BUMBLEBEE CONSERVATION IN AND AROUND CRANBERRY MARSHES

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Introduction

Bumblebees as Cranberry Pollinators

As the most effective pollinators of the American cranberry *(Vaccinium macrocarpon* Aiton*),* bumblebees are valuable components of cultivated cranberry landscapes (Kevan et al., 1983; MacKenzie, 1994; Stubbs & Drummond, 1997). Since cranberry pollen is heavy and is not wind blown (Wyman, 1976), insects are necessary for adequate pollination. Cranberry growers, like farmers of many other agricultural crops, often rely on the European honeybee *(Apis mellifera* Latreille*)* for crop pollination because of the mobility and reliability of honeybee hives. Despite this dependence upon honeybees, however, these commercial bees are not ideal cranberry pollinators. Cranberry flowers are not particularly attractive to honeybees because they produce only small amounts of nectar and pollen (Kevan et al., 1983; Wyman, 1976). Bumblebees, on the other hand, are able to efficiently obtain pollen and transfer it between cranberry flowers (Free, 1993) because of their large size and use of sonication (i.e. "buzz pollination"), of which honeybees are incapable (Plowright & Laverty, 1987). Cranberries pollinated by bumblebees have higher yields, larger fruit, and more seeds per berry than those pollinated only by smaller insects (Mohr & Kevan, 1987). In addition, bumblebees work longer hours and in windier conditions than honeybees do (Williams & Christian, 1991). They also forage in the cooler periods of early morning and evening, when honeybees are typically inactive (Corbet et al., 1993; Free, 1955).

Risks of Relying on Honeybees

Better cranberry production is not the only reason to encourage wild bumblebee populations. Bumblebees are native pollinators; honeybees are not. In addition, a potential hazard of relying on honeybees is the risk of parasitic tracheal mites *(Acarapis woodi* Rennie) and Varroa mites *(Varroa jacobsoni* Oudemans) which are known to affect honeybees but have not been found to have an effect on bumblebees. The Africanized, or "killer" honeybee is another potential threat (Kevan et al., 1990; Thomson, 1993). If management practices were modified to better address the habitat needs of bumblebee populations, both cranberry growers and bumblebees could benefit by less reliance on non-native bees.

Bumblebee Population Declines

As a result of habitat destruction and pesticide poisoning (Kevan, 1975; Kevan et al., 1990; MacKenzie & Averill, 1995; Winston & Graf, 1982), bumblebee *(Bombus* spp. Latreille*)* populations have declined or gone extinct in some regions of Britain (Osborne & Corbet, 1994; Williams et al., 1991; Williams, 1986), Canada ((Plowright & Laverty, 1987), France, Belgium (Rasmont, 1988), Poland (Banaszak, 1995; Kosior, 1995), and Turkey (Ozbek, 1995). Although strong evidence for bumblebee population reductions in the United States has not yet been reported, researchers suspect that declines are

occurring here as well (Tepedino & Ginsberg, 2000). It would be wise to take efforts to conserve these native pollinators.

Forage Resources in Agricultural Landscapes

In an agricultural landscape, the presence of an agricultural crop can provide an abundance of forage resources for a relatively short length of time. However, because bumblebees do not store up food resources for long periods of time, a single crop alone cannot sufficiently meet the forage needs of bumblebees. If the availability of forage is not continuous, the colony suffers. One way to address habitat needs of bumblebees is to manage the landscape within and around cranberry beds so sufficient and diverse foraging resources are available to bumblebees throughout the season (Banaszak, 1992; Corbet et al., 1994; Dramstad & Fry, 1995; Free, 1993; Macfarlane & Patten, 1997; Plowright & Laverty, 1987; Williams et al., 1991). A necessary step toward ensuring adequate forage resources is to discern which are most valuable to bumblebees.

Research Overview

Purpose

The purpose of this research was to determine which plant species and plant community types around cranberry farms are most valuable for bumblebee forage.

Methods and Study Sites

Data collection occurred during the spring and summer of 2001 and 2002. Transects were established and divided into sections according to plant community type. Flower abundance surveys and bumblebee surveys ("bee walks") were conducted.

The study sites were three commercial cranberry farms in northern Wisconsin. Native vegetation in uncultivated areas associated with these farms includes several ericaceous (heath family) plants in acidic northern bog communities. Ericaceous plants are mainly pollinated by bumblebees, which are adapted to cooler climates (Free, 1993; Mohr & Kevan, 1987). Conducting this study in the north increased the possibility of finding bumblebee-pollinated plant species in the landscape.

Another reason for conducting research in northern Wisconsin is that cooler temperatures sometimes lead to difficulties in using honeybee colonies (Plowright & Laverty, 1987). Therefore, northern growers in particular could benefit from enhanced habitats for bumblebees and other native pollinators. Also, cranberry farms in the northern part of the state are generally smaller than those in other regions. Native pollinator management strategies involving the surrounding landscape have higher chances of success there (Kevan et al., 1983; Mohr & Kevan, 1987) than in areas with greater flight distances to the center of the cranberry beds. Although it was logical to conduct this study in northern Wisconsin, the results of this research may still be applicable to cranberry farms in central Wisconsin. The following cranberry farms provided study sites for this research:

- Bartling's Manitowish Cranberry Company, Inc., Manitowish Waters area
- Lake Nokomis Cranberries, Inc., about midway between Bartling's and Tamarack Flowage
- Tamarack Flowage Cranberry Company, near Three Lakes

Results

Flower Abundance

In both 2001 and 2002, cultivated cranberry (*Vaccinium macrocarpon*) was the most abundant in terms of number of flowers for all sites. In 2001, the second most abundant was Labrador tea (*Ledum groenlandicum*), while in 2002 it was leatherleaf (*Chamaedaphne calyculata*). Although these plant species were most abundant, they did not receive the most bumblebee visits per flower or flower cluster. When bumblebee visits per flower were calculated, bull thistle (*Cirsium vulgare*) and raspberry (*Rubus idaeus* var. *strigosus*) received the highest number of visits in 2001, while fireweed (*Epilobium angustifolium*) and Joe Pye weed (*Eupatorium maculatum*) were the most frequented in 2002 (Table 1).

Table 1: Number of visits per flower or flower cluster for plant species on which bumblebees foraged during each research trip, all sites combined. Bumblebee visits per flower were multiplied by 100 for ease of interpretation.

Date	Plant Species	Common Name	# Bumblebee Visits/Flower * 100
5/29/01-6/12/01	*Ledum groenlandicum*	Labrador tea	0.12
	Rubus idaeus var. *strigosus*	red raspberry	15.15
	Vaccinium myrtelloides/angustifolium	blueberry	2.44
6/28/01-7/7/01	*Rubus idaeus* var. *strigosus*	red raspberry	6.25
	Vaccinium macrocarpon	large cranberry	0.06
8/11/01-8/16/01	*Aster* sp.	aster	10.00
	Cirsium vulgare	bull thistle	14.29
	Euthamia graminifolia	grass-leaved goldenrod	1.26
	Impatiens capensis	orange jewelweed	0.19
	Solidago canadensis	Canadian goldenrod	1.83
	Trifolium hybridum	alsike clover	0.31
5/21/02-5/28/02	*Chamaedaphne calyculata*	leatherleaf	0.11
6/25/02-7/2/02	*Hieracium aurantiacum*	orange hawkweed	0.24
	Rubus pubescens	dwarf red raspberry	0.38
	Vaccinium macrocarpon	large cranberry	0.01
7/23/02-7/30/02	*Epilobium angustifolium*	fireweed	41.67
	Vaccinium macrocarpon	large cranberry	2.96
8/13/02-8/19/02	*Anaphalis margaritacea*	pearly everlasting	2.50
	Aster pilosus	awl aster	0.34
	Eupatorium maculatum	Joe Pye weed	33.33
	Euthamia graminifolia	grass-leaved goldenrod	4.19
	Polygonum sagittatum	arrow-leaved tear-thumb	0.15
	Solidago canadensis	Canadian goldenrod	3.96
	Trifolium pratense	red clover	4.22

Plant Species before Cranberry Bloom

Early spring was a period when bumblebee forage resources were particularly scarce in the study areas. Leatherleaf (*Chamaedaphne calyculata*) was the earliest blooming plant on which bumblebees were observed to forage. Willow (*Salix* spp.), has been reported to be an important source of nectar and pollen for bumblebee queens in the early spring (Kearns & Thomson, 2001; Medler & Carney, 1963) and was the only plant species in bloom prior to leatherleaf. Bumblebees were not seen foraging on willows in this study; however, this may be due to the relative rarity of willows at the study sites or because the number of bumblebees foraging at the time willows were in bloom was quite low. Since the likelihood of bumblebees nesting near cranberry marshes may be increased by the presence of adjacent early blooming forage plants (Patten et al., 1993), availability of willows or leatherleaf at cranberry farms may help support bumblebee populations.

In early summer, prior to cranberry bloom Labrador tea and raspberry were both important forage plants in 2001. Although bumblebees were not observed to use either of these species in 2002, this may be explained by the timing of the research trips and the weather that year, which was cooler than normal in the spring.

Plant Species during Cranberry Bloom

During cranberry bloom in 2001, raspberry continued to be a useful forage plant for bumblebees. Although the number of visits to raspberry was much lower than the number of visits to cranberry, when the number of bumblebee visits was divided by the number of flowers available for each species, raspberry proved to be more valuable. Cranberry growers have differing opinions regarding plants that bloom concurrently with cranberries. Many growers attempt to eliminate all plants that have the potential to compete with cranberries for pollinators during cranberry bloom. Another less common perspective is that plants near cranberry bogs may help draw bumblebees and other pollinators to the area, where they then forage on those plants as well as cranberries, since cranberries alone may not supply sufficient pollen and nectar. Fireweed (*Epilobium angustifolium*) received a great deal more bumblebee visits per flower than any other species blooming at this time. In fact, the number of visits per flower was the highest of any forage plant species in the study. This plant could help attract bumblebees to cranberry crops if allowed to grow in the vicinity.

Plant Species after Cranberry Bloom

After cranberry bloom, there were more bumblebee forage plants in bloom than at any other time of the season. Grass-leaved goldenrod (*Euthamia graminifolia*) proved to be a very important bumblebee forage plant post-cranberry bloom. When data for 2001 and 2002 were combined, this plant received more bumblebee visits than *V. macrocarpon*. Joe Pye weed (*Eupatorium maculatum*) was another important food resource after cranberry bloom. This plant was second only to fireweed in terms of visits per flower.

Plant Community Type Preferences

Bumblebees foraged in 13 different plant community types in 2001 and 2002 combined (Figure 2). In early summer, 2001, foraging bumblebees used four of the

available 12 plant community types. Bog edges were the most often visited plant communities at this time. During mid-summer (June 28-July 7 2001), foraging bumblebees were found in five plant communities. This was the period during which *V. macrocarpon* was flowering, and the number of visits in cultivated cranberry were greater than anywhere else. At the end of the 2001 season (August 11-16), six plant community types were utilized, with unplanted cranberry beds being most valuable.

In 2002, the number of plant community types in this study increased from 12 to 13; this occurred because, for the sake of this study, a cranberry grower did not mow a dike that had been mowed in 2001. During the first research trip of 2002 (May 21-May 28), bumblebees visited only two plant community types, bog edges and open bogs. Between June 25 and July 2 2002, bumblebees used seven different plant community types. The dry meadow received the most visits per 100 meters during this period, despite *V. macrocarpon* being in bloom. Although cultivated cranberry beds received the most bumblebee visits between July 23 and 30 2002, wet meadows were also important. In late summer (August 13-19 2002), the most heavily utilized plant communities were wet meadow and unmowed dike. Overall, unmowed dike and wet meadow were the two most valuable plant communities during the 2002 season, even when cultivated cranberry beds were included in calculations.

When data from both years were combined, it was evident that the unmowed dike attracted more bumblebees on a 100-meter basis than any of the other plant communities except cultivated cranberry (Figure 1).

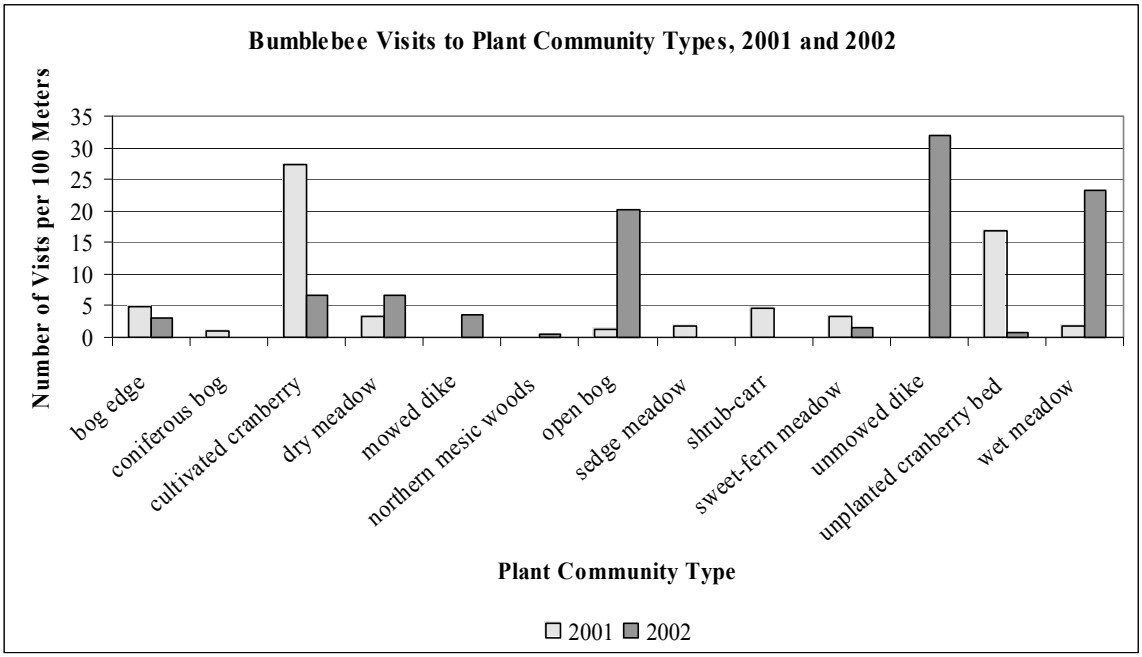

Figure 1: Plant community types visited by foraging bumblebees, all sites combined

Discussion and Recommendations

Diversity in Plant Community Types

This research suggests that diversity in plant community types is important for bumblebee habitat. Diversity is crucial because there is temporal variation in the value of

plant community types. For instance, bog communities are important in the spring and early summer, while wet meadows and unplanted cranberry beds are valuable in late summer.

Importance of Perennials

Bumblebee forage habitat can be improved by managing land for perennials, which pollinators prefer over annuals (Corbet et al., 1994; Dramstad & Fry, 1995; Fussell & Corbet, 1991). Osborne (1994) states, "The most important factor in management for pollinators on farmland is to safeguard and extend areas of perennial herbaceous vegetation," including ditches and other areas usually considered wasteland (Fussell & Corbet, 1991). The results of this study support the claim that bumblebees prefer perennials to annuals: Eleven of the 18 plant species used by bumblebees were native perennial species, and an additional two species were naturalized invasive perennials. Some of the perennial species used by bumblebees in this study were shrubs, (e.g. *C. calyculata* and *L. groenlandicum*), but there was also a large herbaceous component. Perennial herbaceous vegetation corresponds to mid-successional plant communities, which are usually dependent on semi-regular disturbance regimes to prevent invasion by trees and shrubs (Dramstad & Fry, 1995).

Mowing Reduction

While infrequent mowing could act as a disturbance to help maintain perennial plant communities, it is typically done too often on cranberry farms to allow bumblebee forage plants to bloom throughout the season. To help support bumblebee populations on agricultural land, Corbet *et al* (1994) recommend not mowing large areas all at the same time. Infrequent, rather than regular, mowing is recommended to enhance bumblebee flowers (Fussell & Corbet, 1991). Data and observations from this study indicate that a reduction in mowed areas in cultivated cranberry landscapes could be beneficial to bumblebees and other pollinating insects. The most obvious example of the benefits of reduced mowing from this study was the dike that was mowed in 2001 and allowed to grow in 2002. This simple adjustment transformed this from one of the least used areas to one of the most valuable areas for bumblebees.

Enhancement Plantings

Besides managing the existing vegetation for bumblebees, another possibility is to establish enhancement plantings (Comba et al., 1999). The recent cranberry surplus has forced many growers to allow some cranberry beds to lie fallow. It may be possible to view this fallow land, as well as other uncultivated areas, as opportunities to create additional habitat for native pollinators. These areas could be allowed to regenerate naturally, or wildflower mixes could be planted (Osborne & Corbet, 1994). Comba *et al* (1999) suggest planting native species because they are evolutionarily adapted to coexist with native pollinators. The findings of this research support this view since almost all of the plants used by bumblebees were native species. Enhancement plantings would have to consist of plants that are attractive to bumblebees; that flower in uninterrupted succession through the season; that are hardy enough to thrive in Wisconsin; and that are reasonably easy to control. Plants meeting most of these criteria are already found in the landscapes at the cranberry farms in this study.

Suggested Plant Species

If forage plants are to be made available to bumblebees throughout the season by land management techniques, it is helpful to recognize which plants would best accomplish this goal. The following suggestions (Table 2) are based on the blooming periods of bumblebee forage plants and analysis of forage plant preferences obtained through this study. All of the suggested plant species are native to Wisconsin and are perennials. They are recommended only if they were found to be attractive to *Bombus terricola,* the primary cranberry pollinator at the study sites. The exception is *Salix* spp., on which no bumblebees were observed to forage during this study, but which has been previously documented as a valuable bumblebee plant in early spring. These species are suggested with the intent that if they already exist on land around cranberry farms, their growth should be encouraged. If they are not currently growing on the land, or if they are scarce, they could be enhanced with plantings. Reproductive mechanisms for each species (Lorenzi & Jeffery, 1987; Muenscher, 1980) are included in Table 2 and should be considered when deciding on planting locations or areas to reduce mowing. This table also includes information regarding the invasiveness of each plant species according to the USDA (USDA, NRCS, 2002).

Potential Risks

Knowledge of a plant's means of reproduction and invasive potential can help eliminate the possible problem of plants invading cranberry beds. For example, if a plant reproduces primarily through rhizomes rather than wind-blown seeds, it may not be problematic if allowed to grow in an area separated from cranberry beds by water. If reproduction is through wind-dispersed seeds, however, it would be important to allow for adequate space between these plants and cranberry beds or to ensure that the species could be easily controlled with herbicide. If a plant species is considered invasive, it is particularly important to keep in mind its ability to spread rapidly and compete with other plants for resources.

Table 2: Suggested plant species to encourage through enhancement plantings or other land management techniques.

Plant Species	Common Name	Blooming Period	Reproduction	Invasive?
Salix spp.	willow	Early Spring	seeds or fragments of shoots	no
Chamaedaphne calyculata	leatherleaf	Spring	seeds (wind-dispersed)	no
Ledum groenlandicum	Labrador tea	Spring	seeds or root suckers	no
Rubus idaus var. *strigosus*	raspberry	Mid-Spring to Mid-Summer	seeds or root suckers	no
Epilobium angustifolium	fireweed	Mid-Summer (blooms with cranberry)	seeds or root suckers	yes
Impatiens capensis	jewelweed	Mid-Summer to Late Summer	seeds	no
Eupatorium maculatum	Joe Pye weed	Late Summer	seeds	no
Euthamia graminifolia	grass-leaved goldenrod	Late Summer	usually rhizomes; sometimes seeds	no

Conclusion

Enhancement plantings or mowing reduction are ways in which cranberry growers could enhance habitat for bumblebees around their marshes. Although there are some risks involved with these methods, since there would be greater potential for plants to inoculate cranberry beds, these risks could be minimized by wise planning and some knowledge of the plants to be established. Improving habitat for bumblebees by ensuring a steady supply of forage resources would help reduce the devastating effects of habitat loss and fragmentation on bumblebee populations.

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