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The contribution of roadside grassland restorations to native bee conservation

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ABSTRACT

Marginal habitats such as hedgerows or roadsides become especially important for the conservation of biodiversity in highly modified landscapes. With concerns of a global pollination crisis, there is a need for improving pollinator habitat. Roadsides restored to native prairie vegetation may provide valuable habitat to bees, the most important group of pollinators. Such roadsides support a variety of pollen and nectar sources and unlike agricultural fields, are unplowed, and therefore can provide potential nesting sites for ground-nesting bees. To examine potential effects of roadside restoration, bee communities were sampled via aerial netting and pan trapping along roadside prairie restorations as well as roadsides dominated by non-native plants. Management of roadside vegetation via the planting of native species profoundly affected bee communities. Restored roadsides supported significantly greater bee abundances as well as higher species richness compared to weedy roadsides. Floral species richness, floral abundance, and percentage of bare ground were the factors that led to greater bee abundance and bee species richness along restored roadsides. Traffic and width of roadside did not significantly influence bees, suggesting that even relatively narrow verges near heavy traffic could provide valuable habitat to bees. Restored and weedy roadside bee communities were similar to the prairie remnant, but the prairie remnant was more similar in bee richness and abundance to restored roadsides. Restoring additional roadsides to native vegetation could benefit pollinator conservation efforts by improving habitat on the millions of acres of land devoted to roadsides worldwide, land that is already set aside from further development.

1. Introduction

Any loss of biodiversity is cause for concern, but declines of animal pollinators are especially worrisome because their loss may in turn affect flowering plant proliferation. Changes in pollinator abundances affect plant reproduction and gene flow (Bawa, 1990) and recent experimental evidence directly demonstrates that plant communities could be negatively affected by a loss of pollinator diversity (Fontaine et al., 2006). Additionally, animal-mediated pollination is required for agricultural crops that account for 35% of global food production (Klein et al., 2007). Threats to pollinator communities may affect not only pollinators themselves but also native plant communities and agricultural productivity. Concerns about a global decline of pollinators (Kearns et al., 1998; Biesmeijer et al., 2006) have increased interest in investigating and promoting habitat that can support pollinators (National Research Council, 2007).

Bees are considered the most important taxon of pollinators, and face increasing threats from anthropogenic sources, including habitat loss and fragmentation (Frankie et al., 1997; Kearns et al., 1998), agricultural intensification (Kremen et al.,

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2002; Klein et al., 2007), pesticide use (O'Toole, 1993; Kearns et al., 1998), and introduced species (Allen-Wardell et al., 1998; Goulson, 2003). Losses of wild bees have been documented in some regions of the world (Williams, 1982; O'Toole, 1993; Vinson et al., 1993; Banaszak, 1995; Biesmeijer et al., 2006), with declines suspected elsewhere (National Research Council, 2007).

In highly human-impacted environments lacking unmodified land, marginal habitats become especially important for the conservation of biodiversity. Linear habitats (such as hedgerows, crop margins and roadsides) have been shown to have value to other invertebrate pollinators, primarily butterflies (Munguira and Thomas, 1992; Feber et al., 1996; Ries et al., 2001; Croxton et al., 2005; Saarinen et al., 2005). Roadsides (road verges) can be important habitat for rare plants (National Research Council, 2005), some birds and small mammals (Adams, 1984; Camp and Best, 1994), and ants and beetles (Keals and Majer, 1991; Vermeulen, 1993). Given that bee diversity can be high in intermittently disturbed areas with early-successional plant communities such as un-mown power-line strips (Russell et al., 2005), railway lines, and hedgerows (Saure, 1996), roadsides may provide suitable bee habitat. Although it has been suggested that road verges have potential conservation value to wildlife (Way, 1977), there is a paucity of studies concerning the effects of roadside vegetation management on wildlife. To my knowledge, no studies have examined the effects of plant restoration on bee communities compared to non-restored land in any type of habitat, including roadsides.

The contribution of roadside management to conservation has long been recognized in Britain, the Netherlands, and Australia, where a broad range of roadside management practices incorporate ecological goals (Way, 1977; Forman et al., 2003). Roadside vegetation management in the United States has recently begun to include native species restoration and management of existing native vegetation (National Research Council, 2005). In the state of Kansas, where only a small percentage of unplowed prairies remain (Noss et al., 1995), the Kansas Department of Transportation (KDOT) maintains over 650,000 acres of roadsides (F. Markham, KDOT employee, pers. comm.). Conventional roadside maintenance has involved planting non-native, fast-growing grasses (*Bromus* L. spp.) and legumes (such as *Coronilla varia* L.), frequent mowing (multiple times over the growing season) and herbicide application when necessary to control noxious weeds. In 2000–2001, KDOT initiated several re-vegetation projects by which existing exotic vegetation was replaced by a seed mix of prairie grasses and forbs to restore roadsides to native vegetation (F. Markham, pers. comm.). By promoting native grass and wildflower re-establishment, KDOT and other Midwestern states using similar strategies expected to prevent erosion and control weeds via competition, thereby reducing mowing frequency and herbicide use (Henderson, 2000; Forman et al., 2003).

Suitable bee habitat must include a diversity of flowering species and nesting substrates because of the range of specialized floral and nesting requirements of bees. Bees of both sexes may exploit many floral species for nectar, while females may utilize only one to several closely related species for specialized pollen needs or a variety of forbs for more generalized pollen needs (Wcislo and Cane, 1996). Nesting preferences of bees are highly variable: many species dig subterranean nests in their preferred location and soil type, while others nest above ground in plant stems or dead wood or require specific nest-building materials such as mud, resin or snail shells (Linsley, 1958). Much like the crop field margins sown with wildflowers that increase numbers of nectar and pollen feeding invertebrates within predominantly agricultural landscapes (Feber et al., 1996; Pywell et al., 2005), roadsides seeded with native vegetation increase the diversity of plants in the areas in which they occur, making pollen and nectar sources more abundant compared to adjacent areas (Forman et al., 2003). Additionally, roadside restorations may offer nesting sites for bees, particularly ground-nesting bees. Yearly tilling in neighboring agricultural fields reduces the survival of bees nesting within the fields (Delaplane and Mayer, 2000). While roadsides may be minimally tilled in preparation for the planting of vegetation following a large disturbance that removed existing vegetation, unlike agricultural fields, roadsides are neither disturbed by heavy equipment nor plowed regularly. It has been previously suggested that roadsides, in addition to providing additional habitat to wildlife, might also provide connectivity to habitat fragments (Forman et al., 2003; Croxton et al., 2005). Thus, roadside restorations could serve as protective corridors through which pollinators could move in highly modified landscapes.

Here I present results from a study investigating the effects of roadside prairie restoration on bee communities. I focus on three questions: (1) do roadsides restored to native vegetation support a greater abundance and richness of bees than roadsides dominated by non-native vegetation; (2) are certain roadside characteristics associated with bee abundance and species richness; and (3) to what extent do bee communities along restored and weedy roadsides resemble the bee composition of a native prairie remnant?

2. Methods

2.1. Study area

I sampled 14 road verges in Kansas, all of which had a width of 18 m or greater and bordered two-lane or four-lane paved roads (Fig. 1). Roadside sites were separated by considerable distances (across six counties, covering approximately 4200 km^2) and were located within a landscape matrix of suburban development, rangeland, and agricultural row crops. Use of the land surrounding roadside sites was classified using percent coverage of natural habitat within a 200 m radius from the sites sampled and scored to one of three levels: $\leqslant$30% semi-natural (agricultural fields and suburban areas) = 0, ~50% semi-natural (meadow or limited agricultural fields) = 1, $\geqslant$70% semi-natural (CRP fields, meadows) = 2. Values were determined on the ground and by use of aerial photographs (available at <http://www.kansasgis.org>). Surrounding land use did not differ significantly between weedy and restored roadsides (Mann–Whitney U test, $p > 0.1$).

Seven study sites were roadsides that had been reseeded with a mix of native prairie forbs and grasses, hereafter referred to as 'restored roadsides'. These sites were mown every two to four years with the exception of one site which was