Biodiversity Analysis in East Gippsland Before and After the 2019/2020 Wildfires

First, here is the Background of my project

My placement was with the Victorian National Parks Association.

It’s very simple: we are non-profit, and we’re trying to protect parks in Victoria.

One of the projects I worked on is the Life After Fire. So here’s what happened….

This raised the questions: Did the wildfires damage biodiversity? And by how much?

My analysis goals here is to compare the biodiversity before vs. after the megafires

Hopefully the result will help VNPA in planning future conservation activities.

Trying to answers the questions, we utilized data from 3 sources:

First is (1) the species occurrence from the Atlas of Living Australia database

The other two sources are: (2) Fire History and (3) Vegetation class from the Victoria government (Department of Energy, Environment and Climate Action)

Here’s the time scope of the datasets: Using the temporal extend of the Fire, we crawled ALA species occurrence, divided into two periods: before, after

For the spatial scope. we rasterised the sf polygons of vegetation class onto grid cells. Each cell has One-Thousand-meter resolution.

There are quite a few problems with these data sources.

We addressed the problems with standardizing sampling periods and effort procedures, also with measurement method

The 3 data sources were weaved together using spatial operations. And here is a preview of the dataset to be analyzed.

In **Standardising sampling periods**

Our goal is to create temporally and spatially comparable sampling periods.

In burnt regions, we identified burnt\_after by extracting sighting records up to 18 months from the fire start date in each cell

Then, we created nine 18-month pre-fire period to account for the increasing effort post-fire.

In unburnt regions, we randomly assigned Fire Start Date (from burnt cell to unburnt cell with matching habitats). Then apply the same pre-fire periods creation.

*While there was overlap among the nine pre-fire periods, we did not treat these as independent, rather using them as an indication of pre-fire variation to compare to post-fire estimates of biodiversity.*

In **Standardising sampling effort**

The Goal is to account for varying sampling completeness across treatments.

We did 2 things:

**Double Control**: comparing burnt\_after to both (1) burnt\_before and (2) unburnt\_after -> identify if changes are specifically due to fire or broader temporal trends

**Control for Sample Completeness with iNEXT R package**

Let’s get to the **Measurement method**

So, how do we measure the biodiversity?

Let’s agree on some definitions

• Abundance — the total number of individuals in an area. Does not matter what species they are.

• Species Richness – Number of species in an area. Does not matter how abundant they are.

Biodiversity does not just mean there are many types of species within an area.

It means incorporating BOTH the Species Richness and the evenness of their abundances.

Therefore, We use the Hill Numbers as diversity measurement.

Hill numbers come in different orders. Besides from Species Richness, we have Shannon and Simpson diversity.

Shannon gives more weight to rare species

Meanwhile, Simpson diversity gives more weight to common or dominant species.

Now let’s break it down with an example. Say, We have 2 grid cells.

Grid cell A has one species dominance (which is the Blackbird with 7/10 individuals), while others are rare

Grid cell B: where all bird species are equally common.

Even though these 2 cells have similar abundance, similar species richness, Hill Numbers tell us that cell B is more diverse as B has higher Shannon and Simpson diversity than A.

We did not only calculate these numbers, but utilised the iNEXT R package **rarefaction** and **extrapolation** with Hill Number framework to tackle the sample completeness problem.

Finally, let’s now get to the **insightful** part.

Intuitively, We might have the initial assumption that fires would lead to a decline in biodiversity,

**but when consider all selected species groups and vegetation classes,** in BURNT regions, after-fire period had greater diversity than 9 periods of burnt\_before (no 95% CI overlap).

Similar case happened to UNBURNT regions.

* This suggests that the 2019/2020 wildfires **DID NOT** lead to an immediate and sustained decline in **overall** biodiversity.

That was before vs. after. Now let’s focus on After to compare between Burnt vs. Unburnt.

Species Richness is roughly similar between burnt and unburnt regions. BUT greater Shannon Diversity in **burnt\_after** shows that

(higher Shannon) Greater overall species richness + More even distribution of individuals among species + Presence of more rare species

(lower Simpson) Presence of a few highly dominant species as some species can populate faster.

How come?

* Some possible explanations we’ve found from the literature are: (1) Resilience to Fire (2) Post-Fire Recovery Process, which creates unique conditions favoring certain species in burnt areas. (3) Increased Detectability

**However**, we would want to emphasize that this overall increase in diversity **should not** be interpreted as a universally positive outcome of the megafires. The overall trend masks significant variations among specific groups and habitats, as well as the detrimental effects of extreme fire severity, which is one of the major limitations of this project.

Next, we compare across time-since-fire periods

* We can see that **diversity estimates generally increased with time since fire in burnt areas**, while there was no clear trend in unburnt regions.

The trend has Initial Dip, Then Increase

Diversity estimates were generally **lower** in burnt areas compared to unburnt areas in the **first 9 months** after the fires. This initial dip is likely due to the immediate impacts of fire on species survival and habitat availability. All three Diversity estimates got down to the **worst during the period of 3-6 months**. After that, diversity estimates in burnt areas **increased steadily**, generally surpassing those in unburnt areas by the **9-12 month mark**. This trend continued, with diversity estimates peaking around **12–15 months post-fire** before slightly declining in the final period (15–18 months), except for the Shannon.

**Possible Drivers of the Increase:** Several factors could contribute to this post-fire increase in diversity:

* **Regeneration and Colonization:** Many plant species, especially those adapted to fire, respond to fire cues by germinating from seed banks or resprouting from underground structures. This regeneration process, coupled with the influx of species that specialize in colonizing recently burnt areas, contributes to the observed increase in diversity.
* **Resource Availability:** Fire alters resource availability, creating opportunities for species that can exploit these new conditions. For example, the abundance of dead wood and post-fire vegetation provides habitat and food sources for various insects, fungi, and other organisms.
* **Reduced Competition:** Fire can reduce competition by eliminating dominant species or opening canopy gaps, allowing less competitive species to thrive. This shift in competitive dynamics can increase species diversity.

**However**, these are **only short-term observations**, and we would want to emphasize that **long-term monitoring is crucial** to fully understand the lasting impacts of megafires and changing fire regimes on biodiversity.

**Driving the Overall Trend:** The results highlight that the diversity estimates in **Lowland Forests** post-fire closely **match the overall trend of increased diversity** observed when grouping all taxon groups and habitats together. This suggests that this habitat **likely plays a significant role in driving the overall pattern of diversity response** to the megafires.

Fire can lead to an overall increase in diversity in certain ecosystems, this effect is not uniform across all habitats.

Further research focusing on individual habitats and the specific adaptations of their resident species is crucial to gain a more nuanced understanding of how fire shapes biodiversity in the long term.

VNPA can incorporate this information in allocating their conservation efforts into needed habitats.