Agriculture, Ecosystems and Environment 225 (2016) 140–149

Contents lists available at ScienceDirect

Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

Field-scale habitat complexity enhances avian conservation and avian-mediated pest-control services in an intensive agricultural crop

Sara M. Kross[a,b,*], T. Rodd Kelsey[b], Chris J. McColl[b], Jason M. Townsend[a,c]

[a] Department of Wildlife, Fish & Conservation Biology, University of California, Davis, CA 95616, United States
[b] The Nature Conservancy, 555 Capitol Avenue, Ste 1290, Sacramento, CA 95814, United States
[c] Hamilton College, 198 College Hill Road, Clinton, NY 13323, United States

ARTICLE INFO

Article history:
Received 24 November 2015
Received in revised form 28 March 2016
Accepted 29 March 2016
Available online 26 April 2016

Keywords:
Ecosystem services
Farm
Alfalfa
Lucerne
Weevil
Biodiversity

ABSTRACT

The relationship between on-farm avian conservation measures and the potential provisioning of pest-control services by birds is poorly understood in intensive agricultural landscapes, especially in temperate regions. We used an exclusion experiment to test the effects of field- and landscape-scale habitat complexity on avian-provisioned pest-control services and assessed avian abundance and diversity across 32 conventional alfalfa (*Medicago sativa*) fields in winter and early spring in California. Alfalfa is a key forage crop around the world and is grown on approximately 30 million hectares globally each year. Bird foraging reduced the abundance of the most significant insect pests of alfalfa by over 33%. The presence of complex edge habitat (presence of at least two trees >1.5 m) led to higher avian abundance within fields, which in turn led to reduced pest insect populations at sampling points close to the field edge. Fields with complex edge habitat also harbored nearly three times as many bird species as those with simple edge habitat. The distance from the nearest riparian habitat, a measure of landscape diversity, did not affect bird abundance or diversity in winter alfalfa fields, which may be related to the homogenous landscape in which our study was based. Our results show that relatively simple conservation measures in intensively managed farming landscapes, such as planting small trees along a field edge, can result in increased abundance and diversity of over-wintering birds, with direct benefits to farmers through increased avian-mediated pest-control services.

1. Introduction

Dramatic loss of biodiversity globally has been primarily driven by large-scale loss of natural habitats (Pimm et al., 1995), much which has been a result of agricultural land conversion. Nearly 40% of terrestrial land is devoted to agriculture (Foley et al., 2011) and escalating expansion and intensification of farming practices to produce more food for a growing human population has been linked to continuing biodiversity declines (Geiger et al., 2010; Green et al., 2005; Sala et al., 2000). For example, agriculture has been characterized as the “greatest extinction threat to birds” (Green et al., 2005).

Given the scale of biodiversity loss, it is increasingly recognized that conservation of biodiversity cannot be achieved solely though protected reserve systems (Fahrig 2001; Chazdon et al., 2009). Thus, there have been calls for the expansion of biodiversity conservation beyond the reserve system (e.g. Chazdon et al., 2009) and particularly into agricultural landscapes (Scherr and McNeely, 2008). There is also increasing recognition that human populations rely on the ecosystem services provided by biodiversity, such as biological control of crop pests (Losey and Vaughan, 2006; Perrings et al., 2006; Tilman et al., 2002). Thus, designing or restoring agroecosystems that are capable of conserving biodiversity may also enable farmers to take advantage of functional natural diversity that provides ecosystem services at the farm and landscape levels and, as a result, benefit both people and nature (Cumming and Spiesman, 2006; Perrings et al., 2006; Power, 2010; Tscharntke et al., 2007).

Compared with more diverse agroecosystems that incorporate diverse cropping systems and non-crop habitat, and which typically characterize developing world agricultural landscapes and smallholder systems, intensively farmed and simple monoculture landscapes support lower biodiversity and receive fewer ecosystem services (Foley et al., 2005; Power, 2010; Tscharntke et al., 2005). Wildlife-friendly farming practices, including maintaining refugia habitat, restoring natural habitat along field

* Corresponding author.
E-mail address: SaraMaeKross@gmail.com (S.M. Kross).

http://dx.doi.org/10.1016/j.agee.2016.03.043
0167-8809/

margins, and reducing chemical inputs and diversifying crop types, have been suggested as a way to preserve wildlife populations in farming areas (e.g. Donald and Evans, 2006; Fahrig et al., 2011; Quinn et al., 2014). Large-scale, long-term conservation programs in farmland are rare, but programs such as the European Union's agri-environmental schemes and the U.S. Farm Bill's conservation programs have shown that such practices can be effective for conservation, although they often do not benefit rare species (e.g. Kleijn et al., 2015), and the effects of such schemes on ecosystem-services for farmers are rarely measured (Batáry et al., 2015).

Birds are often targets of conservation actions, particularly in agricultural landscapes (e.g. Vickery et al., 2004) in part because they have declined dramatically in these systems, can respond positively to improved management, and are easily measured indicators of ecosystem health (Gardali et al., 2006). The complexity of field-edge and landscape-scale habitats has been shown to increase bird diversity in a number of European and tropical systems (Batáry et al., 2011; Kellermann et al., 2008; Vickery et al., 2004), suggesting such actions could be effective for bird conservation. Also, at broader scales, the proportion of natural and semi-natural habitat in the landscape in which a field is embedded can influence the efficacy of increasing field-edge habitat for bird diversity (Batáry et al., 2011; Quinn et al., 2012). Unfortunately, there have been few examples from temperate North America (but see Jobin et al., 2001; Quinn et al., 2012) or intensively cultivated landscapes that can be used to evaluate the potential for bird- or broader biodiversity-conservation benefits of similar practices.

Pest-control services provided to US farmers by beneficial insects are estimated to be worth \$4.5 billion per year (Losey and Vaughan, 2006), however very few studies have quantified pest-control services provided by birds. Landscape complexity and the presence of natural habitats has been shown to influence avian-mediated pest-control services in coffee agroforestry (e.g. Johnson et al., 2009; Karp et al., 2013; Railsback and Johnson, 2014) and management to encourage diverse bird assemblages have been shown to be beneficial for both avian conservation and invertebrate pest management (reviewed in Wenny et al., 2011). However, most of these studies have been conducted at a small scale (1–4 sites), in non-intensive systems, and in predominantly tropical agroforestry systems such as coffee and cacao (e.g. Johnson et al., 2010; Karp et al., 2013; Kellermann et al., 2008; Railsback and Johnson, 2014). We therefore have few comparable figures for the value of birds as natural enemies of agricultural pests, especially within intensive temperate and Mediterranean agricultural systems. With 21% of avian species at risk of extinction, the ecosystem services provided by birds are likely to decrease in the coming decades; a fact that will only be appreciated after the decline of each species (Sekercioglu et al., 2004).

In this study, we sought to address the potential for birds as significant contributors to pest control in an intensively cultivated crop in North America and to quantify how these potential pest control services vary with implementation of farm-scale practices to improve habitat for birds. We conducted exclusion experiments in 32 fields representing a gradient of both local- and landscape-scale habitat complexity in alfalfa (*Medicago sativa*, also known as lucerne) to quantify the abundance of key invertebrate pests in the presence and absence of potential bird predation. Alfalfa is grown on approximately 30 million hectares globally each year (Yuegao and Cash, 2009). North America is currently the top-producing

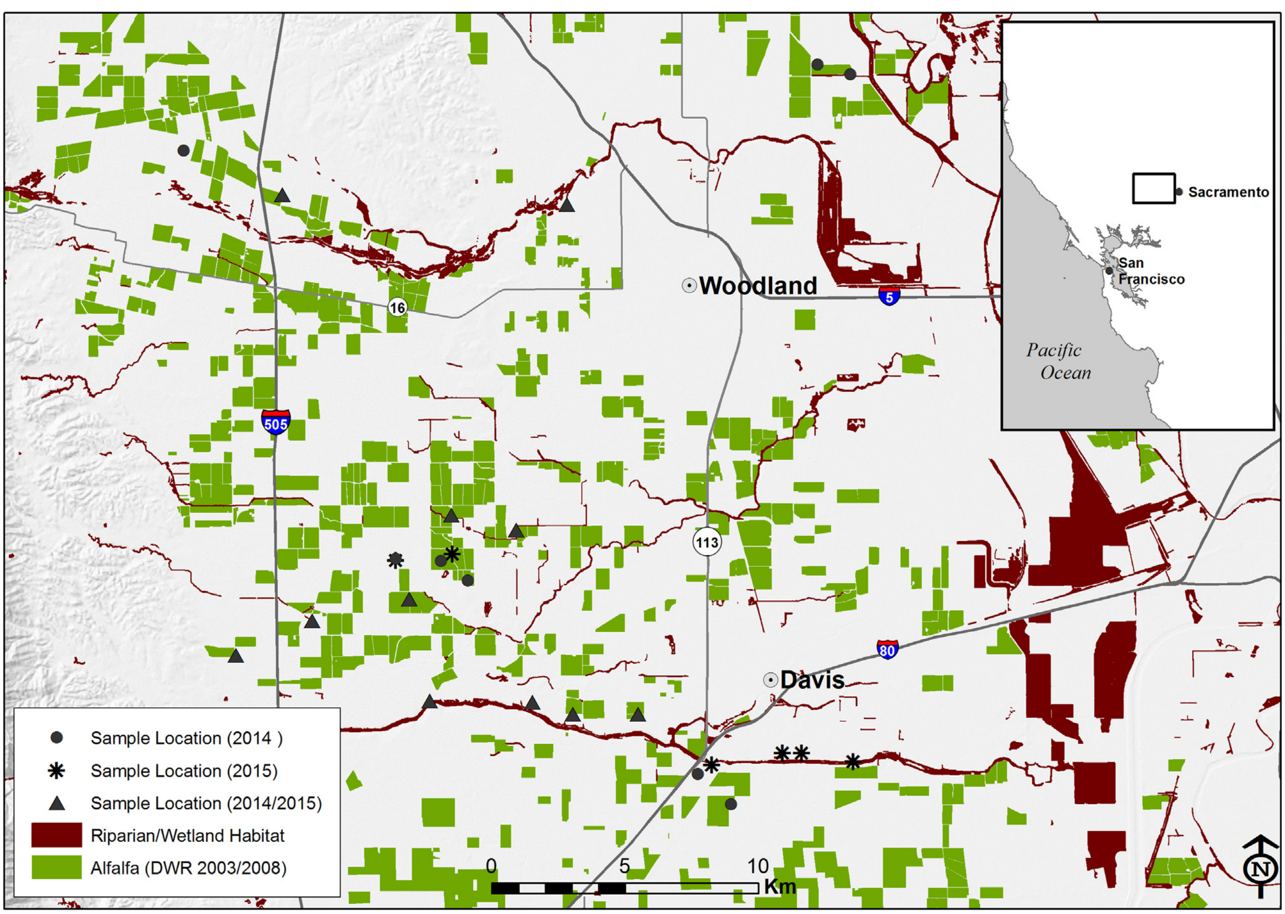

Fig. 1. Map showing experiment locations and locations of riparian habitat.