



# Bee diversity and abundance in three different habitats of eastern Newfoundland

Robin Sellars and Barry Hicks

## ABSTRACT

In a study of bee communities in eastern Newfoundland, we found no significant differences in the diversity and abundance of bees among open woodland, pasture, and low density semi-urban habitats. Using cup-traps and Malaise traps, we collected 17 species in 7 genera. *Bombus vagans bolsteri* (Hymenoptera: Apidae) comprised 54% and *Lasioglossum quebecense* (Hymenoptera: Halictidae) 25% of all individuals collected. The greatest diversity and abundance was found in the open woodland habitat, although rarefaction analysis did not show the diversity in this habitat to be statistically different from that of the pasture and semi-urban habitats. Bees probably do better in the natural woodland habitats because these areas afford considerably more nesting habitat and provide greater abundance and diversity of nectar resources.

## RÉSUMÉ

Dans une étude des communautés d'abeilles de l'est de Terre-Neuve, nous n'avons trouvé aucune différence significative de diversité et d'abondance des abeilles entre des forêts ouvertes, des pâturages et des habitats semi-urbains de faible densité. À l'aide de pièges-gobelets et de pièges Malaise, nous avons recueilli 17 espèces de 7 genres. *Bombus vagans bolsteri* (Hymenoptera: Apidae) et *Lasioglossum quebecense* (Hymenoptera: Halictidae) représentaient 54% et 25%, respectivement, de tous les individus recueillis. La plus grande diversité et abondance fut trouvée dans les boisés ouverts, bien qu'une analyse de raréfaction n'ait pas montré que la diversité dans cet habitat soit statistiquement différente de celle des pâturages et des habitats semi-urbains. Les abeilles font probablement mieux dans les boisés naturels parce que ces zones offrent plus d'espace de nidification et une plus grande abondance et diversité de ressources en nectar.

## INTRODUCTION

Bees play an important role as pollinators in natural and managed ecosystems. Seed and fruit production relies on bees as pollinators (Richards, 1993). Humans may affect bees adversely by eliminating nesting sites, decreasing foraging resources, fragmenting and destroying natural habitats, and by the use of pesticides (directly or indirectly). However, some studies have shown that some bee species may adapt well to anthropogenic disturbances and thrive (Tommasi et al. 2004; Hernandez et al. 2009; Banaszak-Cibicka and Zmihorski 2012; Richards et al. 2011).

The Newfoundland and Labrador bee fauna is small compared to adjacent mainland areas. Presently, 74 species have been recorded in Newfoundland (Cory Sheffield personal communication; personal observations) while Nova Scotia has 217 species recorded (Sheffield et al. 2003; Sheffield et al. 2008; Sheffield et al. 2009). Decline of bee populations in some other Canadian jurisdictions has been found (Colla and Packer 2008) but the present state of bee populations in Newfoundland is virtually unknown. Newfoundland does not have the same stress on bee populations that are experienced elsewhere where there is a population decline; namely bee diseases, intensive pesticide-based agriculture, and habitat loss due to expanding urbanization. Climate change is affecting many habitats globally and is expected to negatively impact pollinators in the future (Memmott et al. 2007; Winfree et al. 2009; Potts et al. 2010). The insect species composition of Newfoundland ecosystems is vulnerable to climate change because of the range

---

Received 18 November 2014. Accepted for publication 8 January 2015. Published on the Acadian Entomological Society website at [www.acadianes.ca/journal.html](http://www.acadianes.ca/journal.html) on 8 May 2015.

**Robin Sellars and Barry Hicks:** College of the North Atlantic, 4 Pike's Lane, Carbonear, NL, Canada, A1Y 1A7.

Corresponding author (email [robin.sellars@cna.nl.ca](mailto:robin.sellars@cna.nl.ca))

expansion and introduction of non-native and sometimes invasive species including the wool-carder bee, *Anthidium manicatum* (Hymenoptera: Megachilidae) (Hicks 2011a).

The purpose of this research is to address the impact of different land-uses on the diversity and abundance of native bee species. Three types of habitat were chosen for comparison based on how they are utilized presently and the different floral resources and nesting habitats available. Most of the bees in this area utilize existing cavities (Apidae) or dig nests in the ground (Halictidae and Andrenidae), with one genus nesting in twigs (*Hylaeus*). We hypothesized that habitats that were more disturbed, such as those in semi-urban locations with their greater floral diversity, would provide more nesting habitat and floral resources and therefore greater diversity and abundance of bees.

## METHODS

### Sample locations

Sampling occurred around the town of Carbonear in eastern Newfoundland. Two transects were established in each of three habitats: open woodland, pasture and low density semi-urban (Table 1). All habitats are within the boreal shield of the Maritime Barrens ecoregion. The woodland included two areas in Balsam Fir/Black spruce forests with open areas containing ericaceous plants such as Labrador tea (*Ledum groenlandicum* (Oeder) Kron & Judd), leather leaf (*Chamaedaphne calyculata* (L.) Moench), blueberry (*Vaccinium angustifolium* Aiton), and partridge berry (*Vaccinium vitis-idaea* L.) along with numerous wildflowers (Table 2). The two pasture habitats are primarily grass with some red clover (*Trifolium pratense* L. (Fabaceae)) and other flowering plants (Table 2) and are used for hay production. No intensive farming has occurred there in more than a decade. The two semi-urban habitats, near the centre of town, were located in a garden containing predominately grass, with white and red clover (*Trifolium repens* L. and *Trifolium pratense*), dandelion (*Taraxacum officinale* F.H. Wigg (Asteraceae)), Canada thistle (*Cirsium arvense* (L.) Scop. (Asteraceae)), and a variety of flowering plants (Table 2).

### Sampling protocol

Nine cup-traps (3 white, 3 yellow and 3 blue) were placed at alternating 5m intervals along a 45m transect in each of the 6 sites. Each trap consisted of a 13-oz plastic beer cup (10 cm in diameter and 14 cm deep supplied by Solo Cup Company, Toronto, Ontario) placed in a stand above ground. The cup was  $\frac{3}{4}$  filled with solution of 50% propylene glycol (Eastchem, Mt. Pearl, Newfoundland) and

**Table 1.** Sampling locations in three habitat types in eastern Newfoundland to assess bee abundance and diversity.

Habitat type	Site	Location (latitude, longitude)	Approximate size (m <sup>2</sup> ) *
Woodland	Camp McCarthy	47°42'58.6"N, 53°17'09.5"W	299
	Gunnar's Pond	47°42'53.3"N, 53°17'11.1"W	2211
Pasture	Poole's pasture	47°44'54.0"N, 53°13'07.6"W	52272
	Wareham's pasture	47°45'08.4"N, 53°14'35.2"W	75600
Semi-urban	Capt. Frank's Lane	47°44'27.3"N, 53°12'55.0"W	307
	Coll. North Atlantic	47°44'06.7"N, 53°13'59.5"W	1333

\* Woodland sites were within a much larger continuous forest that covers over one hundred square km.

**Table 2.** The most common floral resource differences in order of descending prominence in three habitat types in eastern Newfoundland.

Woodland	Pasture	Semi-urban
<i>Vaccinium angustifolium</i> Aiton	Grasses	Grasses
<i>Vaccinium vitis-idea</i> (L.)	<i>Trifolium pratense</i> L.	<i>Trifolium repens</i> L.
<i>Ledum groenlandicum</i> (Oeder) Kron & Judd	<i>Solidago rugosa</i> Mill.	<i>Trifolium pratense</i>
<i>Chamaedaphne calyculata</i> (L.) Moench	<i>Chrysanthemum</i> <i>leucanthemum</i> (Tourn.) L.	<i>Taraxacum officinale</i> F.H. Wigg <i>Cirsium arvense</i> (L.) Scop. <i>Achillea millefolium</i> L.
<i>Cornus canadensis</i> L.	<i>Hieracium aurantiacum</i> L.	<i>Ranunculus repens</i> L.
<i>Potentilla anseria</i> (L.) Rydb.	<i>Achillea millefolium</i> L.	<i>Mentha arvensis</i> L.
<i>Rosa virginiana</i> P.Mill.	<i>Centaurea nigra</i> L.	<i>Galeopsis tetrahit</i> L.
<i>Rhododendron canadense</i> (L.) Torr.	<i>Vicia cracca</i> L.	<i>Solidago rugosa</i>
<i>Cypripedium acaule</i> Aiton	<i>Fragaria virginiana</i>	<i>Rosa virginiana</i>
<i>Epilobium angustifolium</i> (L.)	Duschesne	<i>Fragaria virginiana</i>
	<i>Campanula rotundifolia</i> L.	<i>Sorbus decora</i> C.K. Schneid. <i>Linaria vulgaris</i> Mill. <i>Centaurea nigra</i> <i>Senecio jacobaea</i> L. <i>Syringa vulgaris</i> L. <i>Tulipa suaveolens</i> Roth <i>Fragaria ananassa</i> Duschene <i>Viola tricolor</i> L.

50% water with two drops of blue Dawn™ dish washing fluid added. The cups were placed in the field on 2 Aug 2012, cleared and reset weekly for 4 weeks and again for 9 weeks through June and July 2013 (total = 13 weeks). At the same time that cup-traps were placed, one Townes style Malaise trap (Maris House Nets, UK) was set up at one site in each of the habitat types; Camp McCarthy, Wareham's Pasture and Captain Frank's Lane representing the woodland, pasture and semi-urban habitats, respectively. The Malaise traps were positioned within 30 m of the cup-line transect, perpendicular to possible insect flight paths, i.e., against the treeline or against a fence. The Malaise trap was placed in the centre of the pasture site.

The bottles on the traps were changed every two weeks.

### Specimen identification

Identifications were made by the authors using appropriate taxonomic keys (Mitchell 1960; Lavery and Harder 1988; Gibbs 2010; Gibbs et al. 2013; Ascher and Pickering 2015) with verification of rare species by Cory Sheffield (Royal Saskatchewan Museum, Regina Saskatchewan). Voucher specimens are retained at the Carbonear campus of the College of the North Atlantic.

### Data analysis

Individual rarefaction calculations for the combined cup and Malaise traps were calculated for each habitat using the Estimate S online calculator (Colwell 2013).

## RESULTS AND DISCUSSION

We collected 506 individual bees comprising 17 species (Table 3). Two species, *Bombus vagans bolsteri* (Hymenoptera: Apidae) and *Lasioglossum quebecense* (Hymenoptera: Halictidae) make up the majority of the bees sampled. Species abundance and richness was greatest in the open woodland habitat (Table 3). The combined cup-trap and Malaise trap data resulted in 12 species in the woodland habitat, 9 species in the pasture, and 10 species in the semi-urban habitats. The pasture habitat had the greatest abundance of bees ( $n = 112$  bees) when sampled with cup-traps, compared with the 97 and 81 bees in the woodland habitat and semi-urban habitats, respectively (Table 3). The woodland habitat had more bees ( $n = 146$  bees) compared to the other two (pasture,  $n = 39$ ; semi-urban,  $n = 32$ ) when using Malaise traps.

The abundance and number of species of bumble bees was similar those collected by Hicks (2011b) from a blueberry field in Colliers, Newfoundland. Moreover, the number of species found is comparable to that collected in cup-traps over a summer of collecting in cranberry farms from western Newfoundland (Hicks and Sircom, unpublished data). It is interesting to note, however, that *Bombus ternarius* (Hymenoptera: Apidae) was the most common bumble bee collected on the west coast. While *Bombus vagans bolsteri* was present in the cranberry fields, it was not as abundant as *Bombus ternarius*. The dominance of *Bombus vagans bolsteri* in eastern Newfoundland and *Bombus ternarius* in western Newfoundland may be reflective of their adaptation to climate variations of the areas or an affinity to the crop (blueberry verses cranberry).

The common solitary bees included *Lasioglossum quebecense* and *Andrena carolina* (Hymenoptera:

Andrenidae). This may be related to the presence of blueberry in the open woodland habitat and areas surrounding the pasture sites, as both bees are common in blueberry fields (Hicks 2011b, Cutler et al. 2014; Moisan-DeSerres et al. 2014).

**Table 3.** Bees collected in three habitats in eastern Newfoundland in 2012 and 2013.

Species	Location and collection methods					
	Woodland		Pasture		Semi-urban	
	Cups	Malaise	Cups	Malaise	Cups	Malaise
<b>Apidae</b>						
<i>Bombus vagans bolsteri</i> Franklin, 1913	40	116	70	29	5	11
<i>Bombus borealis</i> Kirby, 1837	-	-	2	5	-	-
<i>Bombus (Psithyrus) citrinus</i> (Smith, 1854)	1	-	11	4	3	3
<i>Bombus (P.) fernaldae</i> (Franklin, 1911)	-	1	-	-	-	-
<b>Halictidae</b>						
<i>Dialictus</i> spp.	5	3	3	-	2	2
<i>Lasioglossum boreale</i> Svensson, Ebmer and Sakagami, 1977	5	3	-	-	2	-
<i>Lasioglossum foxii</i> (Robertson, 1895)	-	-	2	-	1	-
<i>Lasioglossum inconditum</i> (Cockerell, 1916)	-	2	-	-	1	-
<i>Lasioglossum quebecense</i> (Crawford, 1907)	17	14	19	-	61	15
<i>Lasioglossum seillean</i> Gibbs and Packer, 2013	3	-	-	-	-	-
<i>Halictus rubicundus</i> (Christ, 1791)	4	-	3	-	-	-
<i>Sphecodes solonis</i> Graenicher, 1911	1	1	-	-	-	-
<b>Andrenidae</b>						
<i>Andrena carolina</i> Viereck, 1909	20	6	-	-	-	-
<i>Andrena milwaukeeensis</i> Graenicher, 1903	-	-	1	-	-	-
<i>Andrena wilkella</i> (Kirby, 1802)	-	-	1	1	5	-
<b>Colletidae</b>						
<i>Hylaeus modestus</i> Say, 1837	1	-	-	-	-	1
<b>Megachilidae</b>						
<i>Osmia proxima</i> Cresson, 1864	-	-	-	-	1	-
<b>Total Bees</b>	242		151		113	

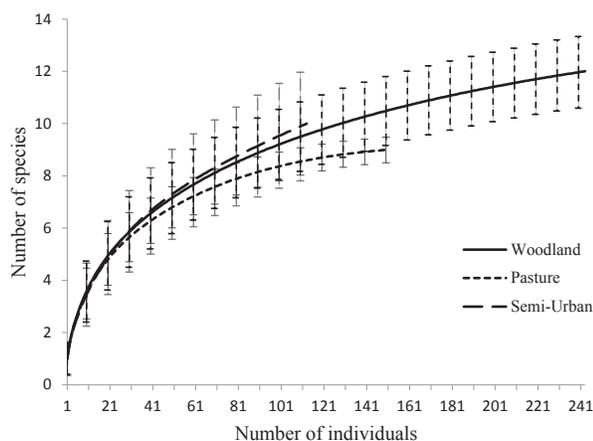
We anticipated that bee abundance would be greater in the low density residential semi-urban area. This area has a greater variety of flowering plants planted by residents (Table 2) and disturbed areas which should provide nectar sources and nesting sites for ground nesting bees. The cup-trap data indicated that bee abundance and diversity was lowest in the semi-urban habitats. However rarefaction analysis (Table 4, Figure 1) indicates that there is no significant difference in diversity among the three sites. Human disturbance of natural habitats is thought to be one of the main drivers of global bee declines (Goulson et al. 2008; Ricketts et al. 2008). Winfree et al. (2009) showed a small, but significant negative effect on both bee abundance and diversity by habitat disturbance. Geslin et al. (2013) also showed that increasing urbanization was detrimental to solitary bee abundance and biodiversity. However Richards et al. (2011) found a change from forest to open habitat resulted in an increase in bee abundance and diversity. Other studies have indicated that bees are thriving in urbanized areas (Tommasi et al. 2004; Winfree et al. 2007; Hernandez et al. 2009; Banaszak-

Cibicka and Zmihorski 2012; Carper et al. 2014). Most studies of urban bees suggest that they are capitalizing on floral diversity found in urban gardens and parks (MacIvor et al. 2014; Pardee and Philpott 2014), and green roofs (Colla et al. 2009). The low density semi-urban habitat in the present study was a mix of lawn grass and disturbed area made up of weedy species and therefore it is not directly comparable to densely populated urban habitats with more intensely cultivated gardens which may explain why diversity was not greater.

**Table 4.** Number of bee species found for three habitats in eastern Newfoundland in 2012 and 2013 using cup-trap and Malaise trap data combined, with 95% confidence intervals created by rarefaction.

Habitat	# of species	95% CI
Woodland	12	9.31-14.69
Pasture	9	8.04-9.96
Semi-urban	10	5.88-14.12

**Figure 1.** Rarefaction curve for combined cup-trap and Malaise trap data including 95% CI for bees collected in three habitats in eastern Newfoundland.



The data indicated that we collected more bee specimens in the woodland habitats but rarefaction analysis (Table 4, Figure 1) indicated that species diversity is not significantly different from the other habitats. This is contrary to Carper et al. (2014) in North Carolina and Winfree et al. (2007) in New Jersey, who showed that areas of extensive forest cover had lower abundance and diversity of bees than either pasture or suburban areas. The woodland habitats of eastern

Newfoundland are in the northern boreal zone and are considerably different in composition and more open than the temperate deciduous forests of eastern USA. A better comparison would be Nol et al. (2006) who found that sections of forest with open spaces had a larger number of bees than denser areas of the forest. Eastern Newfoundland forests are less dense than in the American sites mentioned above and have more open spaces with considerable ground nesting-site habitat variation and diverse floral resources which should support a more diverse and larger bee population. This is particularly important for most of the species found (Table 3) which are ground nesting (Halictidae and Andrenidae). Cutler et al. (2014) also found larger diversity in forest when compared to fields.

Future research on Newfoundland native bees should concentrate on the impact of more extensive urbanization on bee populations. We suggest studies comparing bee abundance and diversity in the major cities (St. John's or Corner Brook) with rural areas. Whether or not bee populations are declining in Newfoundland is unknown at the present time. The ongoing impact of human disturbance and global climate change will undoubtedly affect Newfoundland bee populations in the future. Continued sampling of native bees should be undertaken in Newfoundland to monitor the possible drivers that are believed to cause bee declines in other jurisdictions.

## ACKNOWLEDGEMENTS

The authors would like to thank Cory Sheffield for identification of bee specimens, Kristen Baker and William Sellers for assistance collecting samples. Partial funding for this project was through a Small Research Grant from the Office of Applied Research at College of the North Atlantic.

## REFERENCES

- Ascher, J.S., and Pickering, J. 2015. Discover Life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila). [http://www.discoverlife.org/mp/2oq?guide=Apoidea\\_species](http://www.discoverlife.org/mp/2oq?guide=Apoidea_species). [accessed on March 25, 2014]
- Banaszak-Cibicka, W., and Zmihorski, M. 2012. Wild bees along an urban gradient: winners and losers. *Journal of Insect Conservation* **16**: 331-343.
- Carper, A.L., Adler, L.S., Warren, P.S., and Irwin, R.E. 2014. Effects of suburbanization on forest bee communities. *Community and Ecosystem Ecology* **43**: 253-262.

- Colla, S.R., and Packer, L. 2008. Evidence for decline in eastern North American bumble bees (Hymenoptera: Apidae), with special focus on *Bombus affinis* Cresson. *Biodiversity and Conservation* **17**: 1379-1391.
- Colla, S.R., Willis, E., and Packer, L. 2009. Can green roofs provide habitat for urban bees (Hymenoptera: Apidae)? *Cities and the Environment* **2**: 1-12 (Article 4).
- Colwell, R. K. 2013. EstimateS: Statistical estimation of species richness and shared species from samples. Version 9. User's Guide and application published at: <http://purl.oclc.org/estimates>. [accessed on March 14, 2015]
- Gibbs, J. 2010. Revision of the metallic species of *Lasioglossum* (*Dialictus*) in Canada (Hymenoptera, Halictidae, Halictini). *Zootaxa* **2591**: 1-382.
- Gibbs, J., Packer, L., Dumesh, S., and Danforth, B. 2013. Revision and reclassification of *Lasioglossum* (*Evyllaesus*), *L.* (*Hemihalictus*) and *L.* (*Sphecodogastra*) in eastern North America (Hymenoptera; Apoidea: Halictidae). *Zootaxa* **3672**: 1-117.
- Geslin, B., Gauzens, B., Thebault, E., and Dajoz, I. 2013. Plant pollinator networks along a gradient of urbanisation. *PLoS ONE* **8**: e63421.
- Goulson, D., Lye, G.C., and Darvill, B. 2008. Decline and conservation of bumble bees. *Annual Review of Entomology* **53**: 191-208.
- Hernandez, J.L., Frankie, G.W., and Thorp, R.W. 2009. Ecology of urban bees: a review of current knowledge and directions for future study. *Cities and the Environment*. **2**: 1-15 (Article 3).
- Hicks, B.J. 2011a. Pollination of lowbush blueberry (*Vaccinium angustifolium*) in Newfoundland by native and introduced bees. *Journal of the Acadian Entomological Society* **7**: 108-118.
- Hicks, B.J. 2011b. *Anthidium manicatum* (L.) (Hymenoptera: Megachilidae) found on the island of Newfoundland, Canada. *Journal of the Acadian Entomological Society* **7**: 105-107.
- Laverty, T.M., and Harder, L.D. 1988. The bumble bees of eastern Canada. *The Canadian Entomologist* **120**: 965-987.
- MacIvor, J.S., Cabral, J.M., and Packer, L. 2014. Pollen specialization by solitary bees in an urban habitat. *Urban Ecosystems* **17**: 139-147.
- Memmott, J., Craze, P.G., Waser, N.M., and Price, M.V. 2007. Global warming and the disruption of plant-pollinator interactions. *Ecology Letters* **10**: 710-717.
- Mitchell, T.B. 1960. Bees of the eastern United States. I. North Carolina Agricultural Experiment Station Technical bulletin **141**: 1-538.
- Moisan-DeSerres, J., Chagnon, M., and Fournier, V. 2014. Influence of windbreaks and forest borders on abundance and species richness of native pollinators in lowbush blueberry fields in Québec, Canada. *The Canadian Entomologist*, available on CJO2014. doi:10.4039/tce.2014.55.
- Nol, E., Douglas, H., and Crins, W.J. 2006. Responses of syrphids, elaterids and bees to single-tree selection harvesting in Algonquin Provincial Park, Ontario. *Canadian Field-Naturalist* **120**: 15-21.
- Pardee, G.L., and Philpott, S.M. 2014. Native plants are the bee's knees: local and habitat predictors of bee richness and abundance in backyard gardens. *Urban Ecosystems* **17**: 641-659.
- Potts, S.G., Biesmeijer, J.C., Kremen, C., Neumann, P., Schweiger, O., and Kunin, W.E. 2010. Global pollinator declines: trends, impacts and drivers. *Trends in Ecology and Evolution* **25**: 345-353.
- Richards, K.W. 1993. Non-*Apis* bees as crop pollinators. *Revue Suisse de Zoologie* **100**: 807-822.
- Richards, M.H., Rutgers-Kelly, A., Gibbs, J., Vickruck, J.L., Rehan, S.M., and Sheffield, C.S. 2011. Bee Diversity in naturalizing patches of Carolinian grassland in southern Ontario, Canada. *The Canadian Entomologist* **143**: 279-299.
- Ricketts, T.H., Regetz, J., Steffan-Dewenter, J., Cunningham, S.A., Kremen, C., Bogdanski, A., Gemmill-Herren, B., Greenleaf, S.S., Klein, A.M., Mayfield, M.M., Morandin, L.A., Ochieng, A., and Viana, B.F. 2008. Habitat effects on crop pollination services: are there general patterns? *Ecology Letters* **11**: 499-515.
- Sheffield, C.S., Kevan, P.G., Smith, R.F., Rigby, S.M., and Rogers, R.E.L. 2003. Bee species of Nova Scotia, Canada, with new records and notes on bionomics and floral relations (Hymenoptera: Apoidea). *Journal of the Kansas Entomological Society* **76**: 357-384.
- Sheffield, C.S., Kevan, P.G., Westby, S.M., and Smith, R.F. 2008. Diversity of cavity-nesting bees (Hymenoptera: Apoidea) within apple orchards and wild habitats in the Annapolis Valley, Nova Scotia, Canada. *The Canadian Entomologist* **140**: 235-249.
- Sheffield, C.S., Hebert, P.D.N., Kevan, P.G., and Packer, L. 2009. DNA barcoding a regional bee (Hymenoptera: Apoidea) fauna and its potential for ecological studies. *Molecular Ecology Resources* **9**: 196-207.

- Tommasi, D., Miro, A., Higo, H.A., and Winston, M.L. 2004. Bee diversity and abundance in an urban setting. *The Canadian Entomologist* **136**: 851-869.
- Winfree, R., Griswold, T., and Kremen, C. 2007. Effect of human disturbance on bee communities in a forested ecosystem. *Conservation Biology* **21**: 213-223.
- Winfree, R., Aguilar, R., Vázquez, D.P., LeBuhn, G., and Aizen, M.A. 2009. A meta-analysis of bees' responses to anthropogenic disturbance. *Ecology* **90**: 2068-2076.