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A bustle in the hedgerow: Woody field margins boost on farm avian diversity and abundance in an intensive agricultural landscape

Sacha K. Heath[b,⁎], Candan U. Soykan[a,⁎], Karen L. Velas[c], Rodd Kelsey[d], Sara M. Kross[d,e,f]

[a] National Audubon Society, Conservation Science, 220 Montgomery St., Suite 1000, San Francisco, CA 94104, USA
[b] Graduate Group in Ecology, Department of Environmental Science and Policy, University of California, 1 Shields Avenue, Davis, CA 95616, USA
[c] Audubon California, 400 Capitol Mall, Suite 1535, Sacramento, CA 95814, USA
[d] The Nature Conservancy, 555 Capitol Avenue, Suite 1290, Sacramento, CA 95814, USA
[e] Department of Wildlife, Fish & Conservation Biology, University of California, Davis, 1 Shields Avenue, Davis, CA 95616, USA
[f] Department of Environmental Studies, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819, USA

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ABSTRACT

Considerable funding has been allocated to conservation management of non-crop habitat in agricultural landscapes, particularly field margin habitat such as hedgerows. Evaluation of the biodiversity benefits of non-crop habitat has lagged behind implementation, however, especially in the United States where this habitat has the potential to supply important resources for both common and rare species of birds. We examined the effects of woody field margin vegetation on winter and breeding season avian communities at 103 fields, row crops, and orchards in California's Central Valley, one of the most intensively-farmed landscapes on Earth. We found that margins with hedgerows, treelines or remnant riparian habitat harbored 2–3 times as many bird species, significantly greater species evenness, and 3–6 times higher maximum total abundances of birds than bare or weedy margins. The effect of margin type on richness was modulated by water year, whereas the effect of margin type on maximum total abundance was modulated by adjacent crop type. At the landscape scale, hedgerow and riparian margins that were further from woodland harbored greater species richness; a result that supports our recommendation for targeted development of hedgerows in simplified agricultural landscapes. These results demonstrate that non-crop woody habitats, both planted and remnant native patches, increase the biodiversity value of farms, providing support for policies to preserve remaining habitat and incentivize installation of woody hedgerows.

1. Introduction

With ∼40% of the world's ice-free land surface devoted to agriculture (World Bank, 2015), expansion and intensification of farming threaten to further alter already-stressed ecosystems (Foley et al., 2005). Agricultural intensification has had broad-scale negative effects on biodiversity through habitat loss and certain management activities (Balmford et al., 2012; Geiger et al., 2010; Green et al., 2005). Furthermore, increasing agricultural intensification has been linked to degradation of the ecosystem services provided by biodiversity (Power, 2010) including pollination (Kremen et al., 2007) and biological pest control (Tscharntke et al., 2007). Finding a balance between producing the food, fuel, and fiber required by our growing human population and reversing biodiversity declines remains one of the greatest conservation and social challenges we face.

Avian populations, in particular, are projected to decline with the continued expansion and intensification of agriculture worldwide (Green et al., 2005; Scharlemann et al., 2004), as has been empirically documented throughout Europe (e.g., Donald et al., 2006; but see Reif et al., 2008). In North America, this trend in agriculture has been associated with declines of both rare and common species and is considered a continent-wide threat to land birds (Rosenberg et al., 2016). Nonetheless, there remains potential for supporting abundant populations of many bird species in agricultural landscapes by maintaining landscape heterogeneity (Benton et al., 2003; Peterjohn, 2003) and by providing resources for birds during all periods of their annual cycle, including during breeding (Rodenhouse et al., 1992; Swolgaard et al., 2008), bi-annual migration (Estrada and Coates-Estrada, 2005) and over-wintering periods (Kross et al., 2016; Strum et al., 2013).

If quality resources in agricultural lands supplement those found in

⁎ Corresponding authors.
E-mail addresses: skheath@ucdavis.edu (S.K. Heath), science@audubon.org (C.U. Soykan), velaskaren@gmail.com (K.L. Velas), rkelsey@tnc.org (R. Kelsey), saramaekross@gmail.com (S.M. Kross).

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remnant natural habitats, or if agricultural lands offer better than available alternatives in severely modified landscapes, then sustainable management of them is necessary for biodiversity conservation (Koh and Gardner, 2010). Agri-environment schemes (AES), which are management schemes and policies designed to offset or reverse the negative effects of agricultural intensification on wildlife, have been implemented by governments, non-governmental organizations and industry groups around the world. These schemes encourage farmers to implement specific measures designed to protect and enhance the environment, including habitat management to accommodate wildlife. Birds, as a highly-visible and culturally-valued taxonomic group, have been the focus of many such schemes (Kleijn et al., 2006; Strum et al., 2013). Arguably the policy and management schemes with the largest scope and most thorough scientific assessment are found in the European Union, where nearly €20 billion was spent on AES between 2007 and 2013 (European Commission, 2017). In the United States (US), programs funded by the US Department of Agriculture's Natural Resources Conservation Service earmarked $6.35 billion for nationwide voluntary on-farm conservation projects in 2016 through the Agriculture Act of 2014 (commonly known as the Farm Bill).

For birds in particular, an important conservation practice incorporated into AES has been the retention or re-planting of field margin vegetation (Quinn et al., 2014; Vickery et al., 2004). Managed linear strips of trees and/or shrubs, often called hedgerows, have been a key component of historic low-intensity farming landscapes (Baudry et al., 2000) and provide birds with resources for perching, nesting, refuge from predators, and foraging in an otherwise inhospitable agricultural environment (Baudry et al., 2000; Hinsley and Bellamy, 2000; Vickery et al., 2004). European studies demonstrate that woody hedgerows and other on-farm habitats can contribute significantly to bird diversity and abundance in the agricultural landscape and that hedgerow structure, composition, plant diversity, and proximity to water influence the numbers and species richness of birds in hedgerows (Hinsley and Bellamy, 2000).

Far less research has examined how woody field margin habitat—such as hedgerows, tree lines, or stream/ditch side riparian vegetation—impact bird communities in North America, with notable exceptions showing benefits to birds in Québec (Jobin et al., 2001), in Florida (Jones et al., 2005) and in shrublands adjacent to agricultural lands of North Carolina (Shake et al., 2012), but a negative impact on grassland birds in prairie regions (Quinn et al., 2012; Tack et al., 2017). Furthermore, it is understood that the efficacy of field margin habitats can vary depending on landscape context (Batáry et al., 2011). In spite of ongoing investments and their perceived benefits, few guidelines exist in the US for how field margin management practices can be implemented to target bird communities and increase avian diversity and abundance (Evans et al., 2014).

Here, we present the results of a large-scale study of the effects of woody field margins and landscape-scale habitat characteristics on over-wintering and breeding-season bird communities in California's Central Valley, one of the world's most intensively-farmed regions. Historically, the Central Valley was a matrix of seasonal wetland, riparian forest, grass- and forblands, and oak woodland and savannah but today over 95% of those habitats have been replaced by agriculture and urban areas (McCalla and Howitt, 2016). Currently, most field margins in the Central Valley are comprised of mowed weedy strips, or maintained as 'clean' margins devoid of vegetation. The diversity of historic habitats and the relatively recent transition to a farm-dominated landscape means that hundreds of species of birds, including habitat generalists and species that rely on woodland, riparian, grassland, and wetland habitats, utilize the Central Valley's agricultural lands either for breeding, overwintering, migrating, or as year-round habitat. Creating 'working lands' that support both agriculture and wildlife conservation is a goal of both farming and conservation stakeholders (Central Valley Joint Venture, 2006). In 2016, a total of $88 million was reserved for the State of California's Environmental Quality Incentives Program. Among other practices, this program supports the continued planting of native vegetation hedgerows, riparian canal plantings, and other farm margin habitats to increase biodiversity on farms and to regionally enhance habitat for wildlife, a practice that has been implemented in this region for over two decades (Bugg et al., 1998; Earnshaw, 2004; Long and Anderson, 2010). Despite the goal of providing habitat for birds, research on woody field margin habitats in California has focused on evaluating their benefits for pollinators and other agriculturally-beneficial insects (Morandin et al., 2014; Morandin and Kremen, 2013). Studies detailing the effects of hedgerows and other field margin habitats on birds in California have been preliminary (White et al., 2013), or have focused on single crop-types or seasons (Jedlicka et al., 2014; Kross et al., 2016). To inform and improve state and national policies and incentive programs, we evaluated the effects of different field margin habitat features on both breeding and winter season avian community structure in the context of several local and landscape scale habitat characteristics.

2. Methods

2.1. Study area

We sampled birds in the uncultivated margins around field, row, and orchard crops of Yolo and Solano counties of the Sacramento Valley, California, USA, where farmland occupies 71% and 77% of total county land area, respectively, and is bordered to the west by oak, conifer, and chaparral woodlands and grasslands of California's interior coast range and to the east by the Sacramento River (Fig. 1). In these counties, livestock forage, fruit and nut orchards, wheat, and processing tomatoes are the largest hectarage crop types (Solano County, 2013; Yolo County, 2014). The Sacramento Valley is ranked highest in agricultural production and lowest in agrobiodiversity compared to a set of seven other agrobiodiversity research regions around the globe

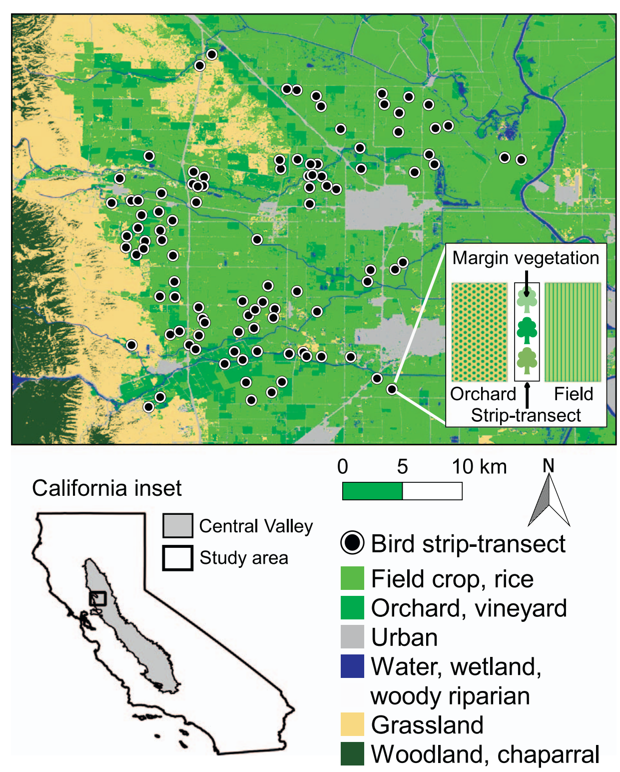

Fig. 1. Study area in Yolo and northern Solano Counties of the Sacramento Valley, with field-scale schematic of strip-transect placement, and California inset identifying the Central Valley and the study area.
Basemap modified from the 2012 Cropland Data Layer (Han et al., 2012).

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