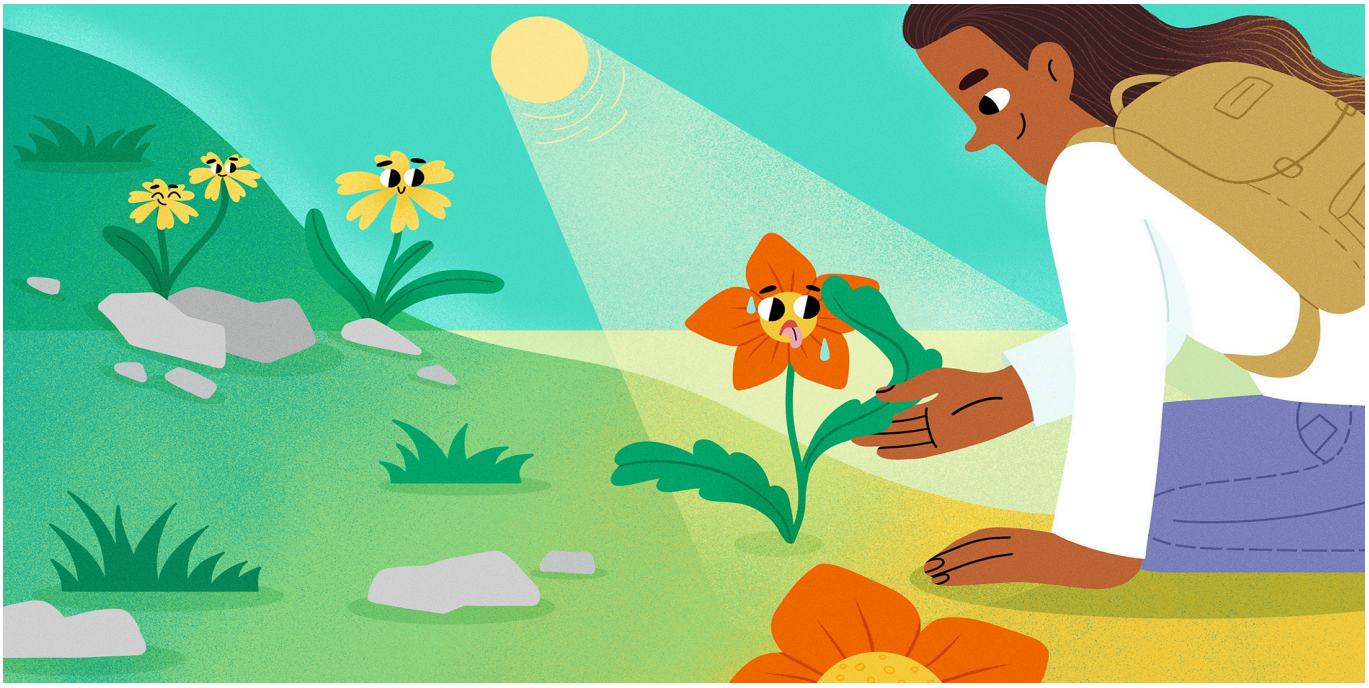
frontiers | Frontiers for Young Minds

BIODIVERSITY
Published: 17 May 2023
doi: 10.3389/frym.2023.947230



CAN PLANTS "MOVE" FAST ENOUGH TO ESCAPE CLIMATE CHANGE?

Laura Camila Pacheco-Riaño[1*], *Suzette G. A. Flantua*[1,2] *and John-Arvid Grytnes*[1]

[1] *Department of Biological Sciences, University of Bergen, Bergen, Norway*

[2] *Bjerknes Centre for Climate Research, University of Bergen, Bergen, Norway*

YOUNG REVIEWERS:

LUCIANA
AGE: 10

PARITHI
AGE: 10

What would you do if temperatures were getting really warm where you live? You might put on some lighter clothes or maybe even move to a cooler place. Many plants do something similar—they "move" to cooler areas to survive current climate warming. Of course, plants cannot move like animals do, but they can slowly change locations as they release their seeds. How do we know that plants are moving? Scientists are studying areas that were first described hundreds of years ago. However, ecologists have found that even though plants respond to warming by changing locations, the temperature increase is so fast that plants cannot always move fast enough to escape the warming climate. This means that some plants might end up living under much warmer conditions than they prefer, which causes them a lot of stress. Stress makes plants vulnerable to other human influences, like land use change or invasive species, which can put entire plant species in danger.

CLIMATE CHANGE'S IMPACT ON PLANTS DISTRIBUTION

DISTRIBUTION

The geographic area in which a species can be found.

The **distribution** of plant species on Earth is closely associated with aspects of the climate, such as the temperature or how much rain falls during the year. Plant species are adapted to the particular climate conditions in which they can best survive and reproduce [1]. As a result, the Earth has many unique ecosystems, such as forests, savannahs, or deserts, where specific plant species are adapted to a certain range of temperatures and rainfall. Some plants prefer cooler conditions, while others prefer the rainforest or the desert. How will climate change impact the distribution of plants around the world?

Earth's climate has changed over the planet's long history, but current climate change is different. Humans are now causing the planet to warm up, and this is happening much faster than in the past. The average global temperature has increased 0.85°C since 1880, and most of this change has happened in the last 30 years.

ALPINE

Alpine is a type of ecosystem found in mountainous regions, characterized by cold and snowy climates, high elevation, and rugged terrain. It is home to a variety of unique and specialized plant and animal species that have adapted to survive in the harsh conditions.

What would you do if it got too warm where you were living? You might put on some lighter clothes or possibly even move to a cooler place. Changing clothes is not an option for plants, so they are left with moving to a cooler place if they want to escape warming conditions. Let us go on an excursion to the mountaintops, to explore the **alpine** ecosystem. Here, we will find plant species adapted to freezing, snowy, and windy conditions. What can these plants do as the climate warms?

HOW DO WE KNOW THAT PLANTS ARE SHIFTING THEIR DISTRIBUTIONS?

SESSILE

Unable to move (like many animals can) from the place they are growing.

Plants have a major limitation when it comes to moving to cooler environments: they are **sessile** organisms, which means they cannot move from place to place like animals that can walk or swim. Instead, plants have developed unique ways of dispersing their seeds into the environment. This dispersal is mostly passive, meaning that seeds are transported away from the mother plant by animals, wind, or water. Most of this movement occurs over relatively short distances, like a few hundred meters. Long-distance dispersal of seeds over kilometers, or even tens or hundreds of kilometers, can also happen but it is rare, and it may take many years for such long-distance dispersal to occur. This slow way of "moving" is one way that plants can respond to climate change. Because this process is so slow, we must observe plants over decades or even longer to actually see changes in their distributions in response to climate change.

ECOLOGIST

A scientist who studies the relationships between living things and their environments.

Ecologists study changes in plant distribution by going to different ecosystems again and again over many years, and identifying all the plant species they see. They also measure the climate conditions to

assess how much the climate has changed. To ensure they always go back to the same area each year, they create what are called **permanent vegetation plots**—small pieces of land marked off so they can be identified (Figure 1). By examining the same plots year after year, ecologists can see which species disappear and which become more common. For some ecosystems, these studies have been done since 1920s [2]. Unfortunately, this kind of study costs a lot of money and takes many years, which is why we do not have much information about how current climate change threatens plants.

PERMANENT VEGETATION PLOT

A permanently marked area where all plant species are recorded and measured. The size can vary depending on the type of vegetation.

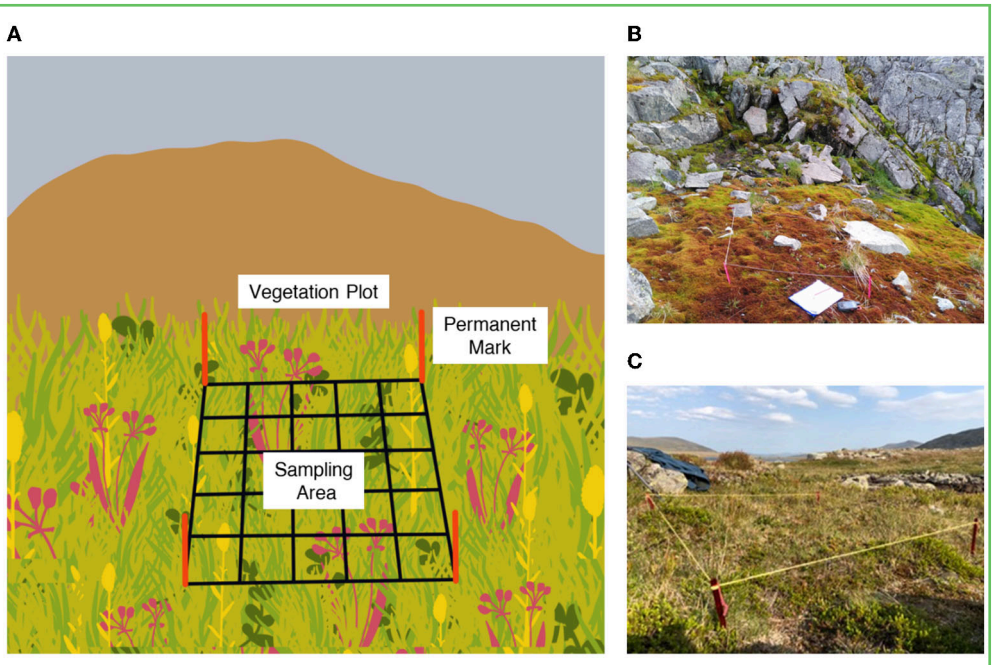


Figure 1

(A) A permanent vegetation plot in a field. **(B, C)** Permanent vegetation plots containing different types of vegetation, in mountain areas in Norway. Red sticks are used to mark the corners of the plots permanently, and to make them visible and easy to find each year (Photograph credits: Sophie Weides and Rosa Kramp).

BOTANIST

A scientist who studies plants.

Another way to study changes in the distribution of plants is to visit vegetation plots made by **botanists** many years ago. Unfortunately, we do not know exactly where these plots are located because the botanists did not mark them! Botanists of the past did not consider that such plots would be very valuable for understanding how plants and ecosystems respond to climate change in the future—because they were not yet aware of how the climate would change. Ecologists must look thoroughly at old books left by these botanists because some botanists added very careful descriptions of how to find the areas they studied. It is like following a map on a treasure hunt! With these old books and sometimes with the help of old maps, ecologists can go back to these historical places, to see which plant species are there now.

For example, in the 18th century, an adventurer called Alexander von Humboldt and his crew went on a very long expedition through the mountains of Central and South America. This trip took them 38 months! Their aim was to describe the plant species in the region, because they were the first botanists to visit. Humboldt found many

plant species that had never been identified before. They wrote down the information on where the plants were found, and luckily those books still exist today. In 2012, by following von Humboldt's footsteps, a group of ecologists went to the same mountains and visited the same places as von Humboldt did. This group compared their species list with the list that von Humboldt made. They found that, today, plants are living at higher elevations than they used to 200 years ago (Figure 2) [3]. This means that plants are moving higher up into the mountains. The same trend has also been found in Europe and North America [4].

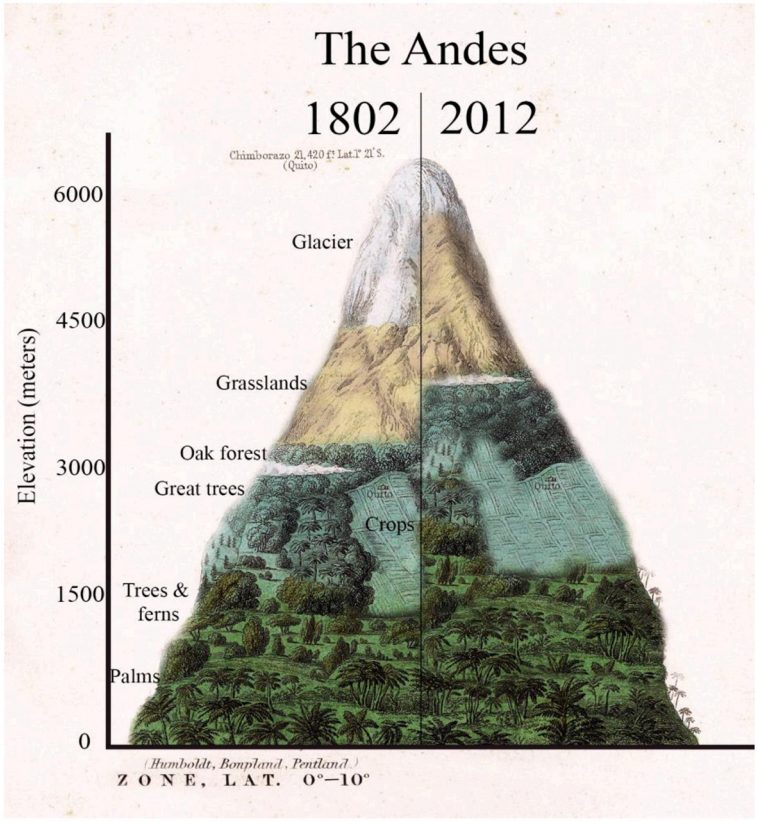


Figure 2

The vegetation zones of the Andes mountains. The left side shows the first edition of Alexander von Humboldt's drawing, based on his studies in the 18th century [6]. The right side shows a representation of the same vegetation zones in 2012. Notice how plants have moved to higher elevations on the mountain as the climate has warmed (Original Source here).

The scientific literature contains a lot of information on where various plant species are found. Just like von Humboldt did 200 years ago, botanists today also describe where plants are. Information about millions of vegetation plots can be found in scientific publications [2]. In Europe alone, there is information on more than 4.3 million vegetation plots [5]. Together, all this information helps ecologists understand how plants respond to climate change.

PLANTS ARE FINDING NEW PLACES TO PUT DOWN ROOTS

The information from permanent and historical plots tells us that climate change is causing plant species to change their distributions.

We see that many plants are trying to escape the warming areas by moving toward the north and south poles, and also by moving higher up toward mountain tops [4]. This is because lower latitudes (closer to the tropics) and lower elevations usually have warmer temperatures.

A telling example was provided by a group of European ecologists who visited European mountain tops that had been studied by botanists a 100 years ago. The European ecologists discovered that almost all the mountain tops visited had many more species today than they did before climate warming started. They also found a larger increase in number of species on mountains where the temperature had increased the most (Figure 3A) [7]. This indicates that the changes in plant distribution that we observe are caused by climate warming.

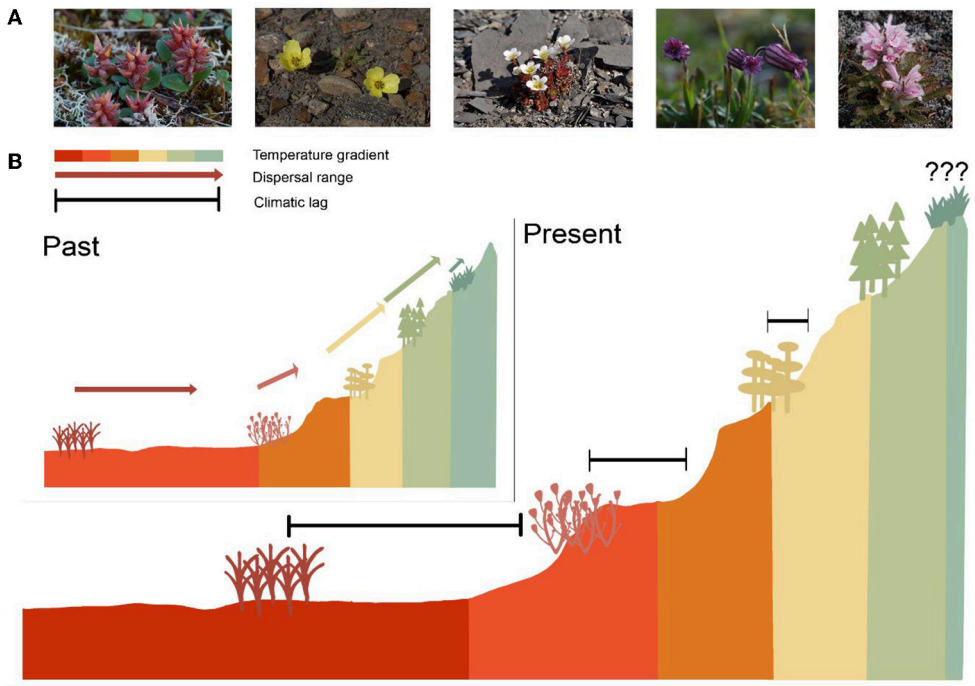


Figure 3

Figure 3

(A) Examples of plant species found on the Norwegian mountain tops when historical plots were restudied [7]. From left to right: polar willow, Svalbard poppy, tufted saxifrage, apetalous catchfly, and arctic hairy lousewort. **(B)** Warm areas are shown in red and cold areas in green. Arrows show the distance the species can disperse. Thick black lines show the climatic lag—the mismatch between the temperature to which the plants are adapted (Past) and the new temperatures due to climate change (Present). Line size indicates the distances plants must migrate to stay within their preferred temperatures.

This tells us that plants that prefer warm temperatures can now move to regions that were previously too cold for them [8]. This all sounds good...but considering that there is not much space on mountain tops, and we are seeing more and more plant species moving upwards, species might be running out of space! We are not completely sure what will happen, as we have not witnessed anything like this before—but it is likely that some of today's plant species that only live in high mountain areas will disappear in the future because they will have nowhere to go when the climate warms further (Figure 3B).

CLIMATE CHANGE IS PUTTING PLANTS IN A TOUGH SPOT

CLIMATIC LAG

A mismatch between the observed speed of climate change and the slower speed at which species are responding to climate change.

Ecologists have observed that even though plants can respond to climate warming by changing their distributions, the temperature increase is often too fast for the plants to keep up. This could mean that plants will not have enough time to disperse before temperatures get too warm for them. This is called **climatic lag**, and it causes plants to live in places where the temperature is not the best for their survival and reproduction (Figure 3B) [8]. Imagine if you could not adjust the heater in your room during the summer, and you could not open any windows or doors!

There may be several reasons for the climatic lags we observe in plant responses. First, plant species must disperse long distances to reach the areas where they prefer to live, and this is often a big challenge for sessile organisms [8]. Second, even if plants can successfully move to the climates they are more comfortable in, there might be additional challenges in the new area, including other environmental conditions that make it difficult for the plants to grow. For example, sometimes there is not enough water, or the soil does not have the nutrients that the plants need [8]. Another problem is the amount of available space. Humans have destroyed many natural areas to use them for agriculture, factories and businesses, as well as cities. Because some plants cannot grow in such areas, they may need to disperse even further to find an ideal place to survive.

One of the biggest problems caused by climatic lag is that many plants might be living in temperatures that are extremely close to the maximum they can tolerate. When temperatures in these regions become too warm, many plants may not survive. At this point, we still do not know how many species are living in such precarious conditions.

CONCLUSIONS

Changes in the distribution of plants are happening more frequently as the climate warms. Ecologists need data that covers a long time period, to understand how plants have responded to past global warming events and to predict how they might respond to future warming. For this reason, ecologists and botanists are still studying the fundamental processes of plant distribution, to better understand how vulnerable plants—and entire ecosystems—are to climate change.

Unfortunately, we cannot help plants face climate change because there is still much, we do not understand about natural processes. But we can all take steps to help! First, we should all keep learning as much as we can about how ecosystems normally function and how climate

change is affecting ecosystems and individual plant species. Second, we should help to keep natural habitats intact, so that plants and animals are not threatened by habitat destruction. We can organize trips to explore national parks and nature reserves near where we live, or we can participate in nature-focused citizen science initiatives. All of these activities will increase our awareness and build knowledge about the distribution of local species so that we can best help plants survive as the Earth warms.

ACKNOWLEDGMENTS

SF was supported by the European Research Council under the EU Horizon 2020 Research and Innovation Programme (grant 741413, Humans on Planet Earth- Long- term impacts on biosphere dynamics), by the TMS- Starting Grant Program funded by Trond Mohn Stiftelse (TMS) and University of Bergen (TMS2022STG03).

REFERENCES

1. Pulliam, H. R. 2000. On the relationship between niche and distribution. *Ecol Lett*. 3:349–61. doi: 10.1046/j.1461-0248.2000.00143.x
2. Dengler, J., Jansen, F., Glöckler, F., Peet, R. K., de Cáceres, M., Chytrý M., et al. 2011. The Global Index of Vegetation-Plot Databases (GIVD): a new resource for vegetation science. *J. Veg. Sci*. 22:582–97. doi: 10.1111/j.1654-1103.2011.01265.x
3. Morueta-Holme, N., Engemann, K., Sandoval-Acuña, P., Jonas, J. D., Segnitz, R. M., and Svenning, J. C. 2015. Strong upslope shifts in Chimborazo's vegetation over two centuries since Humboldt. *Proc. Natl. Acad. Sci. U. S. A*. 112:12741–5. doi: 10.1073/pnas.1509938112
4. Lenoir, J., and Svenning, J. C. 2015. Climate-related range shifts - a global multidimensional synthesis and new research directions. *Ecography* 38:15–28. doi: 10.1111/ecog.00967
5. Schaminee, J. H. J., Hennekens, S. M., Chytry, M., and Rodwell, J. S. 2009. Vegetation-plot data and databases in Europe: an overview. *Preslia* 81:173–85.
6. Johnston, A., Brewster, D., and Berghaus, H. K. 1848. *The Physical Atlas: A Series of Maps and Notes Illustrating the Geographical Distribution of Natural Phenomena*. First. Edinburgh: William Blackwood and Sons. Phutology No. 1. Available online at: https://www.davidrumsey.com/luna/servlet/detail/RUMSEY~8~1~308070~90077931:Geographical-Distribution-of-Plants (accessed February 22, 2023).
7. Steinbauer, M. J., Grytnes, J.-A., Jurasinski, G., Kulonen, A., Lenoir, J., Pauli, H., et al. 2018. Accelerated increase in plant species richness on mountain summits is linked to warming. *Nature* 556:231–4. doi: 10.1038/s41586-018-0005-6
8. Svenning, J. C., and Sandel, B. 2013. Disequilibrium vegetation dynamics under future climate change. *Am. J. Bot*. 100:1266–86. doi: 10.3732/ajb.1200469

SUBMITTED: 18 May 2022; **ACCEPTED:** 26 April 2023;
PUBLISHED ONLINE: 17 May 2023.

EDITOR: Nathan M. Good, University of California, Berkeley, United States

SCIENCE MENTORS: Maria Claudia Segovia-Salcedo and R. Arthee

CITATION: Pacheco-Riaño LC, Flantua SGA and Grytnes J-A (2023) Can Plants "Move" Fast Enough to Escape Climate Change? Front. Young Minds 11:947230. doi: 10.3389/frym.2023.947230

CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

LUCIANA, AGE: 10
I was born in Quito, Ecuador. My city has big mountains around it and is located in the belly button of the world. Since I was little, I have loved plants and animals, especially insects like butterflies, stick insects, cicada and others. I really enjoy collecting bugs and plants during my trekking trips with my parents and I love making drawings of them. Also I love the beach and I try to clean it every time I visit. In the future, I hope to become an animal rescuer.

PARITHI, AGE: 10
I like insects and lizards. I also like to keep on learning about the physics of ecosystems.

AUTHORS

LAURA CAMILA PACHECO-RIAÑO
L. Camila Pacheco Riaño is an ecology Ph.D. student and biogeographer currently studying biodiversity lag responses to climate change in the mountains. She loves to hike in the mountains and learn new things. *pachecoriano.c@gmail.com

SUZETTE G. A. FLANTUA

Suzette Flantua is a global change ecologist, and she studies why some mountains around the world have more species than others. Also, she likes looking into climate change over thousands and thousands of years, to see how plants and birds have responded to changes in the past.

JOHN-ARVID GRYTNES

John-Arvid Grytnes is a professor of vegetation ecology and likes very much to study vegetation in mountain (alpine) areas. Because climate is an important factor for plants, the effects of global warming on alpine vegetation have become a major topic of his research.