I. Literature review

Wildfires have become increasingly severe due to global warming, with higher temperatures, reduced rainfall, and drier conditions contributing to a greater risk of intense fires (Halofsky et al. 2020). This change in fire behavior has significant implications for ecosystems, including the habitats of pollinators like bees. This study seeks to explore the effect of fire severity on bee populations in affected areas, particularly whether the clearing of forested areas by severe fires might increase bee population density due to the resulting open habitats and floral regrowth. Findings from OSU's Extension Service indicate that bees may benefit from such regrowth, as open, cleared areas can foster a variety of flowering plants that attract pollinators (Mola et al. 2021). Yet, existing research does not clearly delineate how bees are affected by fires of varying severities, especially over time.

Previous studies have documented how frequent, high-severity wildfires influence biodiversity, with some research suggesting that high-severity fires may create temporary environments favorable for certain species by increasing habitat openness and sunlight availability (Halofsky et al. 2020). However, the frequency of "reburns," or repeated fires in the same region, may disrupt these benefits by not allowing sufficient time for flora and fauna to repopulate the area (Collins et al. 2019). The increasing frequency and severity of wildfires in the Pacific Northwest (PNW) create a unique context to investigate bee population dynamics, as the region experiences substantial ecological changes following fires.

This study will utilize data from the Oregon Bee Atlas (OBA) combined with burn severity data provided by the Burned Area Emergency Response (BAER) imagery, which covers fires in the PNW from 2000 to 2024. The BAER data provides insights into fire intensity and impact, allowing us to categorize fires by severity. By examining bee populations before, immediately after, and long after fires of different severities, we aim to determine if and how these disturbances influence bee density and diversity. This analysis will provide a temporal perspective on bee population recovery, focusing on how initial losses may give way to long-term gains in bee abundance in areas that experience severe fire events.

Given the rising frequency and severity of wildfires, it is crucial to understand their ecological impacts on pollinators, especially as bees play a vital role in pollination for both natural and agricultural systems (Potts et al. 2010). This project will combine spatial and temporal analyses to investigate post-fire recovery trends for bees across various fire severities. Visualizations will be generated to convey the effects of fire over time and across severities, offering a new perspective on pollinator resilience. By examining bee populations in relation to fire events, this project aims to reveal whether wildfire-induced habitat changes may promote or hinder bee populations in the long term.

Our primary hypothesis is that severe wildfires initially reduce bee abundance due to habitat loss and lack of floral resources. However, we anticipate that bee populations will recover and potentially exceed pre-fire levels as vegetation regrows and new floral resources become available. We further hypothesize that lower-severity fires may have less long-term impact on bees, possibly leading to less drastic changes in population size. This project will also explore whether there are significant differences in population recovery across different bee species and fire severities, as certain bee species may be more adaptable to fire-induced habitat changes, or the flora that are fire-adapted, that in turn attract a certain subset of bees.

References

- Collins, Brandon M.; Stevens, Jens T.; Miller, Jay D.; Stephens, Scott L.; Brown, Peter M.; North, Malcolm P. 2017. Alternative characterization of forest fire regimes: incorporating spatial patterns. Landscape Ecology. https://doi.org/10.1007/s10980-017-0528-5.
- Halofsky, J.E., Peterson, D.L. & Harvey, B.J. Changing wildfire, changing forests: the effects of climate change on fire regimes and vegetation in the Pacific Northwest, USA. *fire ecol* 16, 4 (2020). https://doi.org/10.1186/s42408-019-0062-8
- Mola, J. M., Williams, N. M., et al. (2020). "Wildfire reveals transient changes to individual traits and population responses of a native bumble bee *Bombus vosnesenskii*." *British Ecological Society*, 31(3), e02242. https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2656.13244
- Potts SG, Biesmeijer JC, Kremen C, Neumann P, Schweiger O, Kunin WE. Global pollinator declines: trends, impacts and drivers. Trends Ecol Evol. 2010 Jun;25(6):345-53. doi: 10.1016/j.tree.2010.01.007. Epub 2010 Feb 24. PMID: 20188434.

II. Dataset identification

Please identify the additional datasets you will be using to address your question. * Provide the data source (including web url) * Describe sufficient metadata to convey who collected the data, how it was collected, and what each column contains.

Primary Dataset:
Oregon Bee Atlas (OBA)

- **Source:** Oregon Bee Atlas
- **Description:** The OBA dataset contains observations of bee species across Oregon, including species name, location (latitude and longitude), and collection date.
- **Metadata:** Maintained by the Oregon State University Extension Service, this dataset includes contributions from volunteer citizen scientists. Key columns include species name, geographic location, date of observation, and additional details on collection methods.

Additional Datasets:

1. **U.S. Geological Survey BAER Fire Severity Data**
   - **Source:** U.S. Geological Survey
   - **Description:** Fire severity data from the BAER program provides insights into vegetation impact, which is critical for understanding changes in flora and their effects on bee populations.
   - **Link:** https://burnseverity.cr.usgs.gov/products/baer
2. **Oregon Department of Forestry Fire Occurrence Data (2000–2022)**
   - **Source:** Oregon Department of Forestry
   - **Description:** This dataset includes detailed information on fire location, size, and severity, which will be used to correlate changes in bee populations and habitats.
   - **Link**: https://catalog.data.gov/dataset/odf-fire-occurrence-data-2000-2022
3. **Post-Fire Habitat Restoration Data**
   - **Source:** National Fire Plan Restoration Efforts
   - **Description:** Includes data on habitat restoration efforts aimed at accelerating the recovery of fire-affected areas, with a focus on reintroducing plant species critical for pollinators.

III. Workflow plan

In pros, please describe the workflow you will use tidy your raw data, manipulate and summarize it in relevant ways, test you hypothesis, and visualize it.The goal here is to develop a logic to your workflow before you code. * Include any needed cleaning steps (e.g., “remove non-species such as ‘fly’ from the species column”) * Include any aggregation steps (e.g., “count the number of entries by region and year to calculate species richness”). * Include descriptions of any functions/for loops you will write.

* Include a description the the statistical test you will use, and how you will apply it programatically (i.e., I will simulate the null hypothesis by shuffling the labels…“)

Data Cleaning:

- Remove irrelevant entries (e.g., non-bee species, records with missing location or date information).
- Standardize date formats across datasets and ensure geographic coordinates are consistent.
- Merge the OBA dataset with fire occurrence data, ensuring that observations are matched to relevant fire events and fire severity data.

Data Aggregation:

- Aggregate bee data by region (e.g., county or fire zone) and year to analyze trends in species diversity and abundance over time.
- Aggregate fire occurrence data by region and year to assess the frequency and severity of fires in different areas.

Hypothesis Testing:

- **H1 (Geographic Relocation):** Perform spatial analysis to assess if bee populations have relocated to areas with lower fire severity, using raster data science tools.
- **H2 (Species Diversity):** Calculate species richness before and after fire events, comparing regions with high and low fire severity. Calculate pre- and post-fire species richness and conduct a paired t-test to determine statistical significance.
- **H3 (Diet Patterns):** Correlate shifts in floral composition (from fire severity data) with changes in bee diet preferences, using available floral data (e.g., from the National Fire Plan or Oregon Flora Project).

Statistical Analysis:

- Apply statistical tests such as chi-square tests to assess changes in species diversity.
- Use t-tests or ANOVA to compare species composition in fire-impacted versus unaffected areas.
- Simulate the null hypothesis using label shuffling for permutation tests if applicable.

Visualization:

- Create heatmaps to visualize shifts in bee populations relative to fire occurrences and severity.
- Use bar charts or scatter plots to illustrate changes in species diversity and diet patterns before and after fire events

IV. Partner contributions

Zoe did parts II and III, and I did part I. We both reviewed each other’s work