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Developing Restoration Strategies for Dynamic Population Changes of Plant-Pollinator Networks in a Warming Climate

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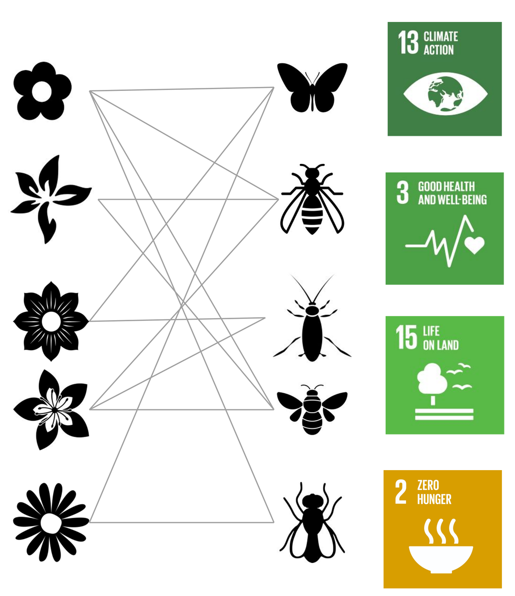
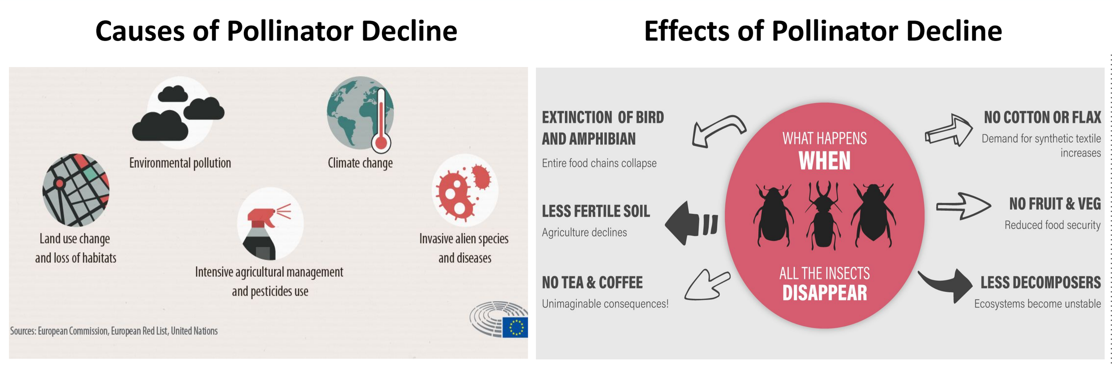
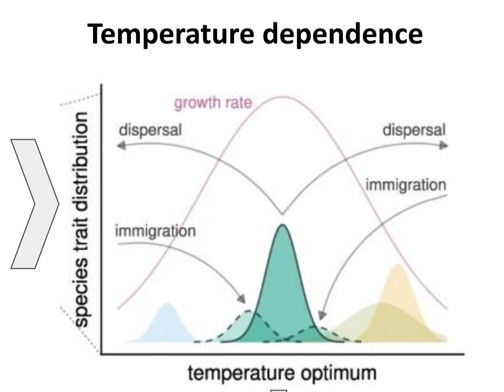
1. Introduction

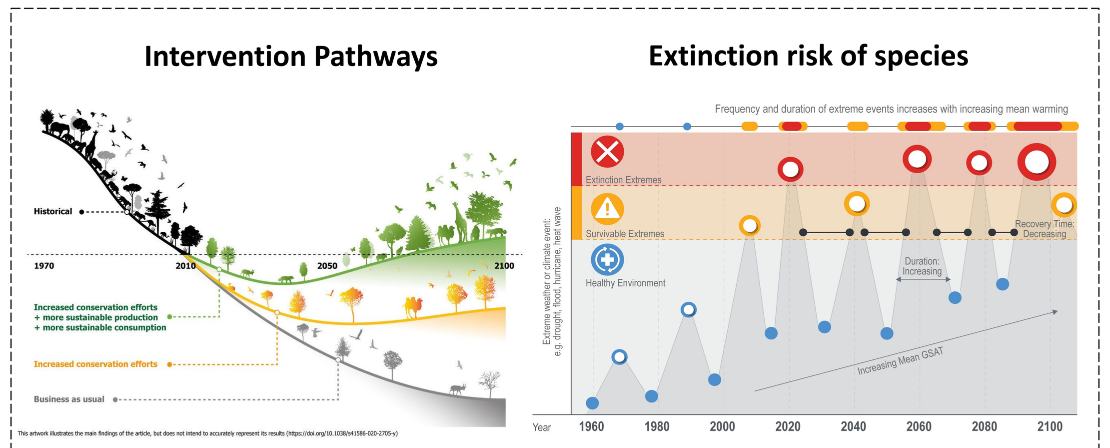
- **Pollination**, vital for food system health, relies on animals for over **75% of** cross-pollinated **crops** (**FAO**).
- In the **past 25** years, **40% of insect pollinators** face extinction due to habitat loss, temperature fluctuations, and pesticide use (**IBPES**).
- United Nations have declared 2021-2030 as **decade of ecosystem restoration**.
- Examining and addressing **pollinator decline** is crucial for the well-being of people and the global agricultural ecosystem.
- To accomplish this, understanding **plant-pollinator networks' dynamics** under **climate projection scenarios** is imperative, allowing evaluation of different restoration strategies for various climatic zones.

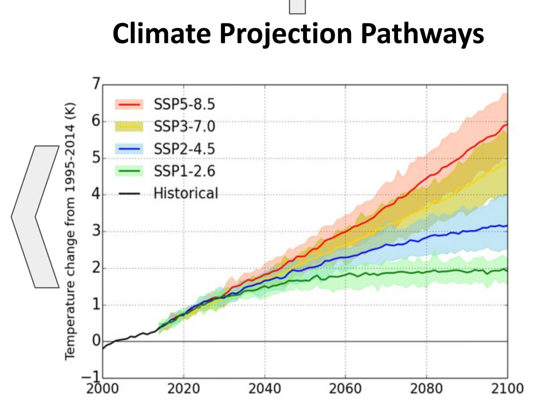


2. Research Overview









3. Scientific Questions

- How environmental degradation due to temperature rise will affect the plant-pollinator population and the dynamics of interdependent network?
- What would be the potential species abundance management strategy to delay the tipping point of the network and increase the abundance of species upto a stable state?

4. Governing Equation

Lotka - Volterra Equation with Hollins type II Functional Response:

Plants

$$\frac{dP_i}{dt} = P_i(\alpha_i^P(T) - \sum_{j=1}^{n} \beta_{ij}^P(T)P_j + \frac{\sum_{k=1}^{m} \gamma_{ik}^P A_k}{1 + h(T)\sum_{k=1}^{m} \gamma_{ik}^P A_k}) + \mu_P$$

Pollinators

$$\frac{dA_i}{dt} = A_i(\alpha_i^A(T) - \kappa_i^A(T) - \sum_{j=1}^{n} \beta_{ij}(T)^A A_j + \frac{\sum_{k=1}^{m} \gamma_{ik}^A P_k}{1 + h(T)\sum_{k=1}^{m} \gamma_{ik}^A P_k}) + \mu_A$$

$$\alpha_i(T) = \alpha_{\text{opt}}\, e^{-(T-T_0)^2/2\sigma_\alpha^2},$$

$$h(T) = h_{\text{opt}}\, e^{(T-T_0)^2/2\sigma_h^2},$$

$$\gamma_{ik} = \frac{\epsilon_{ik}\gamma_0}{K_i^t}$$

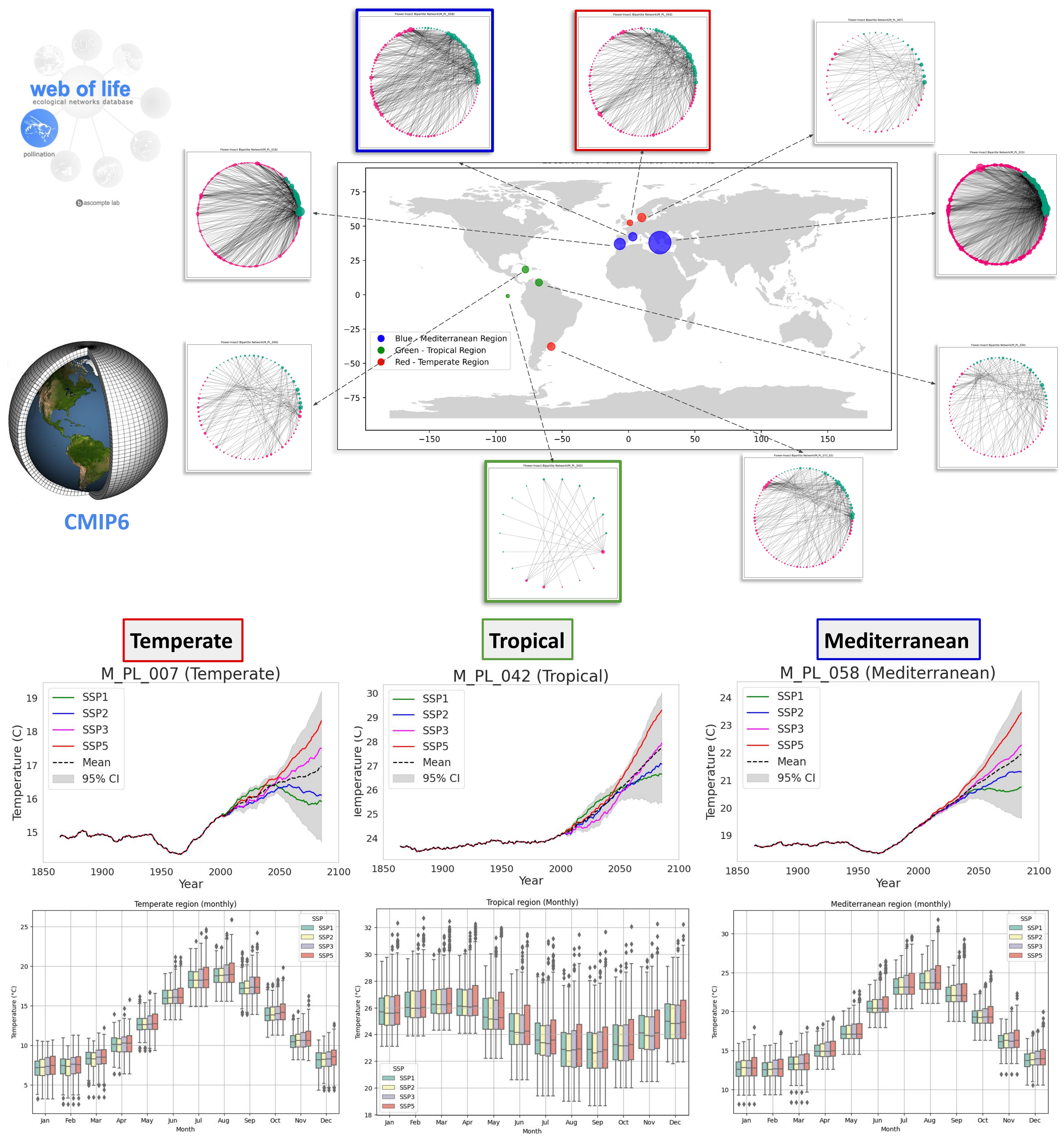
$$k_i(T) = K_{\text{opt}}\, e^{A_K(1/T_0-(1/T))}$$

$$\beta_i(T) = \beta_{opt}(i) \cdot e^{A_k(\frac{1}{T}-\frac{1}{T_0})}$$

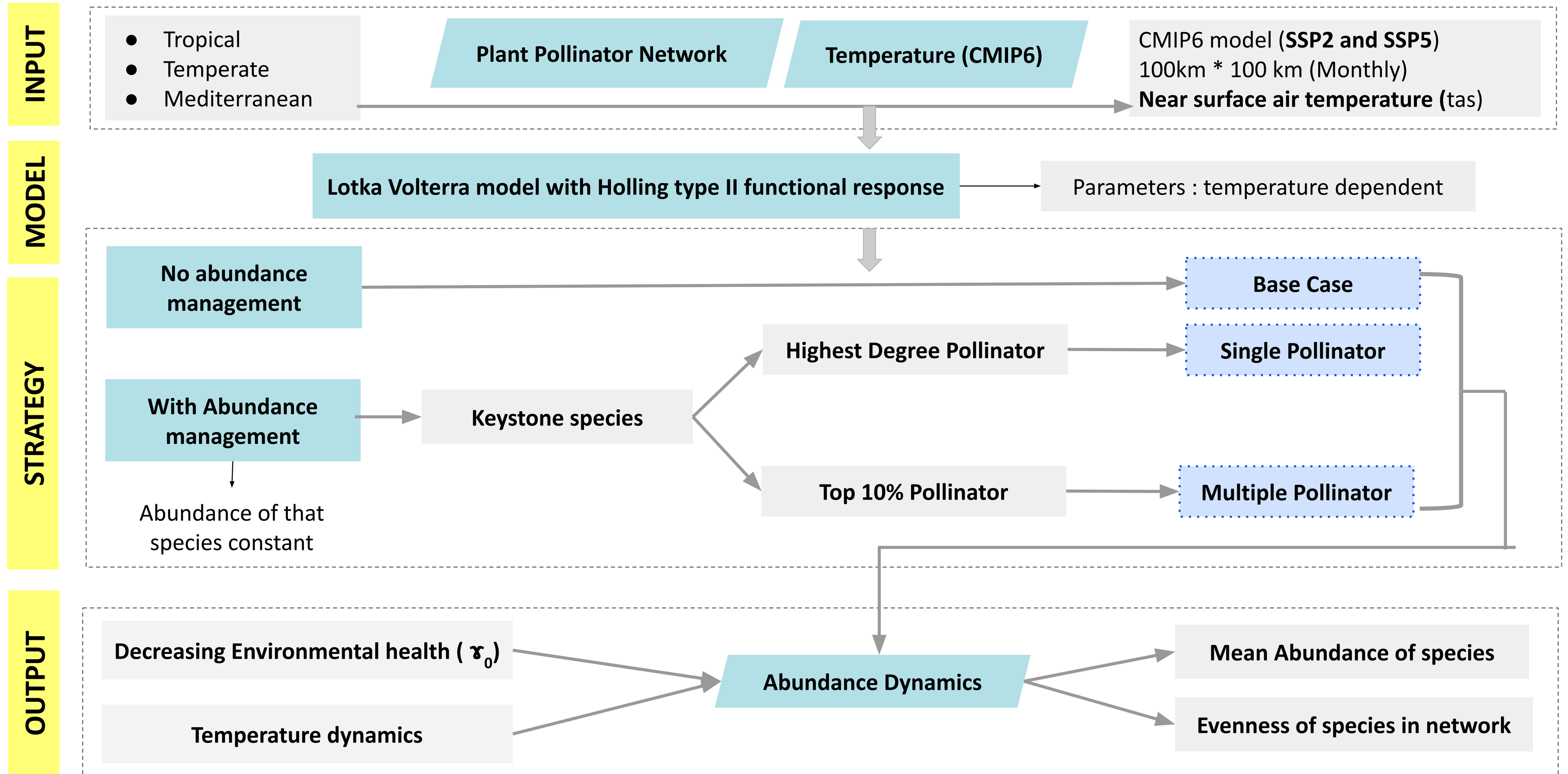
Parameters

- Intrinsic growth rate(α)
- Inter/Intraspecific competition(β)
- Mutualistic strength(γ_0)
- Decay rate(κ)
- Immigration(μ)
- Mutualistic connections(d_i)
- Trade off between degree and mutualistic strength(δ)
- Presence of interaction(ϵ)
- T= Temperature
- T_0= Optimum temperature
- α_{opt}, h_{opt}, k_{opt}, β_{opt}= performance at optimum temperature
- A_k = Arrhenius constant

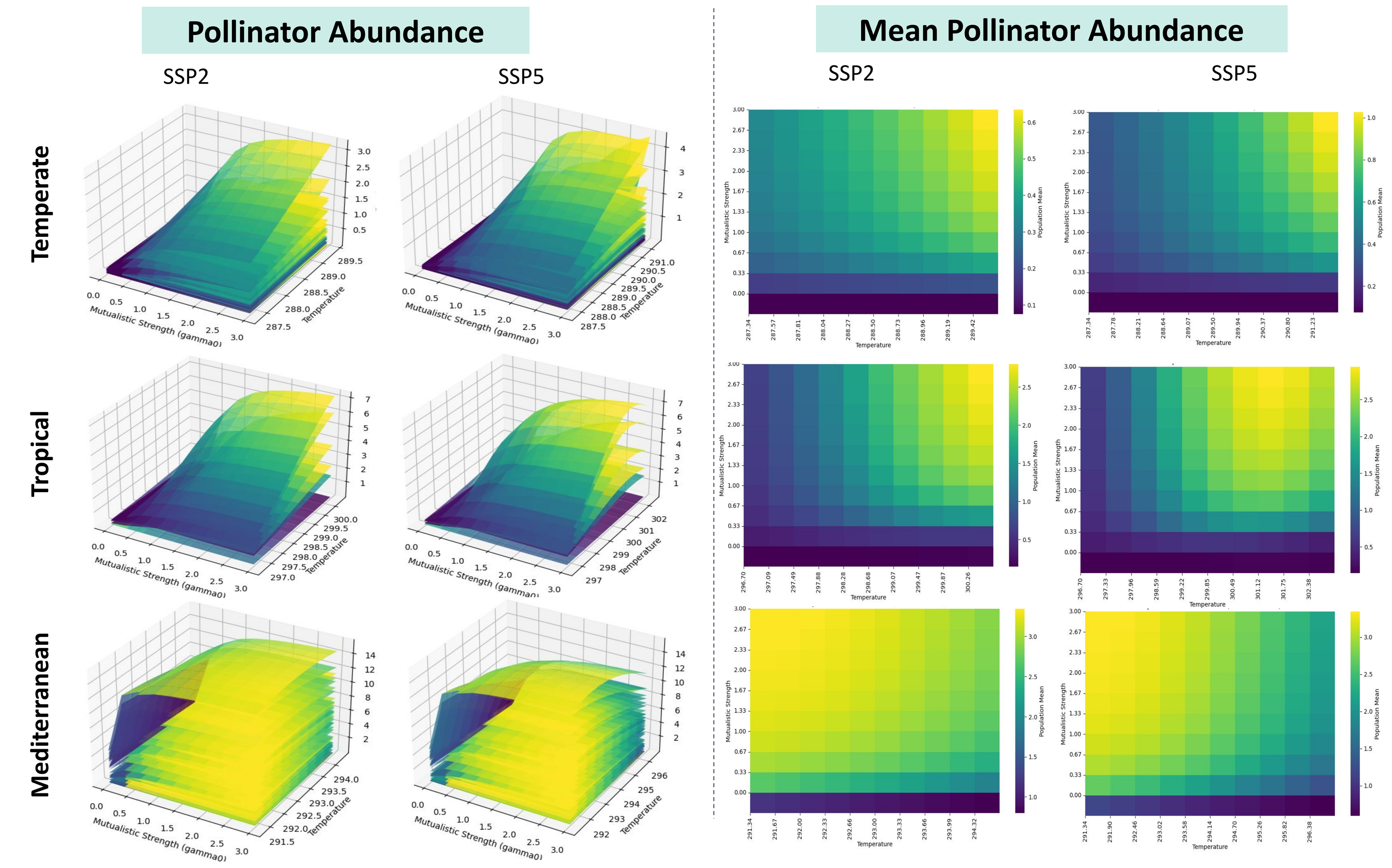
5. Study Area and Datasets

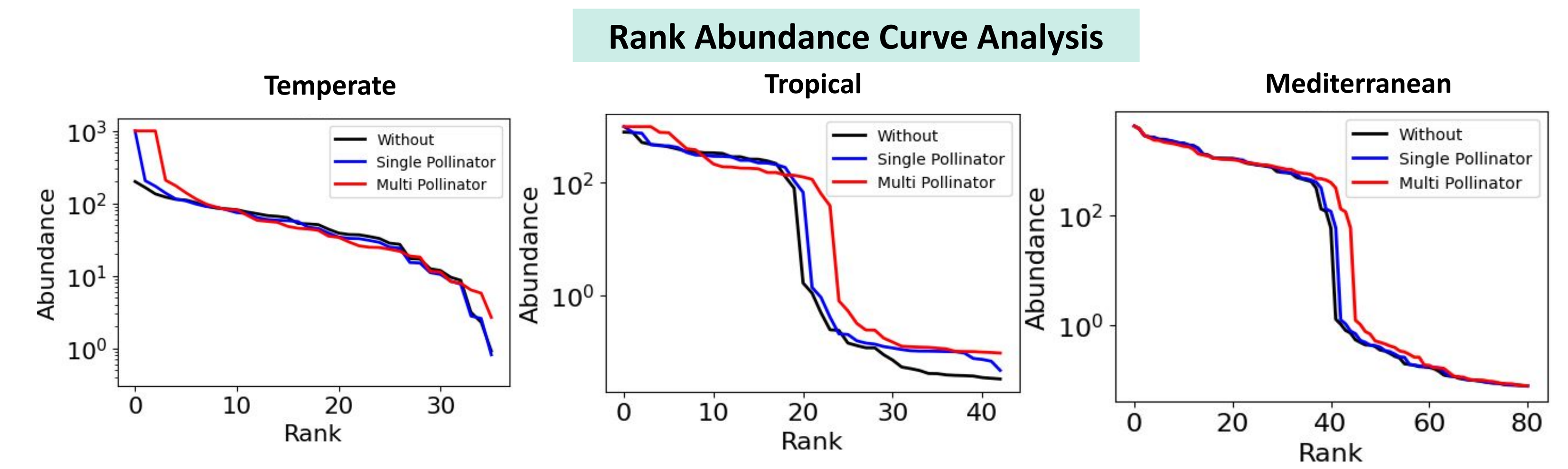


6. Methodology



7. Results





8. Conclusions

- Temperate areas see increased species abundance, while tropical and Mediterranean regions experience declines under certain socioeconomic pathways.
- In temperate zone, species abundance tends to exhibit greater evenness compared to Mediterranean and tropical regions, suggesting that tropical species might face higher vulnerability. Also, it indicates that strategies for species restoration need to be tailored to the specific abiotic conditions prevailing in each region.
- In temperate regions, managing multiple species in a network provides only marginal benefits, while in tropical regions, adopting a multi-pollinator management approach leads to higher evenness.

Future Scope:

- Dynamic abundance management strategies for tropical, mediterranean and temperate region.
- Analyzing the cost-effective optimization of various abundance management strategies can offer insights into which approach to prioritize, both ecologically and in terms of benefits.

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