Title: Assessing pollinator response to natural and anthropogenic disturbances in mixed-conifer forests

Investigators:
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Project duration:
Funding granted to support field activities during the 2016 and 2017 field seasons

Objectives:
1. Evaluate how natural and anthropogenic disturbances structure pollinator communities in early seral forests

2. Assess whether changes in pollinator diversity and abundance are linked to changes in pollination services

3. Test whether remote sensing data (e.g., LiDAR) can be used to discern differences in pollinator communities

Summary of accomplishments over past year:
In April 2016 we established n=41 study plots within the vicinity of the Douglas Complex in southern Oregon based on satellite-derived relative differenced normalized burn ratio (RdNBR) values that quantify post-fire changes in tree basal area. Our study plots represent the full range of fire severity within the ~19,700 ha complex and includes study plots of low fire severity (n=10), moderate-low fire severity (n=6), moderate-high fire severity (n=8), and high fire severity (n=9). We also established study plots that were subjected to high fire severity and were also salvage logged (n=8).

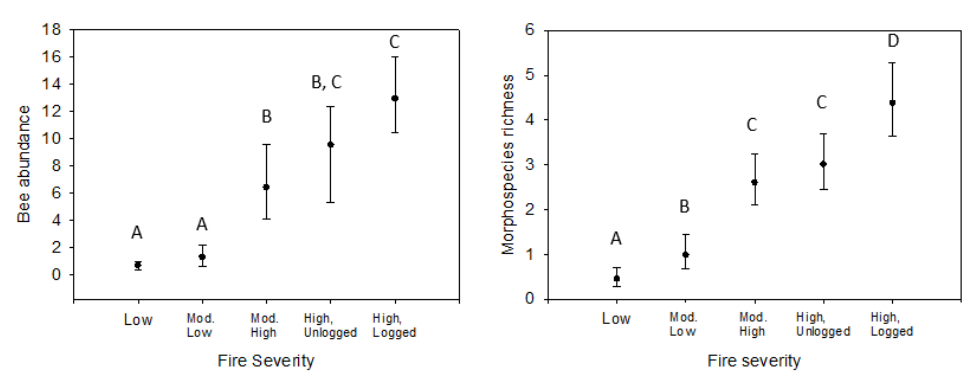

Fig. 1 | Preliminary results indicate bee diversity measures were positively linked to increases in disturbance intensity within burned forest. Mean (95% CI) bee abundance (left panel) was positively associated with fire severity, with the greatest number of bees captured on stands that experienced high fire severity and were subjected to salvage logging. Mean (95% CI) bee morphospecies richness (right panel) showed a similar pattern as abundance. Results are based on linear mixed models for fire severity and sampling date, weighted by number of plots. Estimates with the same letter within each panel are not significantly different at *P* = 0.05.

We sampled bee communities using blue vane traps (BVTs) every 3-4 weeks from May-September 2016. During our four sampling periods, we collected a total of 2,377 bees representing 20 genera and approximately 85 species. Bee abundance varied with sampling date, with the majority trapped during the third collection period (late July-early August, n=1319). Preliminary analyses show a positive relationship between fire severity and bee diversity measures (i.e., abundance and richness), and both measures were greater on stands that were subjected to salvage logging (Fig. 1). The majority of bees captured were ground-nesting species, although a sizable number of cavity- and wood-nesting species were detected across all treatment types (Table 1). We also collected data on relevant habitat variables within the plots such as floral richness and abundance, percent canopy cover, and percent exposed bare ground and we piloted a method for quantifying coarse woody debris which will be used to survey plots in March 2017.

Table 1. Distribution of captured bees by nesting substrate and for disturbance treatments in our study. Ground = bee species that nest in exposed soil, Cavity = bee species that nest in hollow logs or rock piles, Wood = species that nest in tunnels within wood, Stem = species that nest in pithy plant stems, Cleptoparasite = parasitic bee species that do not build their own nest but instead lay their eggs into the nest of other species. We restrict reporting to bee genera with known nesting preferences (17 of 20 genera; 97% of collected specimens).

		Disturbance type				
Nesting substrate	n	Low fire	Moderate-low fire	Moderate-high fire	High fire	High fire + salvage logged
Ground	1853	60 (3%)	51 (3%)	417 (23%)	596 (32%)	729 (39%)
Cavity	278	25 (2%)	3 (1%)	57 (21%)	70 (25%)	123 (44%)
Wood	176	0 (0%)	7 (4%)	20 (11%)	59 (34%)	90 (51%)
Stem	7	1 (14%)	0 (0%)	2 (29%)	1 (14%)	3 (43%)
Cleptoparasite	1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)

In addition to surveying the diversity of bee communities, we also measured reproductive output of the alfalfa leafcutter bee (Megachile rotundata) by placing two nesting structures on each plot with a standardized number of pre-emergent adult bees still in cocoons. After 10 weeks, we collected the nest boxes and quantified the number and size of new cocoons produced on stands as a measure of relative reproductive output. We collected a total of 182 cocoons from nests, with plots that experienced high severity fire and were subsequently salvage logged had greater reproductive output (mean = 4.6 cocoons/nest, SD=8.7) relative to stand that experience low fire severity (mean = 0.7 cocoons/nest, SD=1.7). However, there was high variation in reproductive output among treatments, likely due to modest sample sizes.

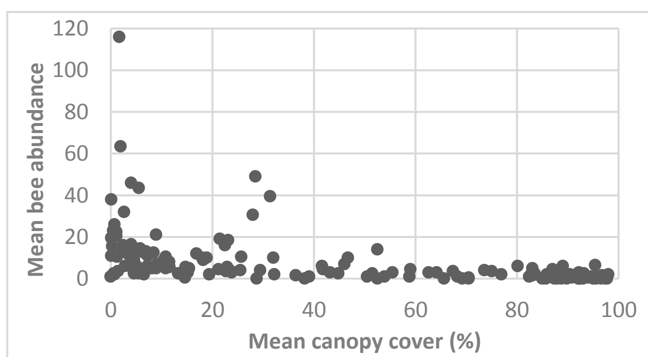

Fig. 2 | Bee abundance decreased with increased canopy cover in burned forest. Stand-level data from 2016 confirm that open areas within forested landscapes harbor more bees. However, how the surrounding landscape structure interacts with stand-level habitat data is currently unknown. We will address this knowledge gap through our study objective #3 that uses remote sensing data, including LiDAR, to determine how landscape-level factors influence local bee diversity measures, and how this may vary among bee guilds (e.g., soil- vs. wood-nesting species).

As proposed in our second objective, we will use an experimental approach to exclude pollinators from flowers to evaluate how differences in bee diversity measures translate to variation in pollination services to native plants. We piloted the use of Helenium autumnale for this experiment, but determined that it would be more effective to use wild plants already established on stands. Our pilot data indicated that salal (Gaultheria shallon) was present on stands across the continuum of disturbance intensity, and we observed several bee genera visiting this plant throughout the spring and summer, including Xylocopa, Bombus, and Anthophora. Therefore, our pollinator exclusion experiments will measure the contribution of native bees to salal fertilization success.

During summer 2016, we measured canopy cover with each stand and found that bee abundance decreases as canopy cover increases (Fig. 2); however, it is unknown how bee diversity measures are linked to canopy cover at different scales within the landscape. Therefore, as part as study objective #3 we will use bee capture data and habitat data collected over the course of this study to discern if remotely sensed LiDAR flight data can be used to predict bee diversity measures. Once data collection is finished after the 2017 field season, we will test this important, yet heretofore unaddressed component of how bees respond to landscape-scale changes in habitat within managed temperate forests.

Problems, barriers, proposed changes to objectives:
We did not encounter any significant problems or barriers that prevented us from meeting our research objectives, only making minor adjustments to the proposed methods based on new information about the study area. For example, our initial site selection found that salvage logging in the Douglas Complex only occurred on stands experience high fire severity, preventing us from looking at the influence of logging severity across the entire fire severity gradient. We also intended to use potted Helenium autumnale for the pollination experiment, but learned that these plants were difficult to raise and transfer to field plots, so we instead chose to use on-site plants for this experiment. Finally, we suspect that the limited number of alfalfa leafcutter bees that were raised on sites may have been due to phenological mismatches between flowering of local plants and the timing that bees emerged from cocoons. Therefore, in 2017 we will instead use mason bees (Osmia lignaria) for this experiment. This species emerges earlier in the season when floral resources are more abundant on our stands, which should provide a better opportunity to evaluate how bee reproductive output is influenced by disturbance intensity

In addition to addressing all of the initial research objectives we proposed, we also expanded the objectives of our study in two significant ways. First, we collected pilot data to evaluate the quality of roadside habitats for bees, as forest roads represent an additional anthropogenic disturbance type within forested landscapes. We established roadside plots that were paired with interior stand plots for low fire severity, high fire severity, and high fire severity + salvage logging treatments (n=5 sites/treatment). We used BVTs and collected habitat data at these roadsides during late summer 2016, and we plan to continue sampling across the entire field season (May-August) in 2017. We collected 1,180 bees on roadside plots representing 18 genera and approximately 48 species, indicating roadsides might provide important habitats for bees and other pollinators within managed forests.

Second, we expanded our project to quantify the physiological health of pollinators foraging across the disturbance gradient by measuring the lipid content of individual bees. We piloted this method in the 2016 field season, netting bumble bees from low fire severity (n=17 individuals), high fire severity (n=35), and high fire severity + salvage logged treatments (n=31). We are working with a collaborator (Dr. Amy Toth, Iowa State University) to undertake laboratory assays that will assess size-specific lipid contents, which are an indication of overall health. We plan to expand our netting of bees in these treatment types in late spring, early summer, and mid-summer 2017, providing additional information about how disturbance type and intensity is linked to pollinator health.

Planned work:
Our planned work remains as outlined in our project proposal. Currently, post-doctoral research associate Dr. Sara Galbraith is refining specimen identification, undertaking preliminary analyses of field and LiDAR data, and preparing for the 2017 field season. Data collection is expected to begin in April 2017 and be completed by mid-September 2017. Analysis and write-up will continue as new data become available, and we expect to submit at least two manuscripts to peer-review journals in 2018. We will also continue to give presentations to scientists and land managers in a variety of settings to highlight our findings.

In addition to our field research, we are also organizing and hosting a workshop in March 2017 titled, "Pollinators in Managed Forest Landscapes." The primary goal of the workshop is to bring together resource managers and pollination scientists to develop an agenda for pollinator research in managed forests of the Pacific Northwest. Researchers from across the country will share results from recent and ongoing projects focused on pollinators within managed forests, and resource managers will be called upon to outline potential investigations to assess how current management actions may impact native pollinators. We expect to host 50-60 participants for the one-day event, including students, researchers, and land managers, and attendees will have the option of receiving continuing education credits from Society of American Foresters and The Wildlife Society for attending.

List of names and brief overview of young professionals engaged with project:
Three young professionals worked as research assistants on this project during the 2016 field season: Ian Lively (B.S., OSU), Nicole Scavo, and Katarzyna Szczurek. All three are interested in pursuing graduate school careers and learned field-, laboratory- and museum-based methods for working with bees, as well as collecting data for an independent project investigating trap bias in BVTs. We are currently seeking 1-2 OSU undergraduate students to assist with laboratory tasks, and we plan to hire 4 full-time young professionals for field work during the 2017 season.

List of presentations and posters:
Rivers, J. W. 2016. Pollinator response to natural and anthropogenic disturbances in mixed-conifer forests. Douglas Complex Status Review Meeting for the Bureau of Land Management, Roseburg, Oregon.

Galbraith, S. M. 2016. The influence of fire severity and post-fire management on bee community composition in a mixed-conifer forest. Oregon State University Postdoctoral Association Annual Research Symposium, Corvallis, OR. Won award for best overall presentation.

List of expected publications:
Galbraith, S. M., J. H. Cane, and J. W. Rivers. Bee response to fire severity and post-wildfire management in a mixed conifer forest. For Journal of Insect Conservation.

Galbraith, S. M., C. J. Dunn, J.H. Cane, and J. W. Rivers. LiDAR-derived habitat variables for predicting bee diversity in mixed conifer forest after wildfire. For Remote Sensing of Environment.