

**Conserving Native Pollinators of Blueberry:
A Case Study**

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I. Background/Problem Statement:

Here we report on efforts to conserve and increase populations of native mason bees, *Osmia* spp., that pollinate lowbush blueberry, *Vaccinium angustifolium* Ait., an important agricultural crop in Maine, Quebec, and the Canadian Maritime provinces. In Maine alone, over 24,291 hectares are managed with an annual field cash value of \$28 million, which generates income of approximately \$56 million annually (NASS 2004).

Cross-pollination of lowbush blueberry by bees is essential for obtaining good fruit set and yield (Free 1993, Delaplane and Mayer 2000). Historically native wild bees were considered important pollinators (Phipps 1930). Pesticide use and habitat alterations have reduced populations of native bees, particularly in the large Maine blueberry barrens, so that it is now necessary for most growers to rent honey bee colonies (Stubbs et al. 1992). The heavy dependence on honey bees to pollinate lowbush blueberry is demonstrated by the fact that in 2002 over 60,000 hives were brought into Maine for pollination of this crop (Drummond and Yarborough 2002). However, parasites, diseases, the threat of Africanization, and low profit margins have jeopardized the supply of honey bees and contributed to a substantial increase in the rental price per colony. These factors have led to our investigations of alternatives to the honey bee for pollination (Stubbs et al. 1994, Drummond and Stubbs 1997, Stubbs and Drummond 1997, 1999, 2001a, Stubbs et al. 1997). Foremost among these alternatives has been our research aimed at the protection and conservation of the native bees that pollinate lowbush blueberry.

Osmia spp., (Megachilidae: mason and leafcutting bees, so named for their use of mud or leaves in nest construction), became our first target group for population enhancement because their phenology is well synchronized with blueberry bloom (Drummond and Stubbs 1997). *Osmia* are efficient pollinators of lowbush blueberry (Stubbs and Drummond 1997), and they readily

accept artificial nesting materials (Krombein 1967, Torchio 1990, Wójtowski et al. 1995).

Human impact, especially through intensive agriculture and urbanization, can contribute to the instability of vital habitat and floral resources for *Osmia*. Many researchers attribute declining native bee populations to habitat destruction and habitat degradation through pesticide use (Torchio 1990, O'Toole 1994, Buchmann and Nabhan 1996, Kremen et al. 2002, Kevan 2004).

II. Objectives/Purpose of the Activities:

We focused on environmental factors within the lowbush blueberry agroecosystem that might be manipulated in the future by blueberry growers in order to conserve and/or increase populations of native *Osmia* bees: 1) availability of nest sites, 2) cultural practices and field characteristics, and 3) forage plants.

III. Details of the case study and the approach taken:

Suitable nest sites are critical to the success of native bees. Natural nest sites reported for *Osmia* spp. include insect borings in dead timber and the hollow stems of plants (O'Toole and Raw 1991). Our observations in lowbush blueberry fields in Maine indicated that natural nest sites generally were not abundant.

Therefore, we suspected nest sites were a limiting factor to population increase. To test this, we hypothesized that fields that were provided with artificial nesting materials should show an increase in *Osmia* spp. over time, whereas less or no increase in *Osmia* spp. would occur in fields without the addition of supplemental artificial nest sites.

Over a 4 year period (1993–1996) we monitored *Osmia* spp. populations at six blueberry fields in Washington County, Maine. Preliminary observations made in 1992 indicated that *Osmia* spp. were present in all six fields. A randomized block design was used: sets of fields in close proximity and similar in size,

vegetation, and cultural practices were chosen for this study, with 3 pairs of fields used. In each pair, one field was randomly designated a treatment field (wooden nesting blocks were provided;) and the other was designated a control field (no nesting blocks were provided). (See Stubbs and Drummond 2001b for a detailed description of our methods.) In 1993, newly constructed nesting blocks were set out in the three treatment fields in the early spring, approximately a month prior to blueberry bud break.

Each spring during bloom for the 4 years (1993–1996) we measured *Osmia* densities in fields with and without artificial nest sites. Bee numbers were measured by counting bee visitors within 1 m² quadrats and by capturing bees using a sweepnet.

In addition to the availability of nesting sites, other environmental factors, such as agricultural (cultural) practices and competition, are thought to limit solitary bee populations (O'Toole 1994). Pritts (1997) noted that cultural practices for *Vaccinium* crops (blueberry and cranberry) doubtless have a large effect on pollinators, but that these practices have not been examined extensively. In our second study, trap nesting in 56 fields over three years was used to examine several other aspects of habitat that might limit *Osmia* populations. The factors investigated were county and sample year; two physical field attributes: field size in acres and the distance to the nearest neighboring blueberry field (a measure of field isolation); and seven blueberry production characteristics: the number of honeybee hives used per acre, whether irrigation was used, whether fields were pruned by mowing or burning, and the amounts of fertilizer, herbicide, fungicide, and insecticide used per acre.

We also investigated alternate forage because some species of *Osmia* emerge at times prior to blueberry bloom in Maine and continue to nest after blueberry bloom ceases. Adult females require nectar and pollen for survival and reproduction throughout their activity period. Alternate forage, however,

varies in nutritional quality. For example, Abel and Wilson (1998) found that *Brassica napus* L. was a superior forage for reproductive success for exotic *Osmia cornifrons* (Radoszkowski) in field cages. For mason bees that use leaf material in the construction of their nests, a suitable source of leaf material is also extremely important. Vegetation surveys, in which we recorded the presence of all plant species in bloom, were conducted around the perimeter of each field and were related to bee densities that occurred in the individual fields.

IV. Analysis:

Fields that had nesting blocks had increased *Osmia* populations. Native *Osmia* spp. densities were significantly higher (Friedman test statistic = 7.11; df = 1, $P = 0.008$) in the three treatment fields that had nesting blocks than in the control fields in 1996, the final year of the study. Individual experimental fields, had as much as a 200% relative increase in *Osmia*. In contrast, none of the control fields showed any increase in *Osmia* (Table 1).

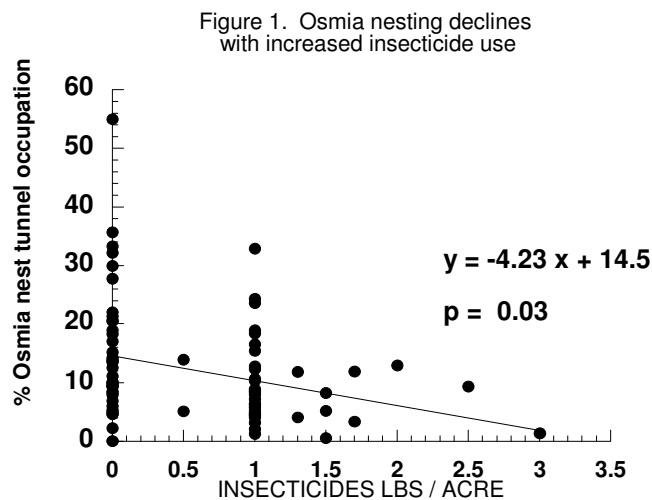
Table 1. Mean \pm SD *Osmia* bees in 1-m² plots for blueberry fields with (treatment) and without (control) 50 nesting blocks.

<u>Year</u>	<u>Treatment (blocks)</u>	<u>Control</u>
1993 Baseline	0.025 \pm 0.026	0.067 \pm 0.039
1996	0.111 \pm 0.059	0.022 \pm 0
% change (1996-1993)/1993	+ 344%	- 67%

In our other study, which was designed to assess the effects of grower cultural practices on *Osmia* populations, nest block use

by *Osmia* differed over the 3 years ($F_{(2, 63)} = 2.301$; $P = 0.049$). In 1992 significantly fewer tunnels per field were occupied (provisioned) than in 1993 and 1994. Mean percentage tunnel occupation per block \pm SD for 1992 was 9.6 ± 6.2 ; for 1993 it was $11.9 \pm 8.6\%$; and for 1994, $13.3 \pm 11.6\%$.

For the 7 cultural practices and 2 field characteristics we investigated, only the amount of insecticide applied to a field in a given year had a significant effect on *Osmia* relative abundance, as measured by % tunnel occupation in nest blocks. The negative relationship between insecticide use and *Osmia* abundance as measured by nesting demonstrates that increased intensity of insecticide use results in the decline of *Osmia* populations (Figure 1).



Availability of potential alternate forage plants varied among fields. Floral surveys indicated that the maximum number of forage plant species prior to blueberry bloom was four (the average was 2 species) and after bloom 22 species (the average 9 species). Seven fields had *Osmia* tunnel occupation of 25% or higher of the total number of tunnels available for nesting as indicated by leaf plugs capping the tunnels. These fields were found in 4 of the 6 counties surveyed: Hancock, Knox, Waldo, and Washington. All seven fields had red maple, oak, and aster present and available as forage along the field perimeter.

Based on these findings, coupled with our previously published pollen analyses and earlier published recommendations for forage plants for native bees in general, we recommend that growers interested in conserving *Osmia* and other native bees encourage the presence of alternate forage plants along their field perimeters. (See Stubbs and Drummond 2001b for the plant species list.)

Our case study illustrates several of the 12 principles of ecosystem approach under the Convention:

- Enhancement of native pollinator populations can reduce a grower's capital expense, ranging from \$50-200 per acre, for honey bee rental in lowbush blueberry production. For a relatively small monetary outlay for nesting materials (approximately \$0.33 per nest block), growers can substantially increase the number of *Osmia* present in their fields.

- The blueberry ecosystem will benefit by becoming more stable and sustainable with increased pollinator biodiversity if growers can move away from dependence upon a single commercial pollinator species.

- Blueberry growers will benefit by reducing risk over time and reducing capital investment. Barriers to implementing such an inexpensive landscape pollinator management system are several. First, growers need to overcome the philosophy that renting pollinators is risk reducing and a means of controlling nature. Second, most blueberries are sold to processing companies and these companies can dictate the quality of fruit thereby making it difficult for growers to reduce pesticide use. Third, education can be a limiting factor. Managing a landscape for flowering plants that enhance pollinator populations requires a certain level of horticultural and botanical knowledge. We believe university based extension outreach and education programs can overcome these barriers.

- Our study suggests that adaptive conservation management can be conducted at the grower field level with successful results for enhancing native bee populations in blueberry.

- Providing conservation nest blocks, reducing insecticide use, and providing alternate forage plants are an integrated adaptive conservation management strategy and all three are necessary for enhancing native bee populations.

- The significant negative relationship between *Osmia* spp. abundance and insecticide use provides further evidence that insecticides adversely affect native bee populations (Hansen and Osgood 1984, Cierzniak 1995, Kevan et al. 1997). It is interesting that herbicides did not show an effect on populations, despite the facts that the majority of growers use herbicides and that researchers have suggested herbicides limit bee forage (O'Toole 1994, Buchmann and Nabhan 1996). However, most growers appear not to apply them to the interface area between blueberry field and forest. Therefore, most fields have alternate forage in this area around the field perimeter before and after blueberry bloom.

- Our case study can contribute to the development of national plans for the conservation and sustainable use of pollinators. It provides concrete evidence that habitat manipulation is a successful means of enhancing native bees.

- As a result of this case study two educational fact sheets were produced to promote increased awareness and responsible actions to conserve and enhance native pollinator populations (www.wildblueberries.maine.edu/FactSheets/301.htm and www.wildblueberries.maine.edu/FactSheets/630.htm). Also see <http://www.umext.maine.edu/onlinepubs/htmpubs/7153.htm>

V. Conclusion:

We focused on habitat manipulation as a management strategy in order to conserve and increase local populations of *Osmia* spp. in Maine lowbush blueberry fields. We investigated the effect of providing artificial nesting sites (wooden trap-nest blocks) on

populations in six fields. *Osmia* spp. populations in the 3 fields that had artificial nesting blocks increased, whereas no increase was observed in the 3 control fields. The effects of cultural practices, field characteristics, and alternate forage plants on *Osmia* spp. abundance also were investigated. We found that reducing insecticide use and encouraging the presence of alternate forage plants along field edges also enhanced populations.

LESSONS LEARNED - In the eight years since we completed this case study we have been extensively involved in producing and disseminating educational fact sheets and publications, presenting many grower talks, and conducting demonstration trials on native bee conservation. To date very few growers have adopted our recommendations for the conservation of native bees. We have come to believe that specific local, state, or national incentives, such as tax credits or other mechanisms, are necessary to motivate growers to implement these conservation practices.

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