Pollination in an urbanizing landscape: effects of habitat fragmentation on wild bee assemblages

RESEARCH REPORT
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INTRODUCTION

Pollination is a vital ecosystem function in both natural and agricultural ecosystems. Pollination function is subject to disruption when disturbance threatens the persistence of pollinator populations. One of the major sources of disturbance to pollination systems is landscape fragmentation: the breaking up and subsequent isolation of previously contiguous vegetation communities. Theory predicts that smaller fragments will support fewer pollinators, and that surviving populations will face higher risks of local extinction within fragments. Therefore, plants that rely on animal pollinators for *successful reproduction also face an increased extinction risk.*

The main objective of my research is to describe and quantify the effects of habitat fragmentation by urban development on wild bee assemblages. The research consists of two main pieces: 1) characterizing the natural spatial variability in the local bee assemblage in relation to possible habitat factors and 2) analyzing the effects of habitat fragmentation on this assemblage. The approach involves sampling the local bee assemblage composition and habitat characteristics in three unfragmented prairie sites and 12 remnant prairie fragments surrounded by suburban residential development near Boulder, Colorado. Fragments range in size from 1 ha to 30ha.

The results will improve our understanding of the mechanisms of pollination and how this ecosystem function may be affected by landscape heterogeneity. It will also provide important guidelines for the conservation of bees and the prevention of pollination disruption in disturbed ecosystems. In combination with a concurrent pollinator study on Boulder City Open Space by Carol Kearns and Diana Oliveras, this research will provide a detailed picture of the influence of urbanization on the abundance, diversity, and patterns of habitat use of wild bees in local prairie. This data will be invaluable for Open Space land managers in developing strategies to conserve pollination function and biodiversity on local public lands.

METHODS

The landscape of the Boulder-Denver corridor in Colorado is particularly well-suited to a study of urban fragmentation effects. This region has undergone rapid urbanization over the last decade, yet local conservation efforts have resulted in the preservation of both large and small tracts of native prairie. The native short- and mixed-grass prairie is home to a diverse pollinator assemblage, and comprises a moderate degree of natural landscape heterogeneity. The study is being conducted on three large tracts of prairie and 12 urban prairie fragments ranging in size from 1ha to 30ha. Sites are chosen on the bases of surrounding land use and range of habitat heterogeneity within the site. The bees found in fragments will be compared with the bee assemblage on the three large, open prairie sites.

The field work for this project in the summer of 2004 took place on 15 sites administered by Boulder County Parks and Open Space (BCPOS), Boulder Open Space and Mountain Parks (BOSMP), Jefferson County Open Space, South Suburban Parks and Recreation District (SSPRD), City of Lakewood, and Louisville Open Space. There were three large, open prairie sites, Hayes/Greenbelt, Beech (both BOSMP), and Green Mountain (Lakewood). The remaining 12 sites were smaller prairie fragments surrounded by suburban residential land use. At each site, I established sampling points that captured the range of habitat heterogeneity within the site based on vegetation, aspect and slope. Each sampling point was marked with a small flag; flags were removed at the end of the summer.

We conducted three complete rounds of sampling over the summer of 2004. Each round of sampling consisted of sampling once at all sites over as short a time span as possible. The bee and floral assemblages change rapidly over the course of the summer so each round of sampling represents a distinct dataset. We found that we could complete a round of sampling in approximately 12 working days. In order to sample a site, we collected bees at each sampling point using blue, white and yellow plastic bowls containing water and a drop of surfactant; these traps were left out for 24 hours, then the bees were returned to the lab, rinsed, and pinned. In order to correct for a potential bias in pan trap sampling, we also used an insect net to capture any bees seen within the plot during a ten minute period. We also collected data on vegetation and microhabitat conditions at each sampling point. To sample vegetation, we walked four 12m vegetation transects at each sampling point, identifying the ground cover and measuring plant height at each step, resulting in approximately 55-65 data points per sampling location. Ground cover was classified as either grass, forb (not in flower), flower, rock, bare ground, or litter. Plants in flower were identified to species where possible, otherwise to genus. Microhabitat data was collected using HOBO Pro Series temperature/relative humidity dataloggers that were left out at sampling points over the same 24 hours that the pan traps were set.

RESULTS

The dates of each round of sampling were: May 26 – June 12, June 29 – July 15, and July 26 – August 11. All of the bees from the summer 2004 field season have now been pinned and labelling will be completed within a week. At this time, however, no identifications have been completed on 2004 bees. My assistant and I have been concentrating on identifications of 2003 bees, and I hope to have all of these bees identified to genus, and many to species, within a month. The abundances of bees for 2004 are shown in Table 1. While raw numbers are presented there, the data have also been converted into a bee capture rate, which is the number of bees captured per bowl per hour that the bowls were set out. This provides a value that is independent of the number of traps set out at a site and that takes into account small variations in the amount of time they were left out.

I have conducted t-tests on capture rates for all three sampling rounds. For the first round of sampling, the data shows that the rate of bee capture at pan traps in urban fragments was significantly less than the rate of capture at pan traps at open prairie sites

(Figure 1). This result fits with theoretical predictions of the effects of habitat fragmentation on animal populations. However, in the second two rounds of sampling the trend is in the opposite direction, that is, mean capture rates in urban fragments were higher than in open prairie. The relationship is not significant in these later two datasets, however (see Figure 2). Further analyses will have to be carried out to better understand this apparently contradictory result. I will also be comparing the sites on the basis of fragment size, not just fragmented versus unfragmented, and it may be that the habitat data that I have collected is a good predictor of bee abundance.

TABLE 1. Bee abundances for summer 2004.

Total bee abundance for all sites (incl. Pan traps, netting, and bees identified and released in the field).

Sampling round 1 (May 26 – June 12) = **2623**
Sampling round 2 (June 29 – July 15) = **1889**
Sampling round 3 (July 26 – August 11) = **1230**

Bee abundances on BOSMP properties

First round of sampling (Hayes/Greenbelt, June 5-6; Beech, June 1-2)

	Pan trap	Bees/Pan/Hour (average)	Net	Released	Total
Hayes/Greenbelt	146	0.214	10	1	**157**
Beech	564	0.904	21	0	**585**

Second round of sampling (Hayes/Greenbelt, July 8-9; Beech, July 12-13))

	Pan trap	Bees/Pan/Hour (average)	Net	Released	Total
Hayes/Greenbelt	122	.200	11	1	**134**
Beech	118	.189	14	10	**142**

Third round of sampling (Hayes/Greenbelt, Aug. 9-10; Beech, August 10-11)

	Pan trap	Bees/Pan/Hour (average)	Net	Released	Total
Hayes/Greenbelt	44	.064	10	13	**67**
Beech	67	.100	9	10	**86**

Figure 1

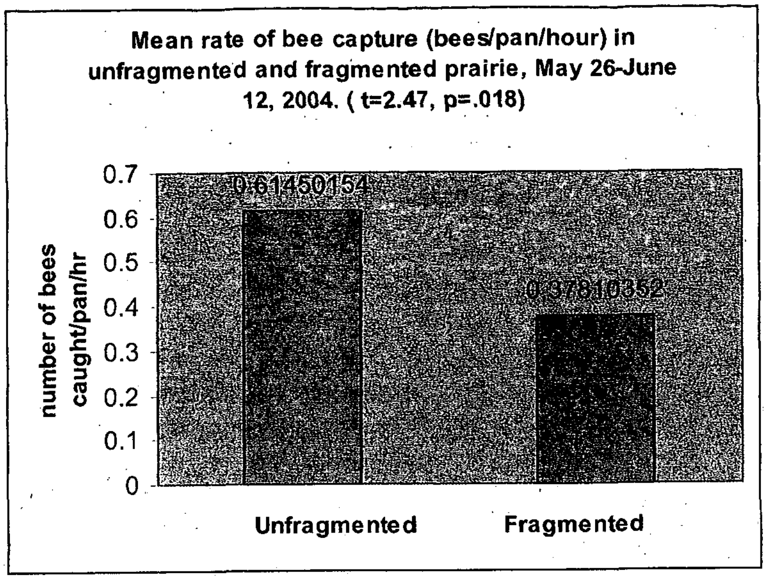
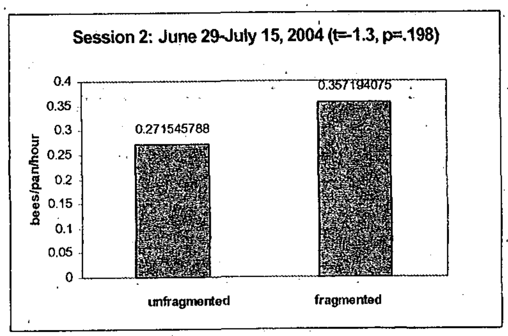
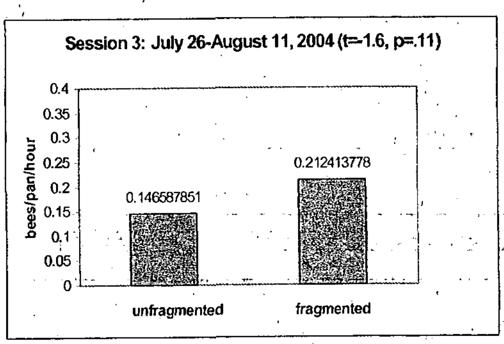


Figure 2: Mean rate of bee capture in unfragmented and fragmented prairie in mid- and late-summer sampling sessions, 2004.





ONGOING WORK:

Bee identifications will take at least a year to complete (we collected over 5700 bees in 2004); I currently have two undergraduate assistants working with the bee specimens in an effort to expedite this process. I will shortly have complete datasets from 2003 so I can begin analyzing them this winter.

For each site, the bee assemblage will be classified in terms of species diversity and abundance, physical characteristics such as body size, and behavioral characteristics such as sociality, specialism, nesting habit, etc. I will use multivariate statistical analyses to determine which variables best predict the composition of a given bee assemblage, looking at fragmentation, fragment size, and local habitat variables.

In addition, I will explore the landscape-level influence of the suburban matrix surrounding the sampling sites using remote sensing of land cover and GIS. I am currently starting to obtain GIS coverages for the greater Denver area. Remote sensing data will provide general information about the vegetation status, and thus potential resource availability, for bees in the surrounding yards and gardens. GIS analysis will incorporate this information and detect spatial relationships between land cover in the matrix and bee assemblage composition in habitat fragments.

Finally, in the summer of 2005, I plan to carry out several small studies to try and fill in some of the gaps in my data. I plan to conduct a small-scale pollination experiment on wildflower species growing at my sites, to determine whether flowers in fragments are receiving adequate pollen services. Also, I will be surveying bee assemblages in several suburban backyards to see whether bees are using both yards and prairie fragments equally as resources.

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Introduction

Pollination is a vital ecosystem function in both natural and agricultural ecosystems. Pollination function is subject to disruption when disturbance threatens the persistence of pollinator populations. One of the major sources of disturbance to pollination systems is landscape fragmentation: the breaking up and subsequent isolation of previously contiguous vegetation communities. Theory predicts that smaller fragments will support fewer pollinators, and that surviving populations will face higher risks of local extinction within fragments. Therefore, plants that rely on animal pollinators for successful reproduction also face an increased extinction risk.

This research analyzes bee assemblage composition and habitat use in two unfragmented prairie sites and remnant prairie fragments surrounded by suburban residential development near Boulder, Colorado. Fragments range in size from 1 ha to 30ha. The response of bees to fragmentation and fragment size is expected to vary with bee body size and behavioral characteristics.

Methods

The study involves data collection over a total of three field seasons. A pilot study of bee habitat use was conducted in the summer of 2002 on Boulder City Open Space. The summer of 2003 was the first full field season of the project and involved 14 properties, 12 of them surrounded by suburban residential development and 2 large, open prairie sites. BCOSMP properties used in 2003 were Beech, Hayes, and Greenbelt Plateau.

At each site, I located and mark sampling points at a density of approximately one sampling point per acre. In locating sites, I attempted to capture the full range of potential bee habitat heterogeneity, based on vegetation, aspect and slope. Marker flags were removed at the end of the field season. In 2003, I completed two full rounds of sampling at each site. The first sampling round took place July 8-26 and the second, August 11-21. Data collection at each sampling point consisted of sampling for bees, vegetation community composition and structure, and microhabitat data.

I collected bees at each sampling point using pan traps: blue, white and yellow plastic bowls containing water and a drop of surfactant, left out for 24 hours. Bee specimens were returned to the lab, rinsed, and pinned. Currently, they have been counted, but not identified; they will eventually be identified to morphospecies.

To sample vegetation, I walked four 12m vegetation transects at each sampling point, identifying the ground cover and measuring plant height next to my big toe at each step, resulting in approximately 55-65 data points per sampling location. Ground cover was classified as either grass, forb (not in flower), flower, rock, bare ground, litter, or feces (in grazed areas). Plants in flower were identified to species.

Microhabitat data was collected at each site, using a subset of sampling points that represented the range of habitat heterogeneity within the site. I collected data on temperature and relative humidity at the soil surface using dataloggers left out over 24 hours. By comparing these data from the same site over the same 24 hour period, I can quantify the range of variability at that site across habitat types.

Results

I completed two full sampling rounds over the summer of 2003. During the first sampling round, Hayes/Greenbelt was sampled on July 16/17 and Beech on July 17/18. In the second round, Hayes Greenbelt was sampled on August 14/15 and Beech on August 11/12.

Total bee abundance at these two sites is summarized in Table 1. In total, 757 bees were collected on Boulder City Open Space property in 2003.

Table 1. Bee abundance on Boulder City Open Space, 2003.

	July 2003 (# of sampling points used)	August 2003 (# of sampling points used)	Total
Hayes/Greenbelt	73(10)	310 (11)	383
Beech	175(8)	199(9)	374

At present, no further analyses have been done. Analyses using habitat data and bee abundance should be completed by early 2004.