BI410 Data Science for Ecological Conservation Term Project Final Writeup

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Introduction

Background

Wildfires, exacerbated by climate change, are increasing in frequency and severity, presenting significant ecological challenges. Recent studies have highlighted the growing concern of how changing fire regimes, driven by warming climates, are altering ecosystems. For example, large and severe fires in the Pacific Northwest have been associated with warmer and drier conditions, which are projected to become more common due to climate change (Halofsky et al., 2020). Additional prior research indicates that post-fire environments can significantly alter plant communities, which directly impacts bee populations by changing the availability of nectar and pollen sources (Nevins et al., 2014). These conditions can potentially have profound impacts on forest composition, regeneration, and post-fire ecological processes, all of which are important for understanding the effects on wildlife, including pollinators such as bees.

Wildfires can reshape habitats by clearing dense forests and altering vegetation composition. However, fires may also facilitate floral regrowth, which could offer bees new foraging opportunities. The role of fire severity in shaping bee populations, particularly in post-fire environments, remains under-explored in scientific literature. Understanding the impact of different fire severities on bee populations is crucial for developing informed land management strategies that support pollinator conservation.

This research aims to investigate how varying fire severities influence bee populations and their distribution in the aftermath of a wildfire. Specifically, it will assess whether fire severity is correlated with changes in bee density. Given the importance of bees in ecosystem health and agriculture, this study could inform strategies for managing post-fire landscapes to ensure the resilience of pollinator populations.

Hypothesis 1: Fire Severity

Null Hypothesis: There is no linear correlation between the severity of a wildfire and the percent change in bee counts after the fire. ($r = 0$)

Alternative Hypothesis: There is a linear correlation between the severity of a wildfire and the percent change in bee counts after the fire. ($r \neq 0$)

Hypothesis 2: Population Change

Null hypothesis: There is no significant difference in bee counts before and after the fire. This means the mean difference between the before fire and after fire groups is zero.

$\mu(before\_fire) = \mu(after\_fire)$

Alternative hypothesis: There is a significant difference in bee counts before and after the fire. This means the mean difference between the before fire and after fire groups is not zero.

$\mu(before\_fire) \neq \mu(after\_fire)$

Data

We used several fire datasets, and one bee dataset, each from two different sources.

Fire Severity Data: Spatial data from the BAER (Burned Area Emergency Response) program, provided by the U.S. Geological Survey, was used to measure fire severity in Oregon wildfires. This dataset includes information about 11 fires that occurred in 2020 (Umpqua, Hood, Holiday, Beachie, Fremont, Ben Young, Brattain, Lionshead, Thielsen, Two Four, Whiteriver). This dataset helps assess the impact of fire severity on the landscape and habitat changes.

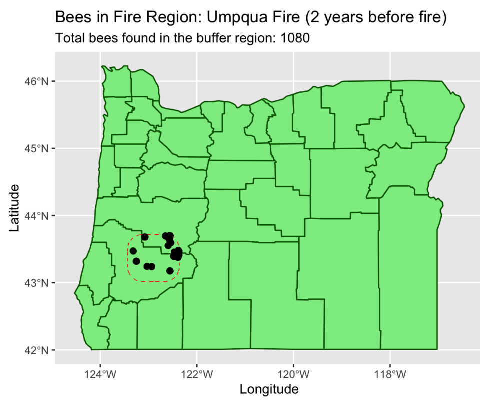
Bee Population Data: Bee population data from the Oregon Bee Atlas (OBA) was used, covering the years 2018 to 2022. We specifically selected data corresponding to the 2020 fires to analyze changes in bee density and distribution two years before and after the wildfires. In this analysis, we excluded plant taxonomy information (genus/species) as our primary focus was on bee populations rather than plant interactions. However, future research could explore species composition changes and plant relationships in more depth.

Oregon Ecoregions Data: A shapefile representing ecoregions in Oregon from the Oregon Conservation Strategy dataset. This dataset was read into the project and then transformed to align with the coordinate reference system of the Beachie 2020 fire dataset. The ecoregions dataset helps plot the other two datasets and assess regional variations in habitat composition.

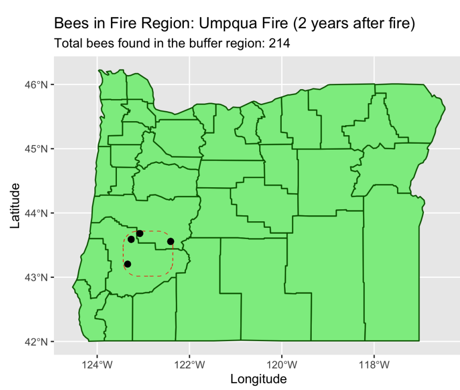
Data wrangling and summarizing

Location <chr>	Average_Severity <dbl>	Percent_Change_in_Bees <dbl>
Umpqua	4.009000	-80.18519
Hood	3.512376	-42.75304
Holiday	3.762565	-56.84790
Beachie	3.687295	-75.21531
Freemont	3.362752	-55.93036
Ben Young	3.325592	42.82561
Brattain	3.059134	-89.86111
Lionshead	3.413909	-46.02235
Thielsen	3.449503	-89.63731
Two Four	3.781873	-50.84746
Whiteriver	3.086412	181.60000

Data engineered "Average_Severity" and "Percent_Change_in_Bees" for regression analysis



Bees (black points) and fire buffer (red dashed line) plotted on Eco Regions dataset 24 months before the fire.



Bees (black points) and fire buffer (red dashed line) plotted on Eco Regions dataset 24 months after the fire.

Hypothesis test

Test for Hypothesis 1: Correlation test between fire severity and percent change in bees

Statistical Test: Pearson Correlation Coefficient

Pearson Correlation Coefficient: -0.48

P-value: 0.13

Result: Fail to reject the null hypothesis. There is no statistically significant evidence of a causal relationship between fire severity and the percent change in bee counts.

Interpretation: Although there is a moderate negative correlation between fire severity and the percent change in bee populations, the lack of statistical significance suggests that this relationship may be due to random variation rather than a true underlying causal link.

Test for Hypothesis 2: Difference of Means Between 24 Months Before and After the Fire

Statistical Test: Paired T-Test

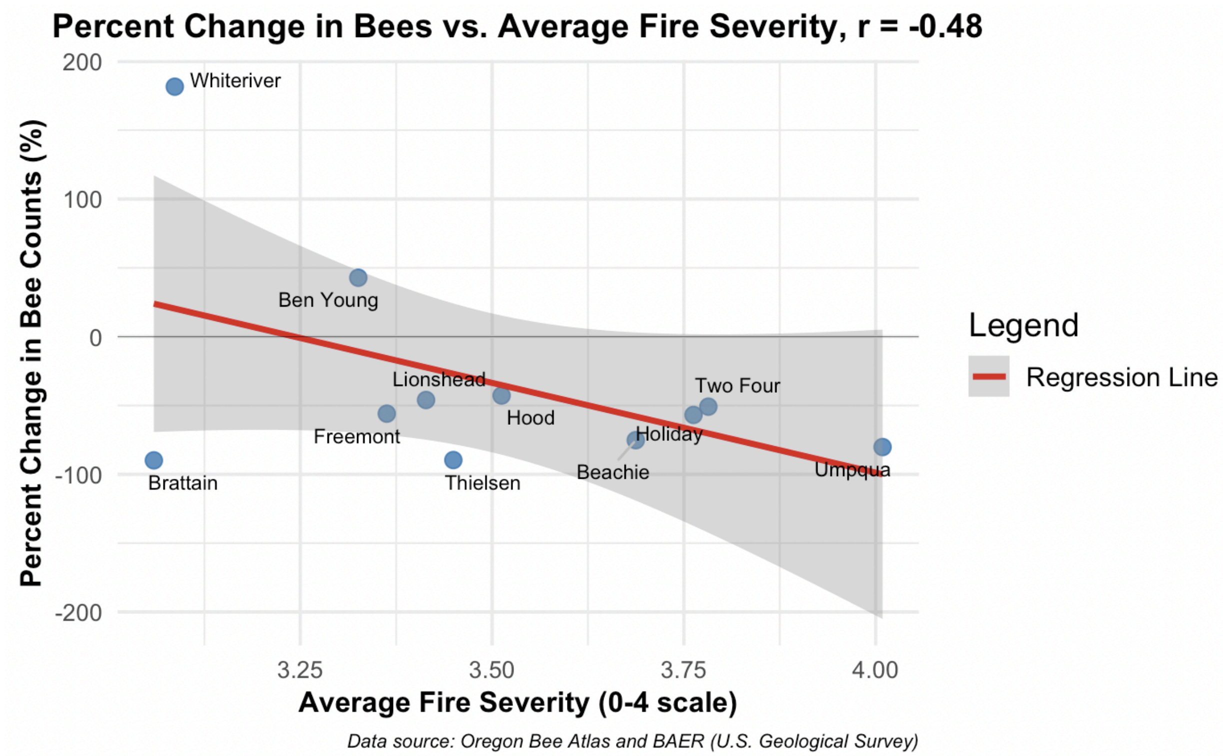
T-statistic: 3.13, Mean Difference: 560.7273

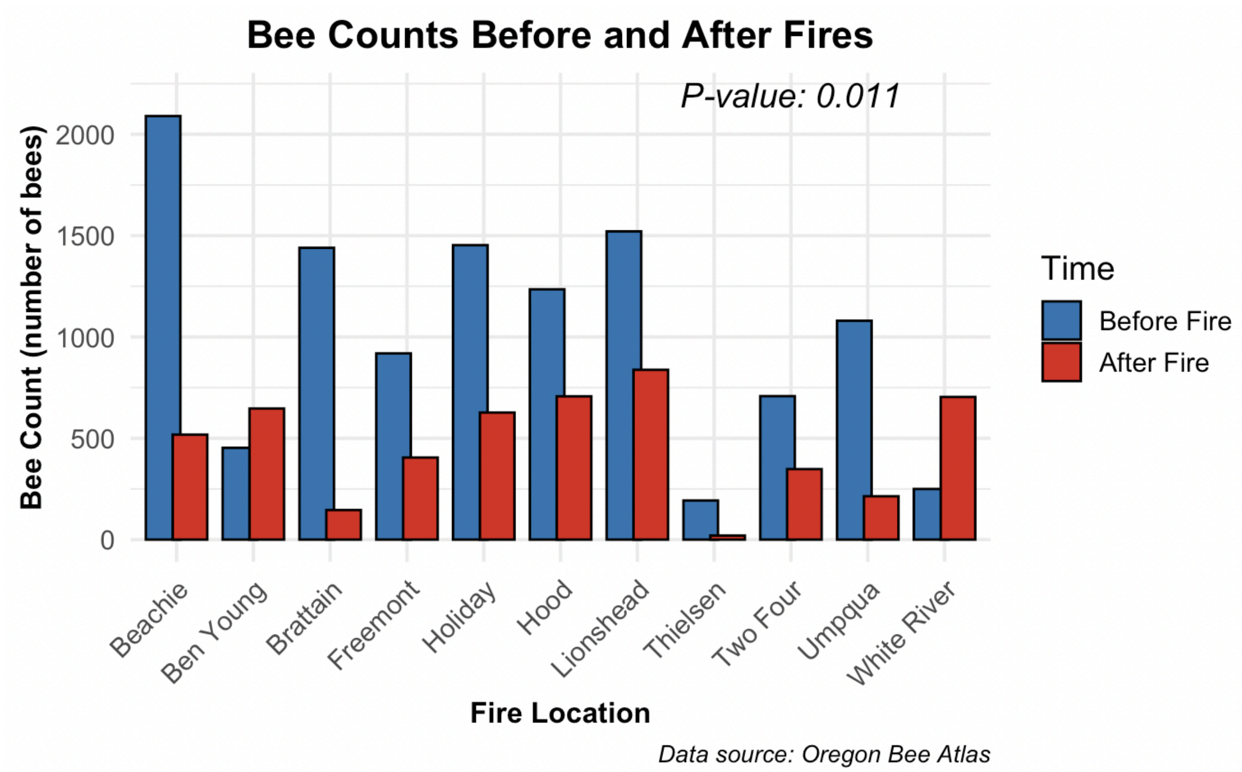
P-value: 0.01

Result: Reject the null hypothesis. There is a statistically significant difference in bee counts before and after the fire.

Interpretation: The significant mean difference between bee populations before and after the fire indicates that wildfires have a measurable impact on bee densities. Specifically, the data shows a notable change in bee counts, highlighting the importance of post-fire environmental conditions in shaping bee populations.

Visualization


Percent Change in Bees vs. Average Fire Severity, r = -0.48
Percent Change in Bee Counts (%)
200
100
0
-100
-200
Whiteriver
Ben Young
Lionshead
Freemont
Hood
Thielsen
Brattain
Two Four
Holiday
Beachie
Umpqua
3.25
3.50
3.75
4.00
Average Fire Severity (0-4 scale)
Legend
Regression Line
Data source: Oregon Bee Atlas and BAER (U.S. Geological Survey)


Bee Counts Before and After Fires
P-value: 0.011
Bee Count (number of bees)
2000
1500
1000
500
0
Beachie
Ben Young
Brattain
Freemont
Holiday
Hood
Lionshead
Thielsen
Two Four
Umpqua
White River
Fire Location
Time
Before Fire
After Fire
Data source: Oregon Bee Atlas

Conclusion

This study investigated the impact of wildfire severity on bee populations in Oregon, specifically focusing on changes in bee density and distribution before and after wildfires. The hypotheses were guided by literature suggesting that post-fire environments can significantly affect pollinator availability due to changes in habitat composition and plant communities (Halofsky et al., 2020; Nevins et al., 2014).

Key findings:

Hypothesis 1 (Fire Severity and Bee Density):
The Pearson correlation test revealed a weak negative correlation (-0.48) between wildfire severity and percent change in bee density, with a p-value of 0.13. This result indicates that no significant linear relationship exists between fire severity and bee density changes. In other words, variations in wildfire severity do not consistently predict changes in bee populations.

Hypothesis 2 (Difference of Means in Bee Counts):
The paired t-test showed a statistically significant difference in bee counts before and after the fires (t-statistic: 3.13, p-value: 0.01). This demonstrates that bee populations see a statistically significant change in post-fire environments, confirming that wildfires have a substantial impact on bee density.

Implications for Bee Conservation and Land Management:
The findings suggest that while wildfire severity may not show a direct linear relationship with bee population changes, the observed shifts in bee density before and after fires highlight the importance of targeted land management strategies. Conservation efforts should focus on supporting bee resilience by considering habitat restoration practices that ensure the availability of nectar and pollen sources. Future research could explore the interactions between bee populations and plant communities more deeply, particularly regarding species composition changes and plant taxonomy.

Understanding these dynamics is crucial to maintaining the resilience of pollinators in post-fire landscapes, ensuring biodiversity preservation and ecosystem functionality, and supporting agricultural productivity reliant on pollination services.

References

Halofsky, J.E., Peterson, D.L., & Harvey, B.J. (2020). Changing wildfire, changing forests: the effects of climate change on fire regimes and vegetation in the Pacific Northwest, USA. *Fire Ecology*, 16(4). https://doi.org/10.1186/s42408-019-0062-8

Melathopoulos, A., Edmunds, B., & Rivers, J. (n.d.). How do wildfires affect bees? *Oregon State University Extension*. Retrieved from https://extension.oregonstate.edu/forests/fire/how-do-wildfires-affect-bees

Nevins, S., et al. (2014). Impact of post-fire environments on pollinator availability. *Journal of Ecology*.