Influence of reclaimed surface mine landscape on bees and plant-pollinator networks in southeastern Kentucky

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Introduction

Pollination is one of the most important plant-animal interactions for not only the reproduction of vital plant communities and productivity of agricultural crops, but also for sustaining terrestrial ecosystems. Globally, both domestic and wild pollinator populations are responsible for pollinating approximately 70% of the cultivated plants. And of those, more than 1500 agricultural plant crops are pollinated by bees. However, recent studies suggest that several phenomena are negatively affecting pollinator populations and their services, such as pesticide use, land use change, climate change and diseases or viruses.

The effects of anthropogenic change on most other bee species are unconfirmed. There are substantial concerns regarding the availability of future pollination services provided by domesticated species, making it essential to understand if native species are in fact experiencing population declines. Recent work suggests an increased reliance upon native and wild bee species that could act as a buffer and compensate for the loss of domesticated pollinators. Native bees play a key role in ecosystem functioning, as they pollinate a wide variety of native plants and agricultural crop species, and therefore may be able to compensate for the reduction of pollination services from the declining numbers of honey bees (Figure 1). Interestingly, some native plant species depend exclusively on pollination provided by native bee species.

Figure 1. Native bee of southeastern Kentucky (H. Carter, 2017)

Anthropogenic disturbance, such as land use change and habitat loss may be the largest factors contributing to pollinator population decline. An important example of anthropogenic disturbance in the Appalachian region is surface mining. Surface mining dramatically alters the landscape due to the removal of large amounts of sediment to access seams of coal which runs through a mountain. In post-mined landscapes, reclamation efforts are often conducted to modify the otherwise unused landscapes to be utilized for agriculture, habitat restoration, and landscape development. Reclamation sites are increasing in number due to the decreasing demand for mining operations.

Few studies have measured bee abundance and richness in the Appalachian region, particularly southeastern Kentucky. The aim of our study was to understand how the number of bee species, bee abundance, and plant-pollinator networks respond to surface mining and reclamation in southeastern Kentucky. Plant- pollinator networks can provide insight into site differences. For instance, through networks, we can evaluate how surface mining and reclamation influences the resilience of plant-pollinator communities by examining the diversity and evenness of interactions in the network.

Methods

Eleven sites located in Perry, Leslie, Knott, Letcher, Harlan, Clay, and Laurel counties in southeastern Kentucky were selected for this study. The sites were selected according to three criteria: (1) their proximity to a surface mine site (disturbance), (2) located on school grounds, and (3) not within a 500m radius of another location. Selection of a site's proximity to a surface mine was conducted using ArcGIS version 10.1.

The sampling location for each site included the entire school yard. To survey the plant species for bees, I used the active sampling method of sweep netting. This allowed me to monitor the presence of a variety of insects on each particular focal flowering plant species. I conducted timed sweep net samples on a particular plant species for fifteen minutes. All bee species observed to visit a flower were collected and preserve it in 70% ethyl alcohol for further identification in the lab. After observations were conducted, plant specimens were

also collected and pressed for further identification in the lab.

Results

During this study we collected a total of 188 bee specimens of 47 species foraging on 13 flower species. The total number of bees collected at sites with mines was 83 while the total number of bees collected at sites without mines was 104. Bee abundance (i.e. number of bees), was significantly influenced by the number of plant species at each site ($F_{1,8}$ =26.64, p= 0.00086) but was not significantly affected by the presence or absence of a surface mine ($F_{1,8}$=0.0006, p=0.98). A total of 17 bee species were collected from sites with mines and a total of 37 bees species were collected from sites without mines. The number of bee species at a site was influenced by the number of plant species ($F_{1,8}$ = 17.37, p = 0.003), but not by the presence or absence of a surface mine ($F_{1,8}$=2.99, p= 0.12).

There was a marginally significant difference between the number of plant species on a school yard, based on the presence or absence of a surface mine ($F_{1,9}$=4.12, p=0.07). Sites without surface mines nearby tended to have more species of plants compared to sites without surface mines nearby.

Figure 2, there was a large difference in the diversity of interactions in the network when comparing sites without surface mines nearby (Fisher's alpha = 70.84) and sites with surface mines nearby (Fisher's alpha= 15.84). The Shannon diversity (evenness) of interactions was also different between the sites. Sites without surface mines nearby had a higher evenness of interactions (3.93) compared to sites without surface mines nearby (2.58). Plant-pollinator networks on both types of sites showed a very low degree of nestedness (few interactions were subsets of species with more interactions; sites with mines nearby = 22.06; sites without mines nearby =33.60- where 0 is low nestedness and 100 is perfect nestedness).

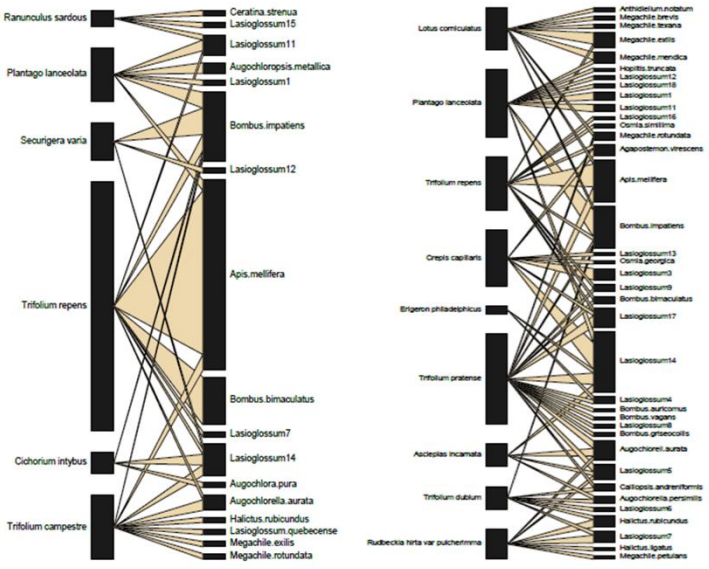

Figure 2. Plant-Pollinator network on surface mine sites (left) vs. network on non-surface mine sites (right)

Conclusions

From this study it has been concluded that there is not enough data for conclusive evidence. However, there was a strong trend in our data set, the network suggests there are several more bee and plant species located on sites without surface mines. Also, there are more interactions and a higher interaction diversity in sites without surface mines. Although we did not find a statistical difference between the number of bees or the number of bee species on sites with and without mines, there was a trend toward higher numbers of bee species on sites without surface mines. Plant-pollinator networks comparing the two types of sites, further elucidate differences between the two, showing a much greater diversity of interactions and a higher evenness of interaction on sites without surface mines nearby. This shows that sites without surface mines nearby have more resilient plant-pollinator networks that would be less vulnerable to disturbance.

References

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