Title: Field surveys to assess the persistence of bumble bee species (*Bombus* spp.) in northeast Texas.
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Abstract:

Bumble bees (*Bombus* spp.) pollinate a variety of flowering plants in both natural and agricultural systems; declines in many bumble bee species worldwide have underscored the need to develop conservation initiatives. In order to implement and evaluate a conservation plan, current populations must be identified and subsequently monitored. Two bumble bee species historically found in northeast Texas, *B. pensylvanicus* and *B. fraternus*, have shown evidence of population declines in other parts of the United States, but information on the current status of this region's populations is scarce. This study employed roadside field survey methods to assess bumble bee species presence and abundance in 2014 across 16 counties of northeast Texas in an effort to aid in the construction of conservation measures. We show that the two most common species of bumble bee along roadsides across the study region are *B. pensylvanicus* and *B. fraternus*. These results suggest that Texas roadsides are a potential starting point for implementing conservation actions for declining bumble bees.

Introduction:

The relationships between flowering plants and their pollinators are both ecologically and economically essential. Pollinators are often considered keystone species (Bond 1994) that ensure "the integrity of the community and its unaltered persistence through time" (Paine 1969). Insects might well be considered the most important of such keystone species, as approximately 80% of the world's wild plants and 75% of agricultural crops depend on entomophily (Klein et al. 2007; Potts et al. 2010).

Bumble bees (*Bombus* spp.) have historically represented some of the most adept pollinators of both wild and cultivated flowering plants owing in part to their robust bodies, long tongues, and generalist floral preferences (Goulson 2010). They are also crucial to natural ecosystems, as simulations of extinction cascades in plant-pollinator networks showed that plant diversity declined most rapidly when the most-linked pollinator species, namely bumble bees, were removed from ecosystems (Memmott et al. 2004). Unfortunately, declines in many *Bombus* species have been documented worldwide (see Goulson et al. 2008); in the United States, *Bombus* species are experiencing greater and more significant losses than other bee taxa (Hymenoptera: Apoidea: Anthophila) (Bartomeus et al. 2013). Factors such as pathogens, pesticides, climate change, and habitat destruction have all been cited as contributing factors to these losses (Berenbaum et al. 2007).

Traditionally overlooked habitats such as roadsides and hedgerows have recently been shown to provide valuable habitat for native bees. Hannon & Sisk (2009) found diverse assemblages of native bees in agricultural hedgerows in southeastern Arizona. Hopwood (2008) found that bee species richness and abundance along roadsides in Kansas were increased to levels similar to prairie remnants when the roadsides were restored to native vegetation. Such studies suggest that native bees utilize marginal habitats and that enhancing those areas will improve conservation of these species.

Five bumble bee species have been previously documented in northeast Texas (Warriner 2012); two of these species, *B. pensylvanicus* and *B. fraternus*, have undergone significant range reductions in other parts of the United States (Grixti et al. 2009; Cameron et al. 2011), leading *B. pensylvanicus* to be designated as a Species of Greatest Conservation Need in the Texas Conservation Action Plan (2012) and *B. fraternus* to be placed on the International Union for Conservation of Nature (IUCN) Red List (Hatfield et al. 2014). Unfortunately, the status of these species in Texas is not well understood because of a lack of consistent monitoring activity and data. Yet, in order to construct conservation measures for these and other bumble bees in Texas, as well as evaluate the efficacy of such measures, it is crucial that populations be continuously assessed.

Here we report the results of a 2014 study to investigate *Bombus* presence and abundance along roadsides in northeast Texas. These results provide a baseline for understanding the current status of populations and for targeting locations where conservation actions may yield maximum benefit.

Study Area

Surveys were conducted in 16 counties that spanned areas of the East Central Texas Plains, Blackland Prairies and Cross Timbers Level III ecoregions of northeast Texas, including Montague, Wise, Parker, Cooke, Denton, Tarrant, Grayson, Collin, Dallas, Fannin, Hunt, Rockwall, Kaufman, Rains, Van Zandt, and Wood (Map 1). The total area covered by these counties is 12,812 square miles, or about 4.7% of the state of Texas. This region historically consisted of native tallgrass prairies and woodlands, but currently much of the natural land cover has been replaced with agricultural land and urban development. All survey sites lay on public property alongside roads of varying capacities, ranging from major interstate highways to small rural roads. Sites were also surrounded by a variety of different landscapes, including rural, urban and agricultural areas.

Methods

Roadside bumble bee surveys were carried out on sunny days during July –September, 2014, to coincide with peak bumble bee activity. Sampling sites were chosen based on accessibility (i.e., public land that was safe to access) and the availability of flowering plants. At least two data points (sampling sites with bumble bees present) were acquired in every county except Rains, where only one site was located.

Once a sampling site was located, bumble bee species presence was assessed during timed 15-minute sampling periods. A straight line was walked in one direction through the flower patch(es) and the number of individuals of each bumble bee species was counted. If there were more than ten individuals of a species, the total was simply recorded as >10. In addition, one voucher specimen of each species observed was collected. Collection of voucher specimens was performed using an aerial net and individual collection jars. These specimens were frozen in a mobile cooler and the euthanized individuals were later pinned and labeled according to curation standards. These specimens were delivered to Michael Warriner, the Program Leader of the Nongame and Rare Species Program within the Texas Parks & Wildlife Department. Sites were also assessed using Texas Natural Diversity Database (TNDD) reporting forms (see Appendix 1).

Results

Of the 42 potential sites visited along the approximately 1,345 miles of roadway driven in northeast Texas, bumble bees were observed at 39. *B. pensylvanicus* was present in all 16 counties and at all 39 sites that possessed bumble bees, while *B. fraternus* was present in nine counties and at 15 sites. No other bumble bee species were observed. A total of 270 bumble bees were counted (217 *B. pensylvanicus* and 53 *B. fraternus*), the majority of which were surveyed foraging on *Helianthus annuus* or *Asclepias* spp. The survey locations and relative abundances of each bumble bee species are represented in Figure 1 and the exact numbers of individuals counted at each site are shown in Figure 2.

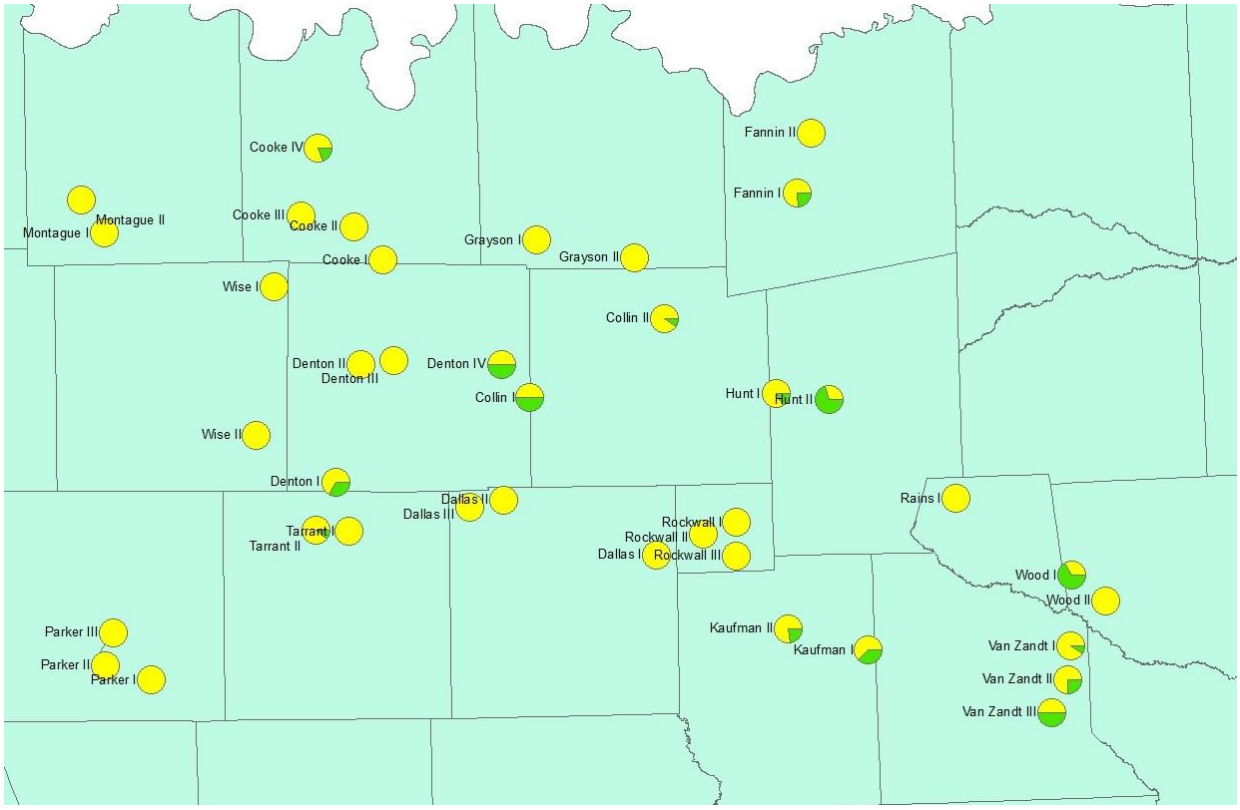

Figure 1: Map showing locations of roadside field surveys with pie charts to show relative abundance of each species. The yellow portion of each circle represents the proportion of individuals that were *B. pensylvanicus* and the green portion represents *B. fraternus*.

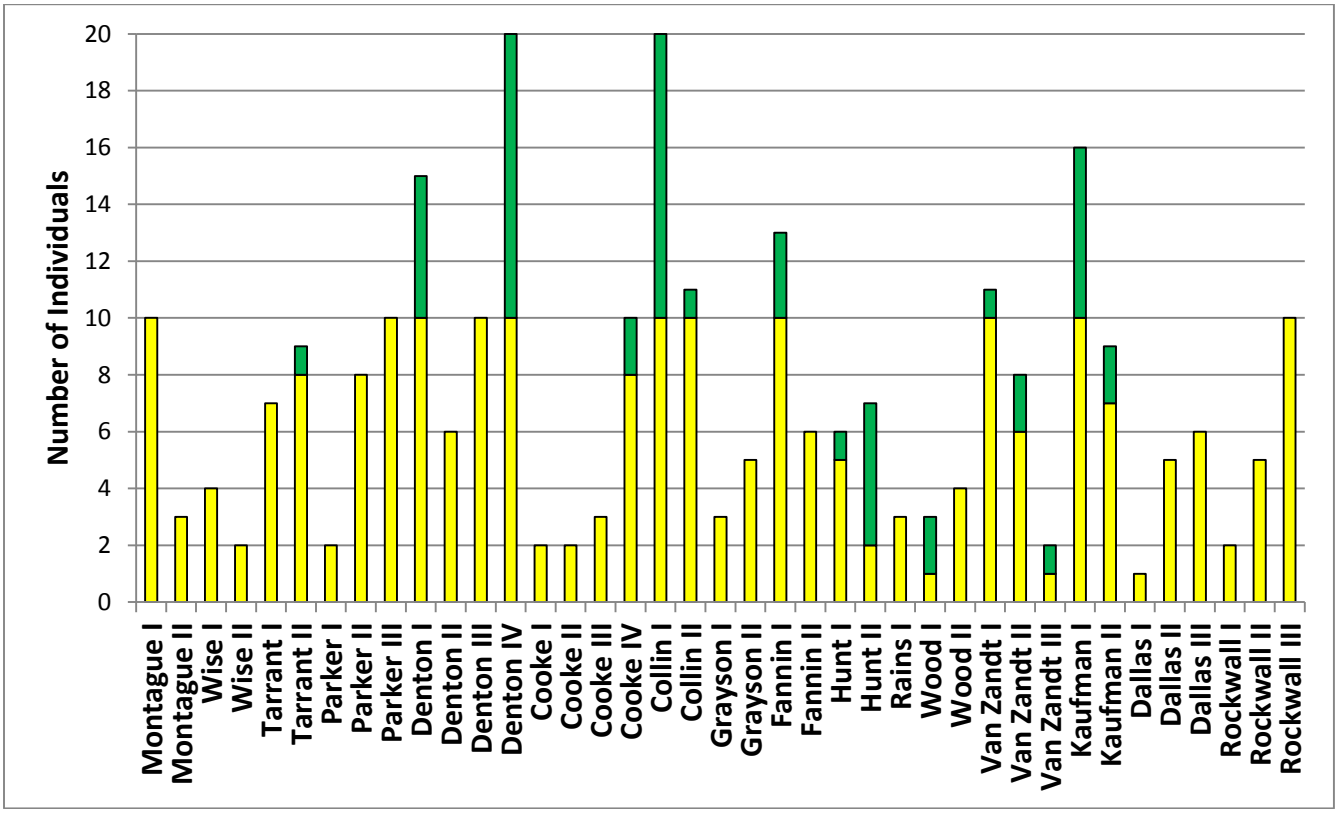

Figure 1: Numbers of individual bumble bees counted at each site, by species. *B. pensylvanicus* is shown in yellow and *B. fraternus* is shown in green.

Discussion

The two most common species of bumble bee found along northeast Texas roadsides were *B. pensylvanicus* and *B. fraternus*, both of which are considered declining on a national scale. Moreover, though the amount of available foraging habitat (i.e., patches of flowering plants) was limited across counties due to roadside mowing, bumble bees were surprisingly common when flowers were present, as evidenced by the fact that they were found at 39 of the 42 potential field survey sites in this study (or approximately 93% of the time). Thus, northeast Texas roadsides represent a potential "ground zero" for implementing conservation practices for these declining species. Simple actions such as limiting mowing of roadsides while flowering plants are present have the potential to greatly impact the abundance of foraging choices for bumble bees. On a larger scale, roadsides could potentially be planted with native flowering plants to enhance bumble bee populations (see Hopwood 2008).

It is recommended that roadside bumble bee surveys be continued and expanded to include a greater area of the state in future years in order to assess the temporal dynamics of these populations. In addition, the presence data reported in this study should be used to develop predicted species distribution maps (see Phillips et al. 2004) for the purpose of identifying suitable locations for conservation measures such as reduced mowing and roadside restorations.

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