With agricultural intensification occurring as widely as it currently is, it comes as no surprise that the effects of which are taking a toll on the environment and the ecosystems surrounding these areas of agricultural focus (Tscharntke et al., 2005; Klein et al., 2007; Hirsh et al., 2013; Kim et al., 2006; Foley et al., 2011). By definition, intensive agriculture is the combination of increased productivity, high pesticide and fertilizer usage, limited crop rotation, minimal grasslands or other natural/semi-natural landscapes, increased farm size, and increased mechanization (Herzog et al., 2006; Le Féon et al., 2010). Many of these factors can be observed in farms around the world, as according to the United Nations' Food and Agriculture Organization (FAO), 3.78 billion acres (12%) of the planet's land unoccupied by ice is covered in croplands, with an additional 8.35 billion acres (26%) used for grazing purposes (Foley et al., 2011). Specifically in the United States, there are a total of 915 million acres (40%) of available land in agriculture: 45.4% of that land is permanent pasture for grazing, 42.6% is cropland, with the remaining 12% being woodlands, farmsteads, and other facilities (USDA, 2014). Concentrating on Iowa, 30.6 million of the 36.0 million acres (85%) belonging to Iowa are in farmland (USDA, 2014). With 38% of the total ice-free land on the planet occupied by agriculture, and a higher proportion within the United States and Iowa specifically, it is understandable that there has been a notable decrease in the proportion of natural or semi-natural landscapes found in these locations with an increase in homogenization and monocultures.

Of particular concern are the tallgrass prairies of the Midwestern United States. This ecotype has been deemed "critically endangered" due to over 50% of its natural flora being converted to other vegetation types (Hoekstra et al., 2005). In Iowa specifically, tallgrass prairies covered approximately 85% of the landscape at the time of European settlement, and by the early 1990s accounted for only 0.01% of the landscape in the state (Hirsh et al, 2013).

Losses in biodiversity across the Midwestern United States are happening at an unparalleled rate and range with the above described intensification in agriculture being one of the main driving forces (Tscharntke et al., 2005). Based on the demonstrated loss of natural and semi-natural landscapes to agriculture, those remaining plots of tallgrass prairies are few and far between, resulting in a textbook case of habitat fragmentation.

Different organisms, particularly those of different sizes, respond differently to habitat fragmentation. Larger, mobile organisms aren't as negatively impacted by habitat fragmentation, as moving to another suitable patch can be done with relative ease. Habitat fragmentation as observed from an invertebrate's perspective relays a very different account as compared to those larger organisms due to the frequent impossibility of their travelling to a more suitable patch (Cane, 2001). The inability to move to a location with proper forage or nesting conditions for invertebrates can ultimately lead to localized extinction, and thus an overall loss of biodiversity. These losses in biodiversity are alarming from a conservation standpoint as well as from an economic one, with special respect to ecosystems services.

Ecosystem services are a means of determining the human values gained or lost in environments from natural resources (Wallace, 2007). Arguably one of the most important ecosystem services is that of animal-mediated crop pollination. Animal-mediated pollination allows for the sexual reproduction of crops and other plants, many of which humans have come to rely on as a means of food resources and economic gain (Klein et al., 2007). Nearly 35% of the world's crops rely on pollination by animals, most commonly by bees, hoverflies, and butterflies (Le Féon et al., 2010), of which bees are arguably the most important pollinating taxon (Greenleaf et al., 2007). The plants and crops that don't explicitly require pollination to achieve sexual reproduction have been shown to benefit from supplementary pollination by way of higher yields or increased seed set (Milfont et al., 2013). In an effort to increase ecosystem services and achieve the desired benefits, managed honey bees have been used for supplementary pollination around the world.

Honey bees, most often *Apis mellifera*, have been widely managed to aid pollination as an ecosystem service when wild or native bees aren't present in sufficient numbers. Honey bee hives are relatively inexpensive, convenient, and versatile as a means of crop pollination, particularly when compared to managing native bees, but are often not the most efficient pollinators of a particular plant or crop. Limitations in morphology, phenology, and behavior of honey bees add to their inability to efficiently pollinate all crops (Cane, 1997). For example, specific floral morphologies can limit honey bee access to pollen or nectar. Poricidally-dehiscent anthers require sonicating, or shaking, of the anther itself in order to release the pollen, which is typically performed by gripping the anther and rapidly vibrating the flight muscles. Honey bees do not have the ability to sonicate, thus are unable to pollinate any plants requiring such an action, such as tomatoes or eggplants (Cane, 1997). The morphology of the bee itself plays a role in its ability to pollinate effectively and to access the nutritional rewards provided by the plant as well. Certain corollas may be too long or too short for the honey bee's tongue to obtain the nectar held within, or, in some cases, *Apis mellifera* is too small to contact the stigmatic surface to allow the pollen to adhere. While honey bees are generally polylectic, they nevertheless exhibit preferences in pollen and nectar choices. Cotton pollen is thought to be too large for honey bees to carry comfortably, and they have been known to dump cotton pollen from time to time or avoid it altogether. Honey bees have also been observed avoiding onion flowers, likely due to the excess potassium salts found in the nectar (Cane, 1997). While the limitations of honey bees can be circumvented by saturating fields with high numbers of hives, it is often not feasible, monetarily or logistically, to do so.

In addition to the honey bees' shortcomings in pollination services, relying solely on one species to provide such an important service highlights a disastrous potential risk. Currently, the losses in honey bee populations are thought to be a result of the spread of *Varroa destructor* parasitic mites, increased exposure to pesticides, and lacking a sufficiently polylectic diet (Dolezal, 2015). Due to these potential factors, honey bee losses exceeded 42% between April 2014 and April 2015 (Kaplan, 2015). Consequently, the inadequacies observed in honey bees has caused much attention to be turned to the pollination abilities found in native bees.

The vast majority of native bees have yet to be "domesticated" as the honey bee has, but a few have allowed themselves to be managed. The alfalfa leafcutting bee, *Megachile rotundata*, nests in stems and, per its namesake, is an avid pollinator of alfalfa. Managed *M. rotundata* nest in transportable shelters filled with laminated and grooved sheets of pine wood or polystyrene (Cane, 1997). This species is particularly useful due to its tendency to overwinter as a prepupa, which allows its emergence to be timed with the bloom of the alfalfa plants. Other stem-nesting bees are used to pollinate apple orchards, particularly those of the genus *Osmia*. Similarly to *M. rotundata*, many species of *Osmia* will nest in artificial shelters and tolerate relocation fairly well. *Nomia melanderi*, also known as the alkali bee, is the only solitary fossorial bee to be managed for commercial purposes, and will readily nest in beds filled with soil of the appropriate texture and moisture. *N. melanderi* also pollinates alfalfa, but because *M. rotundata* is easier to employ, the alkali bee is rarely used due to the difficulty in properly preparing a suitable nesting site. Bumblebees are often used in greenhouse settings to pollinate crops such as tomatoes or cucumbers, but aren't economically efficient enough to be extrapolated to field settings (Cane, 1997).

As described above, particularly with *N. melanderi,* commercially managing native bees in the same way that honey bees have been and continue to be managed is not possible without understanding the nesting requirements and conditions of the bees. Much like other organisms, bees have an ideal habitat they select for. Suitable native bee habitat must contain at minimum both appropriate floral resources and nesting conditions within flight distance of each other (Cane, 2001). Unsurprisingly, floral resources and soil conditions vary with species, but all bees commonly feed on nectar and pollen, use a mixture of the two to provision their offspring, and require nesting sites for their offspring and, in some cases, overwintering. Some species of bees are largely catholic in their feeding preferences, while others are involved in tightly-knit mutualisms with one or more plant species. The species that exhibit polylectic tendencies have the ability to switch floral hosts if one plant should become scarce. Such is not the case with oligolectic species; if their floral host declines in number or perhaps the emergence times or phenology are mismatched, these species cannot alter their floral host. Bees that are long-lived or are multivoltine, having more than one brood period per year, face a problem on the opposite end of the spectrum in that their foraging needs outlast the length of one host's blooming period. These species require not only one suitable plant to meet their needs, but a succession of appropriate plants in bloom for the entire growing period. The two most abundant crops in Iowa, corn and soybeans (*Zea mays* and *Glycine max*, respectively), do provide some forage for bees, though the pollen and nectar provided are in negligibly small amounts and the blooming period is brief. A wide variety of forbs are required to ensure that the foraging requirements of bees are met (Haaland et al., 2011). Intensive agriculture paired with the resulting habitat fragmentation can impose negative effects on all bees, honey bees and native bees alike, particularly when considering the specificity that can arise in plant-pollinator interactions (Cane, 2001; Kim et al., 2006; Hirsh et al., 2013).

Floral resources are an important factor to contemplate when considering native bee maintenance, but an often overlooked aspect of their life history deals with their preferred nesting and overwintering sites (Cane, 1991; Svensson et al., 2000). While there are bees around the world that nest in hollow twigs or sticks, tree hollows, or even rocks (Custer, 1928), the most common place for bees to nest is within the ground. Iowa boasts more than two hundred species of bees, of which approximately 80% are fossorial, or nest in the soil. The tallgrass prairies that once covered 85% of the region provided deep, rich soils that are world-renowned for their quality. Based on this fact, it is understandable as to why bees and farmers alike utilize these soils. Identifying the nesting habits of bees is crucial to being able to provide the appropriate conditions and to recognize when those conditions are absent. The nesting conditions most commonly preferred by fossorial bees are bare ground that is unoccupied by dense vegetation, well-drained, relatively well-compacted soil, and free of cracks or fissures (Cane, 2001). Loams are the prevailing soil types for solitary bee nests, which are composed of approximately 40-40-20% proportions of sand-silt-and clay, respectively. The proportions can vary to a certain degree, producing different types of loams, such as sandy loam, loamy sand, or sandy clay loam (Kaufman and Cleveland, 2008). These conditions are specific, but are not uncommon in natural landscapes.

However, with agricultural practices intensifying and the resulting monocultures dominating the landscapes, the locations that provide both floral resources and the appropriate nesting conditions concurrently are lessening. In addition, the floral resources and nesting sites must occur within the maximum flight range of the bees appropriate for those locations. Foraging distance has been shown to increase with body size (Greenleaf et al., 2007), though body size is not a direct indication of maximum flight distance. Large-bodied bees are able to fly greater distances between their nest site and potential foraging areas. For example, *Bombus terrestris* (found commonly in Europe with a small presence in the United States) was found to forage at least 0.93 miles from their colonies (Osborne et al., 2008). At the other end of the spectrum, smaller bodied bees are unable to fly distances of the same magnitude as the large-bodied bees, typically being limited to 500 to 2,000 feet (Gathmann and Tscharntke, 2002). Bridging the distance between floral resources and nesting locations can prove to be impossible for small-bodied bees as well as large-bodied bees in lesser than ideal habitats. In addition, oligolectic bee species have been shown to travel distances similar to those of polylectic bee species, demonstrating that flight distance is the limiting factor of foraging ranges rather than floral resource availability (Gathmann and Tscharntke, 2002). While body size cannot always be directly applied to flight ranges, it can provide a good indication of approximate maximum flight distance. Considering the limited distances bees can cover, maintaining proper nesting sites and appropriate floral resources within those distances is of the utmost importance, particularly in agricultural areas. If the requirements are not met, losses in biodiversity and local extinction can occur (Gathmann and Tscharntke, 2002; Cane, 2001).

To this end, it can be considered unreasonable, impractical, or unrealistic at this point to remove large portions of land from production in an effort to create conservation reserves. Smaller scales must be considered, while maintaining the hope that the existing smaller increments of land can provide adequate refugia for those organisms negatively impacted by agriculture (Shafer, 1995). The incorporation of contour buffer strips, which are relatively small bands of perennial (non-crop) vegetation placed within agricultural fields perpendicular to the slope of the land (NRCS, 2011), has been practiced by farmers. The overarching aims of contour buffer strips are to reduce sheet and rill soil erosion, trap sediment, and slow runoff from the field, while also possibly providing habitat for wildlife (NRCS, 2011). Placing contour buffer strips in a field not only has the ability to improve soil health, but can cut down on costs to the farmer by way of not requiring additional applications of nitrogen, pesticides, or other chemicals.

In an effort to improve upon and widen the scope of contour buffer strip implementation across the Iowa landscape, the Science-based Trials of Rowcrops Integrated with Prairie Strips (STRIPS) project began in 2003 at Iowa State University. The team of researchers working on the project aimed to test the effects of integrating more native forbs into the vegetation comprising the contour buffer strips at Neal Smith National Wildlife Refuge (NSNWR) with the hopes of continuing to improve water, soil and nutrient retention within the field, with an additional goal of providing native habitat for wildlife. Strips composed of exclusively tallgrass prairie vegetation were implemented in soybean fields at NSNWR in 0, 10, and 20% increments. Little difference was apparent between the 10% and 20% increments, allowing only 10% of a field to be removed from production to receive the wealth of benefits provided. There was found to be a 44% reduction in water runoff, over 80% reduction in both nitrogen and phosphorus runoff, and a 95% reduction in soil erosion (Harris, 2015). The benefits of this practice were found to be highly disproportionate to the monetary losses incurred in the removal of land from production. The sturdy, long-rooted grasses and forbs present in the native tallgrass prairie plants prevent water flow out of the field and increase sediment and nutrient retention (Hirsch et al., 2013; Liu et al., 2008) that is lost in 100% rowcropped fields or in fields with contour buffer strips comprised of grasses only.

Improvements in biodiversity were found as a result of the prairie strips as well. Conversion of 10% to 20% cropland to prairie strips increased plant species richness by 240%, with an increase of 480% in native species richness (Liebman et al., 2013). In terms of wildlife, greater bird species richness was recorded in addition to greater insect predator abundance (particularly soybean aphids) within the prairie strips when compared to the rowcropped areas of the field (Liebman et al, 2013; Hirsh et al., 2013; Schulte et al., 2016). Native bee species observed within the implemented prairie strips were similar to those observed in the neighboring reconstructed tallgrass prairies in the area (Harris, unpublished data). Additional studies have shown that wild bee species richness as well as species composition increases with increased habitat availability (Bommarco et al., 2010). Based on the above described information, incorporating prairie strips within agricultural rowcropped fields has maintained the original goal of contour buffer strips in increasing soil health while simultaneously providing habitat and necessary resources for Iowa's native wildlife as well as providing disproportionate benefits to the farmer.

Prairie strips have been shown to improve access to floral resources for native bees, and while fossorial bees have been found to nest within them, they have been relatively few in number (Moorhouse, unpublished data). As described above, understanding the nesting requirements for native ground-nesting bees is crucial to providing adequate habitat for them to occupy. Reintroducing such habitats, consisting of proper soil conditions and the removal of excess vegetation, within the appropriate flight distance of the prairie strips will fill a critical component previously lacking in the STRIPS initiative. Providing appropriate nesting conditions for native bees in addition to adequate forage within agricultural fields can potentially improve native bee biodiversity, lessen the pollination pressure placed on honey bees, and decrease the effects of habitat fragmentation in the region, while simultaneously increasing the ecosystem service of pollination to crops.

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