolas?**

NO……….. 1 → IR A Q46
SI……....... 2
NO CONTESTA…. 9

Q45 **Cuántas reuniones al año?**

< 6 (1 cada 2 meses o menos)	1
6-12 (entre 1 c/2 meses y 1 por mes)	2
> 12 (más de 1 por mes)	3
NO CONTESTA	9

Q46 **Pertenece a una organización ambientalista o relacionada con la conservación de la naturaleza?**

NO……….. 1 → IR A Q49
SI……....... 2
NO CONTESTA…. 9

Q47 **Cuántas organizaciones?**

1	1
2-3	2
3-5	3
>5	4
NO CONTESTA	9

Q48 **Podría nombrarla/s, por favor?**

Q49 **Cuáles son sus fuentes primarias de información sobre manejo de plagas, incluyendo manejo de conflictos con aves?. Si lo desea, puedo leerle un listado de posibles fuentes de información. Allí puede indicar más de una fuente.**

		NO	SI
1	Universidad	1	2
2	Extensión de una Cooperativa	1	2
3	Agentes del gobierno nacional	1	2
4	Agentes del gobierno provincial	1	2
5	Agroquímicas	1	2
6	Otros productores	1	2
7	Medios masivos de comunicación	1	2
8	Otros (especificar) ________________________________	1	2
9	NO CONTESTA	1	2

APPENDIX D
MOSAIC GRAPHICS FOR RELATIONSHIPS AMONG INDEPENDENT VARIABLES

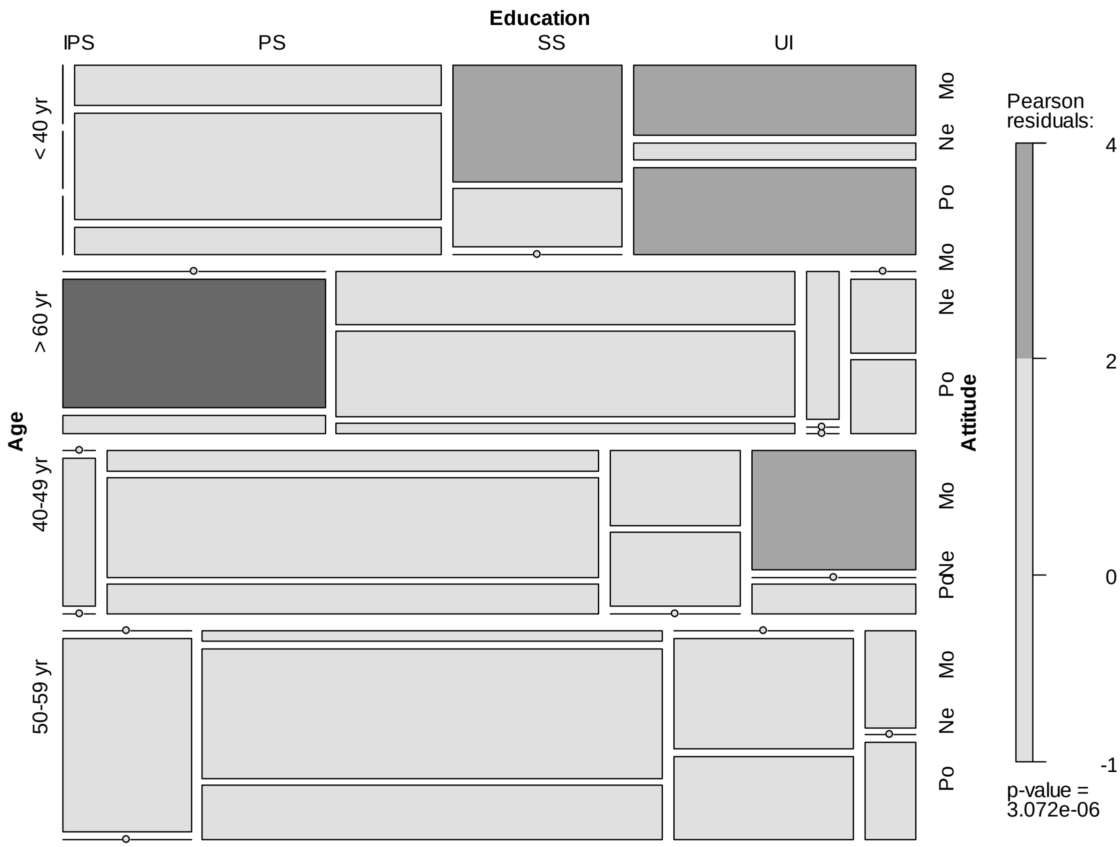

Figure D-1. Mosaic display showing the relationships among age, education and attitudes toward monk parakeets. The area of each rectangle is proportional to the observed frequency of farmers in that rectangle (Friendly 2000, pg. 106). Colors indicate deviations from independence, in this case, higher frequency than would be found under independence (in dark grey). Education: IPS= incomplete primary school, PS= primary school, SS=secondary school, UI=university instruction. Attitudes: PO= positive, NE= negative, MO= moderate.

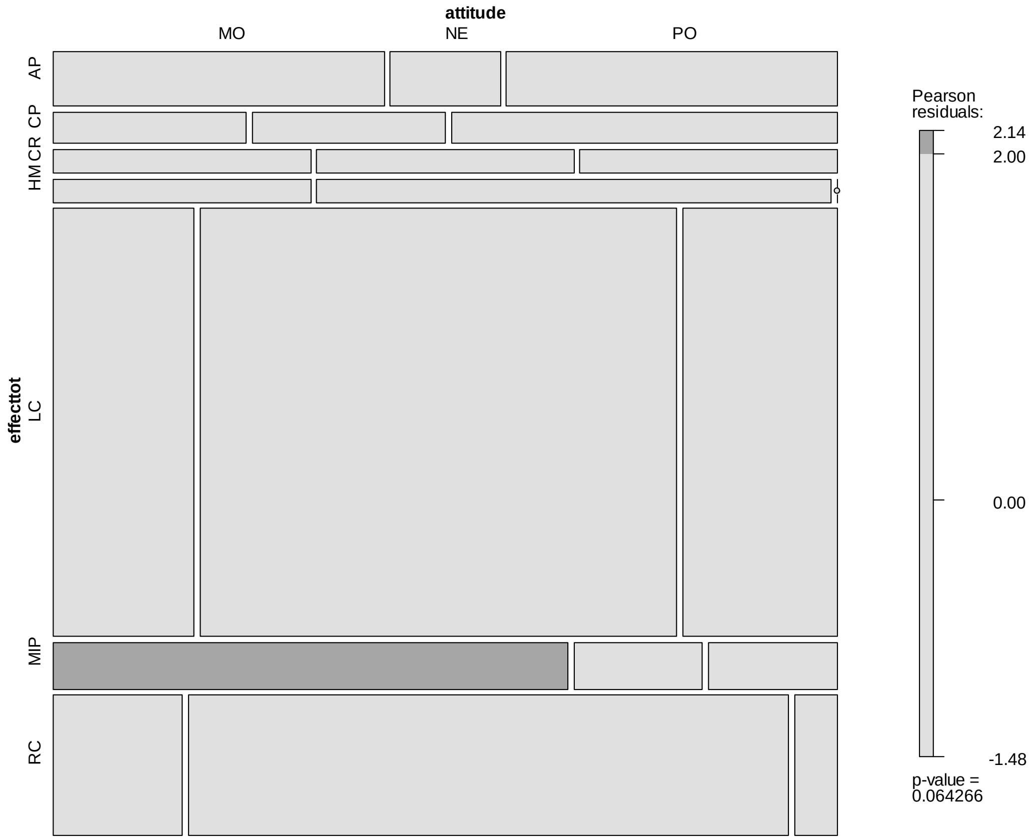

Figure D-2. Relationships among attitudes and beliefs about effectiveness of management strategies. Attitudes: PO= positive, NE= negative, MO= moderate. Beliefs about the most effective management strategy: LC= Lethal Control, LC= lethal control, CP= crop protection, AP= agricultural practices, HM= habitat management, RC= reproductive control, CR= capture and release, IPM= integrated pest management.

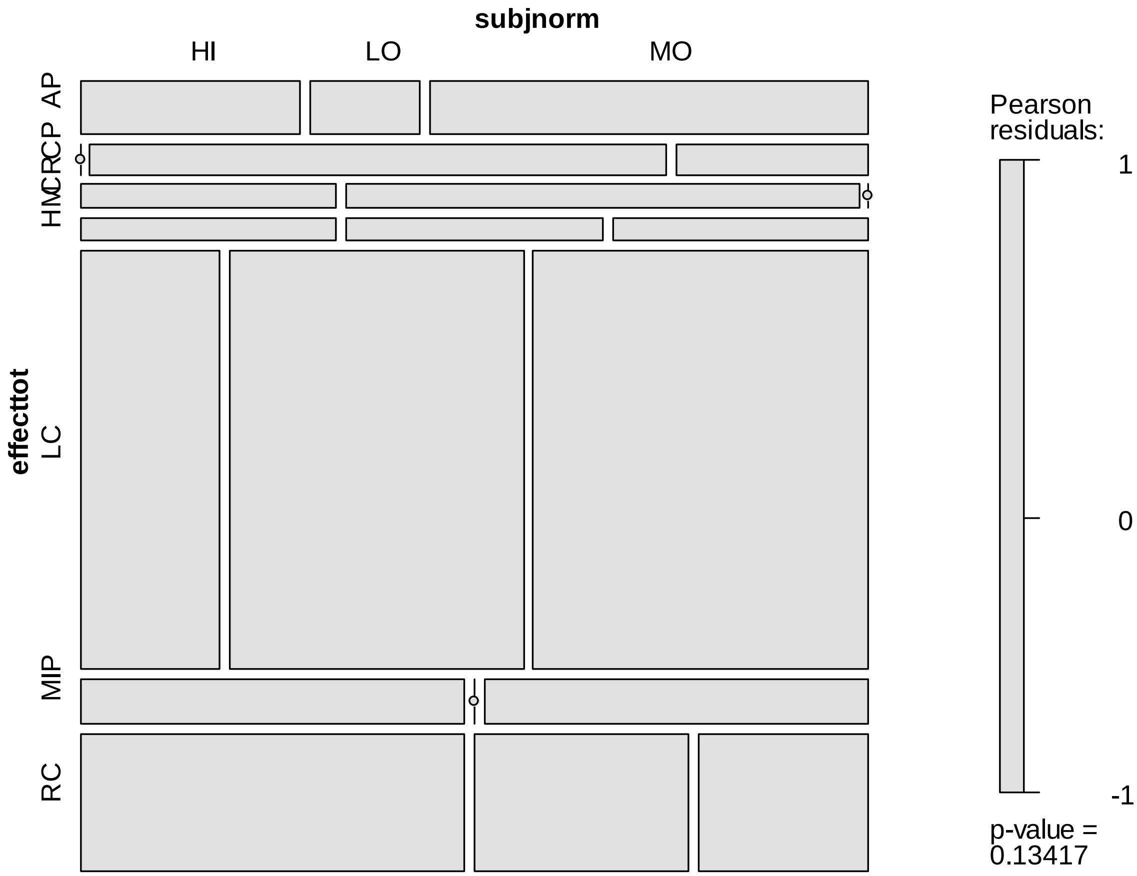

Figure D-3. Relationships between beliefs about the most effective management strategy and influence of subjective norms. Management strategy: LC= Lethal Control, LC= lethal control, CP= crop protection, AP= agricultural practices, HM= habitat management, RC= reproductive control, CR= capture and release, IPM= integrated pest management. Influence of subjective norms: LO= low, MO=moderate, HI=high.

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BIOGRAPHICAL SKETCH

Sonia Beatriz Canavelli was born on 1968 in Paraná (Entre Ríos, Argentina). She graduated with a bachelor's degree in biology at the Universidad Nacional de Córdoba in 1994. Before finishing, she started working in the Wildlife Department at the National Institute of Agricultural Technology (INTA), Paraná Experimental Station, in projects dealing with bird pest management in Entre Ríos and Santa Fe provinces (Argentina). In January 1996, she became involved in field projects about Swainson's hawk ecology in Argentina, due to the massive mortalities that occurred from pesticides at that time. Between 1998 and 2000, she conducted a master's program at the University of Florida (UF). Upon her return to Argentina, she helped to design and implement a regional bird monitoring program to monitor the status of bird populations on the pampas region. However, because bird mortalities were occurring because of the illegal use of pesticides to kill birds that damaged crops, and farmers' claims about bird damage to crops continued, Sonia returned to research on bird pest damage. Between 2003 and 2005, Sonia completed course and test requirements for a doctorate program at UF and in 2006, back again in Argentina, Sonia started a research program on human-wildlife conflicts, including monk parakeet and eared dove damage to crops. In addition to research activities, Sonia teaches courses related to wildlife management and conservation at local universities. Sonia has been married to Carlos Cappellacci since 1998, and both live with their lovely daughters, Luciana (10) and Eugenia (5), in Paraná (Entre Ríos, Argentina).