The Importance of Bees in Natural and Agricultural Ecosystems

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Abstract: As the world's most important group of pollinators, bees are a crucial part of agricultural production and natural ecosystem function. Bees and the pollination they provide are relevant to the nursery industry because of their role in the performance of seed increase plots as well as the importance of pollination in supporting persistent plant communities in restored areas. Agricultural producers can increase seed or fruit production with colonies of European honey bees, managed native bees, or by managing land to increase populations of native bees. By meeting requirements for food and nesting resources restored areas can support similar levels of species richness and abundance of native bees. Although the specific species of bees present may differ between restored and remnant sites, pollination function and community resilience can be restored.

Keywords: pollination, seed production, seed increase, bees, restoration

The Importance of Bees in Natural and Agricultural Ecosystems

Pollination services provided by insects are an indispensable component to both natural and agricultural ecosystems (Kremen and others 2002, Pauw 2007, Klein and others 2007). Estimates of the value of insect pollination of agricultural crops in the United States range from $150 million paid for pollination services to $3.07 billion in total crop value (Morse and Calderone 2000; Losey and Vaughan 2006). While agricultural intensification and urbanization may be reducing the numbers of wild pollinators (Kremen and others 2002), native (as opposed to managed) bees can still provide abundant crop visitation in a variety of landscape types (Winfree and others 2008). Although many taxa, including moths, flies, beetles, hummingbirds, and bats, function as pollinators, bees are most effective in many cases (Steffan-Dewenter and Tscharntke 1999). This is true for a few reasons. Bee larvae and adults both rely almost entirely on pollen and nectar for sustenance. Therefore the number of visits bees make to flowers, as well as the distance moved between flowers, are greater than in other pollinator taxa (Willmer 2011). As well, bees as a group have a wide range of sizes and morphological adaptations that enable mutual relationships with a wide range of host plants (Thorp 1979, 2000; Michener 2000). Conversely, wasps, the most similar group of organisms, feed on nectar only as adults, hunting other arthropods to provide the nitrogen needed for larval development. Other groups of animal pollinators important in temperate areas (butterflies, flies and beetles) also only feed on pollen and nectar as adults.

The mutual relationship between bees and plants is complex. The vigor of a bee community is determined by plant species richness and diversity at both small and large scales (Steffan-Dewenter and Tscharntke 1999; Hendrix and others 2010). Similarly, seed production and, potentially, eventual plant recruitment is dependent on a species rich and diverse bee community (Steffan-Dewenter and Tscharntke 1999; Slagle and Hendrix 2009). A variety of floral visitors is important as different bees have different habits and interact with the flower in different ways, improving pollination; a variety of accessible plants provides greater niche space (Potts and others 2003).

Providing Supplemental Pollination Using Honey Bees

Ensuring high levels of pollination can produce larger yields and higher quality fruit. Supplemental crop pollination is most commonly provided with managed colonies of the European honey bee. Convenience and predictable efficacy has made the honey bee an integral part of modern agriculture. About 150,000 honey bee colonies are rented to U.S. growers for pollination annually, with almonds, apples, and cherries comprising about half of all colony rentals (Burgett and others 2010). The European honey bee is very well suited to commercial pollination. Colony strength can be visually inspected and extremely high numbers of pollinators can be placed anywhere within the agroecosystem at a time that suits the grower. These traits allow growers certainty there will be sufficient pollination service when and where it is needed.

However, relying on pollination by managed honey bees has drawbacks. Pollination efficiency varies by crop, and some pants (such as alfalfa) are not effectively pollinated by honey bees. Additionally, Colony Collapse Disorder and honey bee colony death due to mites and disease continue to be problems. Although there has been much research into honey bee health recently (Figure 1), rentals of honey bee colonies are becoming increasingly expensive (about $90/colony in the western U.S.) and may be unavailable in certain areas (Burgett and others 2010).

Encouraging Native Bee Pollination

Because of these drawbacks, growers in some systems have chosen to actively manage native bees for pollination. A robust population of native bees can provide pollination service throughout the growing season, which is important if the grower has a variety of crops requiring pollination that may flower at different times. In agricultural systems, diverse and species rich plant communities near pollinator dependent crops can increase pollination and greatly add to crop value (Kremen and others 2004).

The amount of land hosting diverse floral resources in the few hundred meters surrounding a flowering crop is directly related to pollen deposition (Kremen and others 2004). Additionally both small and large alterations to the farmscape, such as leaving areas fallow, planting strips of wildflowers, or reducing tillage can increase local presence of pollinating insects (Vaughan and others 2007). Limiting pollinator exposure to pesticides cannot be stressed enough. Avoiding treatment of flowering crops or spraying in the evening with a low residual insecticide is the most important single thing a grower can do to limit pollinator mortality (Johansen and Mayer 1990). For more information see 'Farming for Bees' published by the Xerces society.

Figure 1. Bees feeding on a special diet formulated by the USDA-ARS. Honey bee die off may be caused by a combination of poor nutrition, pesticide exposure, pests, or pathogens. Honey bee colony rental is becoming increasingly expensive despite recent progress in understanding and mitigating honey bee stressors. (Photo: Stephen Ausmus USDA-ARS).

Effect of Restoration on Bee Populations

In natural settings a robust plant-pollinator community fosters ecosystem resilience because each supports the other (Fontaine and others 2005). A strong bee community requires a diverse selection of plants to provide places for nesting as well as sustenance throughout the season (Potts and others 2005; Franzén and Nilsson 2010). The diversity of a flowering plant community is closely linked to the functional diversity of a complementary community of pollinating insects (Fontaine and others 2005). Seed production in most plants is, in some years, limited by inadequate pollen deposition (Burd 1994), and many native forbs greatly increase seed production with pollinator visitation (Figure 2) (Cane 2008). Pollen limitation may be the most significant cause of reproductive failure in fragmented habitats (Aguilar and others 2006). For all these reasons, a robust community of native bees is necessary for thriving plant communities in restored areas (Handel 1997).

Although there may be structural differences in bee communities between remnant and restored areas, bee species richness and pollination function can be restored to levels similar to remnant native habitat (Exeler and others 2009; Williams 2011) as long as necessary food and nesting resources are available within foraging range (Potts and others 2005; Winfree 2010). Nesting resources can take the form of bare soil, dead woody substrate, pithy or hollow stems, or rodent burrows depending on the bee species. Food for bees is entirely composed of pollen and nectar produced by flowers. The timing and variety of floral resources available are important mediators of the bee community at a site. Restored areas should have plant species that provide pollen and nectar for the duration of the growing season. These plants have been referred to as 'framework' and 'bridging' plants depending on their role in the support of the pollinator community (Dixon 2009).

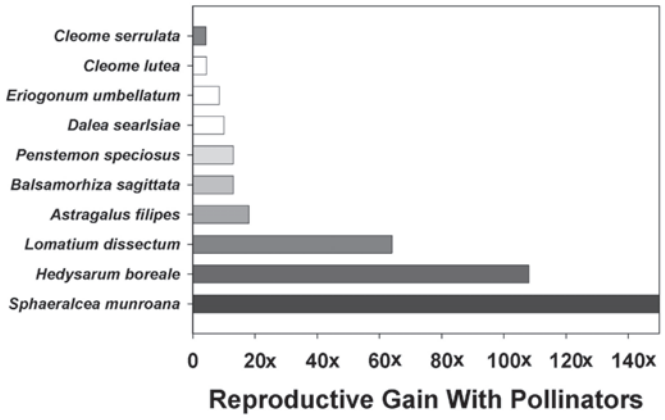

Figure 2. Pollinator visitation can greatly increase plant seed production. Increased seed production may increase resilience of plant communities.

Framework plants provide copious amounts of pollen and nectar to a wide range of bee species. This will ideally create a large and diverse bee community that then provides pollination to a number of less attractive plant species (Ghazoul 2006). However this strategy may fail if the framework plants chosen compete with other plants through pollination. It is difficult to predict if plant species sharing pollinators will compete for or mutually facilitate pollination (Menz and others 2011).

Bridging plants provide nectar and pollen in resource-limited times of year. The necessity of bridging plants depends on the length of the growing season and the pollinators involved (Dixon 2009). If the growing season is short enough bridging plants may not be needed because floral resources may be very common during the short time bees are actively foraging (Menz and others 2011).

Summary

Pollination is a crucial part of seed or fruit production; many native forbs and annuals produce much more seed when pollinators are present (Cane 2008; Slagle and Hendrix 2009). Pollination can be increased or ensured through introduction of European honey bee colonies or by managing the agro-ecosystem for native bee habitat. Honey bees may be an attractive choice for some growers because of their simplicity and general efficacy. However the cost of importing colonies may be high and honey bees are ineffective pollinators for some crops. By providing food and nesting resources near crops requiring pollination a species rich community of native bees can be maintained providing quality pollination service throughout the growing season.

An abundance of floral and nesting resources will also foster a strong community of native bees in restored areas. Replanting shrubs or woody plants, if appropriate, will complement existing soil nesting sites to provide nesting opportunities for a wide variety of bees. Restoring a site with a mixture of plants that offer nectar and pollen throughout the growing season will support a variety of bee species with different periods of activity. A diverse bee community can increase the likelihood restored plantings will persist by ensuring ecosystem function is restored along with the plant community.

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