## Introduction

Due to climate change, *Abies religiosa*, the safe haven for Monarch butterflies (MBBR), are being threatened in the near future.

- *Abies religiosa* is a fir tree that lives in high elevations in Mexico and thrives on the winter and spring rainfall since they are sensitive to droughts.
- Due to the lack of rain or an increase in temperature, it can eventually lead to a forest fire. This can cause the branches in these trees to thin, overall reducing the amount of *Abies religiosa* species in this area.
- The Monarch butterflies are attracted to these trees, especially during November to March due to the rainfall when the trees are at their best.
- However, if the branches are thinned, the tree cannot provide a shield of protection and could kill the butterflies.
- It is crucial to save these trees because Monarch butterflies usually migrate back to the same sites.

Researchers came up with the method to test *Abies religiosa* in four different sites based on elevation.

## Methods

Seeds

- Researchers collected *A. religiosa* seeds along 3100-3500 meters at 50 meter intervals. They then gave the seeds a sanctuary in order to receive the proper care, like providing sunlight and shade.

Test sites

- They conducted a test at four different locations and planted five to eight different populations at: 3400m, 3600m, 3800m, and 4000 meters.

Measurements

- Researchers measured plant height twice a month and plant diameter every six months. They also considered the plants survival and how that affects the competition of the seeds with other plant species, like shrubs.

Climate

- Precipitation was measured by capturing rainwater into rainwater traps per site. The temperature and precipitation at each site were both calculated to find the averaged and the monthly mean.

Data

- The study examines how differences in climate between the origin of tree seeds and planting sites affect tree growth, biomass, and survival.
- Using mixed effects models, researchers analyze fixed effects, like provenance climate, transfer distance, and their interaction along with random experimental design factors.
- Simplified models identified key climate variables, influencing traits which were refined into final models predicting tree performance under future climate scenarios.

These insights guide assisted migration strategies in sharing seed selection aligns with anticipated climate conditions to optimize forest growth and ecological benefits.

## Results

- Based on the researcher's equations, they found that as the *Abies religiosa* populations that were transferred further, into higher (colder) elevations, the seedling's survival decreased.
- The main factor that shaped the overall results depended on the site climate. For example, the furthest site, at 4000m, did not have any results due to frost damage. However, at 3400m, the seedlings ended up having the largest growth height.

## Discussion

- Since the seedlings were not able to survive in 4000m, researchers suggested if another trial occurred, to perform multiple tests per site.
- Survival was 68% along the 3800 meter mark, which indicates that Abies religiosa species is able to survive on the Nevado de Toluca volcano at that elevation. However, above that elevation, the species begins to die.
- The article mentions that other tests were done at the 4000 meter mark on the Nevado de Toluca volcano, such as *Senecio cinerarioides* and *B. conferta*, and both species had completely died at the specified elevation.
- Despite the Nevado de Toluca becoming the largest wintering colony for Monarch butterflies during 2023-2024, researchers predict that climate change will push the species to migrate to areas with climates resembling their original overwintering habitats.
- Slowly establishing *Abies religiosa* at higher elevations could be a viable and an important approach to providing overwintering sites for migratory Monarch butterflies in response to climate change