The Impact of Land-Use Practices on Native Bee Abundance and Diversity in Southeastern Massachusetts

E. Apiche, Z. Thuotte, A. Germaine, P. Sanon, F. Ajayi, A. Oguma, and M. Bankson

Division of Science and Math, Massasoit Community College, Brockton, Massachusetts, USA

Twitter: @MassasoitSTEM; Email: stemstarter@massasoit.edu

Introduction

- Insects account for 60-70% of flowering plant pollination with bees at the forefront, emphasizing their fundamental importance to both the ecosystem and crop production (Corbet, *et. al.*, 2015; Williams *et. al.*, 2001).
- The superior pollination services of native bees (Kremen *et. al.*, 2002) may become increasingly critical as colony collapse disorder threatens domestic honey bee hives (Ellis *et. al.*, 2010; Horth and Campbell, 2017).
- The collective effect of an abundant and diverse native bee community is thought to be beneficial in providing pollination services to a diverse ecosystem (Klein *et. al.*, 2002).
- Land-use practices, such as the expansion and intensification of agriculture, along with excessive use of pesticides and herbicides, may negatively impact native bee abundance (*Vaissière et al.*, 2009) and diversity (Holzschuh *et. al.*, 2007).
- This ongoing study evaluates the impact of land-use practices on ecosystem health, utilizing native bee abundance and diversity as indicators.

Study Sites

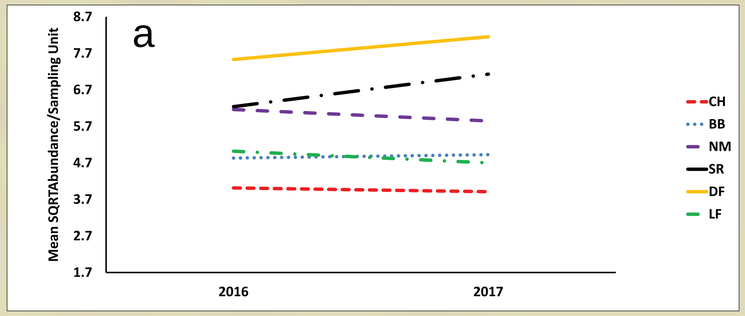
Table 1 Assessment of land use for six study sites located in Southeastern Massachusetts. Native Meadow and Beaver Brook are located on the Brockton campus of Massasoit Community College.

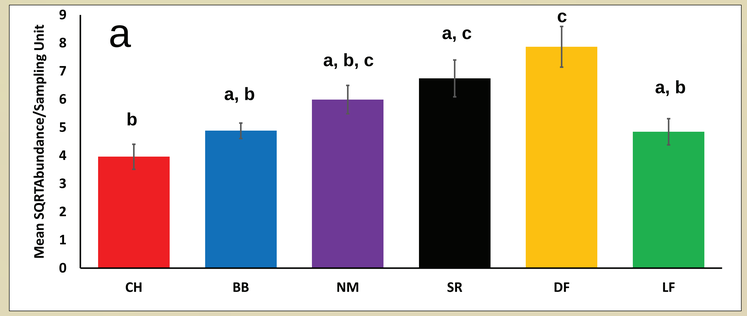
Location	Christo's	Beaver Brook	Native Meadow	Sachem Rock	Dunrovin Farm	Leland Farm
Sustainable Land-use	no	yes	yes	no	no	no
% Impervious Land Cover	46.85%	46.03%	32.03%	7.88%	1.93%	0.50%
Classification	Urban	Urban	Urban	Rural	Rural	Rural

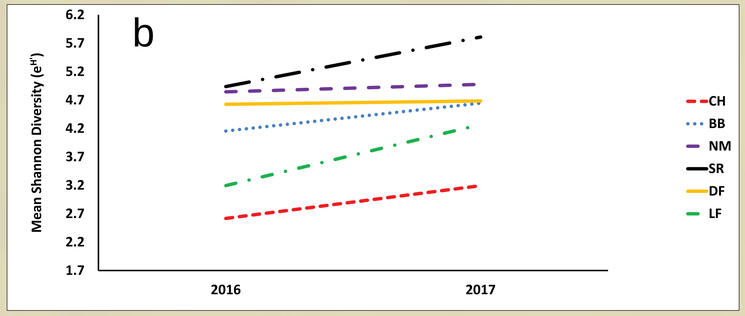
Methods

- Collection occurred from April to October in 2016 and 2017.
- Bees were caught via pan traps (10 replicates of 3 colors: blue, white, and yellow) left in the field for 24 hours (Droege, 2015), as well as sweep netting performed by two researchers for 30 minutes (Popic, 2013).
- Samples were preserved in 70% ethanol and then washed, pinned, and identified to genus.
- Geographical Information System Software (ArcGIS) was used to quantify % impervious within a 300-m buffer at each study site.
- Shannon diversity index was calculated based on genera per site and exponentially transformed ($e^{H'}$). Abundance was normalized per sampling effort and a square root transformation applied.
- Two-way ANOVA was performed to measure the effect of location, year and the interaction of these variables on native bee abundance and diversity.

Results







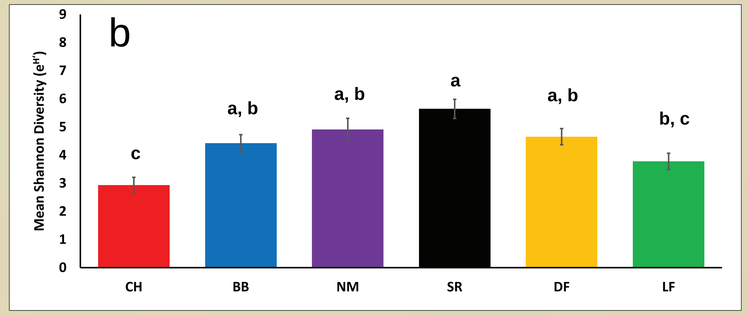


Figure 1 Interaction plots of year and site on bee abundance **(a)** and diversity **(b)** for 2016 and 2017. Site had a significant effect on Shannon index ($p < 0.001$) as well as on abundance ($p < 0.001$). Year had no significant effect on either Shannon index ($p = 0.090$) or abundance ($p = 0.641$). In addition, there was no significant interactive effect of year and site on Shannon index ($p = 0.058$) or abundance ($p = 0.067$), thus year was omitted in subsequent analyses (Figure 2).

Figure 2 represents mean bee abundance **(a)** and mean Shannon diversity **(b)** ± SEM for 2016 and 2017. Both abundance (ANOVA $F_{5,137}=8.63$ $p<0.001$) and diversity (ANOVA $F_{5,137} = 8.63$, $p<0.001$) differed significantly among some sites. Sites that share lowercase letters were not statistically different (Tukey's HSD pairwise comparisons).

Discussion & Conclusion

- There was no significant year to year change in abundance and diversity from 2016 to 2017 across all sites. Specific changes in native bee abundance and diversity may be due to normal seasonal variation.
- Sites in rural areas had relatively higher native bee abundance and diversity compared to sites in urban areas, suggesting that rural sites provide a habitat better suited for the local native bee community.
- Native Meadow, a site in an urban area, where sustainable landscaping practices are employed, had the second highest native bee diversity among our study sites, suggesting that such practices may be beneficial to the local bee community.
- Sites with higher bee abundance did not display higher bee diversity, suggesting that land-use practices may affect these markers differently.
- Proximity to an urban center (classified based on % impervious) as well as land-use practices may impact the biodiversity and abundance of native bee communities. However, whether these effects are positive or negative will likely depend on the land-use practices employed

Acknowledgements

A. Estabrooks, A. Goguen, A. Santos, A. Schofield, B. Moise, B. Avrahami, C. Patel, C. Oyatta, D. Brown, D. Da Silva, E. Holdgate, E. Valsamis, F. Lynce, G. Monteiro, I. Dibona, I. Ruesch, J. Bradley, J. Bernard, J. Dyer, J. Litterio, J. Moore, J. Palmer, J. Teixeira, J. Urena, K. Oriaku, M. Healy, M. O'Keeffe, Q. Li, R. Bercy, R. Franciosi, R. Leist, R. Hayes-Huer, R. Henshaw, R. McEachern, R. Patten, R. Soibifaa, S. Auriemma, S. Buresh, T. Foley, T. Junior, V. Alfama, V. Sequeira, V. Venkat, W. Sullivan, X. Li. This research was supported by the state of Massachusetts STEM Starter Academy grant, the Balfour Foundation, and the National Science Foundation.

Literature Cited

Corbet, A., Sarah., Williams, H., Ingrid., Orsbone, L., Juliet (2015) Bees and the Pollination of Crops and Wild Flowers in the European Community, Bee world 72.2 47-59.

Droege, S. (2005). Tips on how to use bee bowls to collect bees. *Available from: http://online. sfsu. edu/~ beeplot/pdfs/bee% 20bowl, 20.*

Ellis, J. D., Evans, J. D., & Pettis, J. (2010). Colony losses, managed colony population decline, and Colony Collapse Disorder in the United States. *Journal of Apicultural Research*, *49*(1), 134-136.

Holzschuh, A., Steffan-Dewenter, I., Kleijn, D. and Tscharntke, T. (2007), Diversity of flower-visiting bees in cereal fields: effects of farming system, landscape composition and regional context. Journal of Applied Ecology, 44: 41–49. doi:10.1111/j.1365-2664.2006.01259.x

Horth, Lisa and Campbell Laura (2017), Supplementing Small Farms with Native Mason Bees Increases Strawberry Size and Growth Rate. *Journal of Applied Ecology p.1-9*

Klein, M., Alexandra Vaissière E., Benard, Cane, H., James, Steffan-Dewente, I., Cunningham, A., Saul, Kremen, C., Tscharntke T., (2007) Importance of pollinators in changing landscapes for world crops, Proceedings of the Royal Society (Biological Sciences). DOI: 10.1098/rspb.2006.3721

Kremen C., Williams, M., Neal and Thorp, W., Robbin (2002), Crop pollination from native bees at risk from agricultural intensification. Proceedings of the National Academy of Sciences in the United States of America.

Popic, T.J., Davila, Y.C., & Wardle, G.M. (2013). Evaluation of Common Methods for Sampling Invertebrate Pollinator Assemblages: Net Sampling Out-Perform Pan Traps.

Williams, M., Neal, Minkley, L., Robert, and Silveria, A., Fernando, (2001), Variation in Native Bee Faunas and its Implications for Detecting Community Changes. Ecology and society.