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Multi-level analysis of bird abundance and damage to crop fields

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ABSTRACT

Bird damage to agricultural crops is an important cause of economic loss for farmers worldwide. Predictive habitat models relating bird abundance and damage to characteristics of the agricultural environment at multiple scales are a key tool for designing management programs to reduce impacts of birds on agricultural production. In this study, we explored habitat features influencing abundance and damage of monk parakeets (*Myiopsitta monachus*) to corn (*Zea mays*) and sunflower (*Helianthus annuus*) fields, as a basis for the design and evaluation of management strategies for preventing damage in the future. Using a multi-level approach, we evaluated within-field, field, and landscape variables at three spatial scales potentially related to monk parakeet abundance and damage in crop fields. Monk parakeet abundance and damage was greater in sunflower than in corn fields. Landscape variables, such as distance to nearest site 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. Relationships varied depending on the crop under consideration and spatial scale of analysis. Based on this study, managers should consider both local and landscape factors when planning management measures to prevent bird damage to crops.

1. Introduction

Resolution of human–wildlife conflicts is a significant challenge because these conflicts are widespread, have large economic impacts, and often require solutions that take into account the landscape context of the problem. Bird damage to agricultural crops, which is an important cause of economic loss for farmers worldwide (Conover, 2002; De Grazio, 1978), is one source of such conflict that may be tied closely to patterns and processes on the landscape (Clergeau, 1995). Because most birds that cause agricultural damage move over large areas, bird abundance, spatial distribution of foraging, and consequently crop damage may be related to the way birds perceive and are affected by elements of the landscape that occur at multiple scales, such as quality of food within foraging patches, size and shape of crop fields, and habitat composition surrounding the fields (Amano et al., 2004, 2008; Clergeau, 1995; Hagy et al., 2008; Otis and Kilburn, 1988; Tourenq et al., 2001).

The scales at which bird pests respond to the landscape have profound implications for management (Clergeau, 1995; Zaccagnini et al., 1995). For example, if local factors such as plant density or field shape are the most important factors influencing bird damage to crops, individual landowners potentially can manipulate these factors to decrease the problem. However, if crop damage is strongly influenced by landscape-level factors (e.g., distribution of crop fields across the landscape, availability of other habitats for nesting, etc.), land use decisions at multiple scales may influence crop damage sustained by individual farmers, and design of effective management programs will require more complex programs or policies that integrate multiple landholdings. The correct spatial scale for management thus depends on how birds perceive and use the landscape.

Predictive habitat models that relate bird abundance and damage to characteristics of the agricultural environment are a key

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tool for designing programs to reduce impacts of birds on agricultural production (Amano et al., 2008). Detection of useful predictor variables for the effects of landscape structure on the occurrence of birds is dependent upon selection of the right scale for analysis (Boscolo and Metzger, 2009; Lawler and Edwards, 2002). Likewise, the spatial scale at which landscape variables are measured is likely to affect detection of relationships between bird damage to crops and landscape structure and composition. Although some studies of bird pests have evaluated both local and landscape factors in the same study (Amano et al., 2004, 2008; Hagy et al., 2008; Otis and Kilburn, 1988; Tourenq et al., 2001; Zaccagnini et al., 1995), none of these studies analyzed multiple spatial scales at the landscape level nor explicitly evaluated the scale at which landscape variables best explain bird abundance and damage to crop fields.

The objectives of this study were to: (1) examine the association of environmental variables with abundance and crop damage of monk parakeets (*Myiopsitta monachus*) across three levels of organization (within-field or plot level, field or patch level, and landscape level), and (2) compare performance of landscape-level measures at three spatial scales where landscapes are defined as mosaics of spatially heterogeneous land cover within a specified radius of crop fields where bird abundance and damage were measured. Monk parakeets are among the most important bird pests causing damage to grain crops in South America, particularly in Argentina and Uruguay (Bruggers et al., 1998; Bruggers and Zaccagnini, 1994; Spreyer and Bucher, 1998). Although high quality foods for monk parakeets in agricultural landscapes are maturing grain crops (e.g., sunflower and corn, Aramburú, 1997; Aramburú and Bucher, 1999; Spreyer and Bucher, 1998), parakeets also forage on wild seeds, fruit of native trees, and other grain and fruit crops (Spreyer and Bucher, 1998). This species constructs stick nests 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), and uses nests all year around for breeding and roosting. Monk parakeets forage out from the nest and then return to that site, thus functioning as central-place foragers (Stephens and Krebs, 1986). Daily movement from the nest site to foraging areas generally is between 3 and 5 km, although possibly longer (up to 24 km) during the non-breeding season (Spreyer and Bucher, 1998). Considering the large daily movement of monk parakeets, their nesting habits, and generalist foraging behavior (Bucher et al., 1991; Hyman and Pruett-Jones, 1995), we expected characteristics of the landscape around a crop field, as well as field-level factors, to influence abundance and damage of parakeets in that particular field.

2. Methods

2.1. Study area

The study was conducted in a 525,000-ha area comprising the Department of Paraná (Entre Ríos Province, Argentina, Fig. 1). The area is characterized by diverse production activities, with a predominance of crops, beef cattle and milk production (Engler and Vicente, 2009). Crop fields, pastures, and remnant woodlands are interspersed across the study area.

2.2.1. Sampling scheme

The study was conducted in the 2006–2007 and 2007–2008 austral summer seasons (December to February). Damage to grain crops by monk parakeets occurs principally to ripening sunflower and corn, which were the focus of this study, and also occasionally to sorghum, wheat and rice (Spreyer and Bucher, 1998). We used a geographic information system (ArcGIS v.9.2) to place a grid with a cell size of 10 × 10-km over Paraná Department and selected 25 non-contiguous grid cells in 2006 and 31 cells in 2007 using systematic sampling with the first cell selected at random and every other cell selected thereafter. This sampling scheme allowed us to cover the study area within the time-limits imposed by crop maturation and represents the number of fields we could evaluate before harvest.

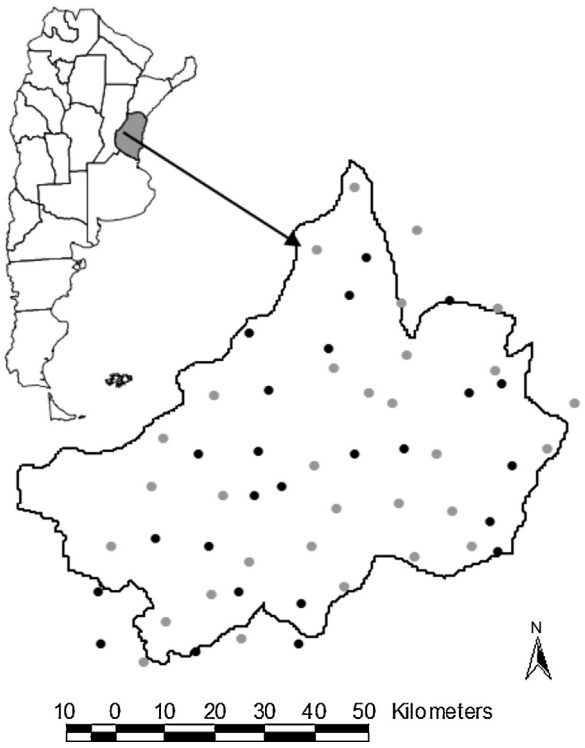

Fig. 1. Map showing the location of Department of Paraná (Entre Ríos Province, Argentina) and the crop fields sampled in 2007 and 2008. Black dots indicate corn fields ($n = 25$) and grey dots indicate sunflower fields ($n = 31$).

We identified the nearest corn or sunflower field to geographic coordinates for the central point of each cell. Based on the type of crop we sampled in the first cell, when possible we choose a different type in the next cell in order to have both types of crop fields with a relatively even distribution throughout the study area (Fig. 1). A crop field (or patch) was defined as a contiguous area covered by corn or sunflower that differed from its surroundings. Based on a first visit to each crop field, we 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 13 corn and 11 sunflower fields in the 2006–2007 summer season (hereafter 2007 season) and 9 corn and 16 sunflower fields in the 2007–2008 summer season (hereafter 2008 season). The mean size (SE) of corn fields was 22.52 ha (3.46), and the mean size of sunflower fields was 24.25 ha (2.99).

2.3. Bird abundance surveys

Monk parakeets were surveyed using field-edge (180°) unlimited distance point counts in the direction of the crop (Bibby et al., 2000; Freemark and Rogers, 1995). The observation period at each point was 5 min. Points were located on the border of crop fields in proportion to their size (range = 4–11 points per field) with a minimum distance of 200 m between consecutive points to decrease the possibility of double counting birds (Freemark and Rogers, 1995). Surveys were conducted between