Climate change is altering the seasonal rhythm of plant life-cycle events

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Credit: AI-generated image (disclaimer)

"*Si sta come d'autunno sugli alberi le foglie.*"

"We are like autumn leaves on branches," Italian poet Giuseppe Ungaretti wrote in his 1918 poem *Soldati* (Soldiers), on the tragedy of human life and war.

If the popular image of autumn is decadence and nostalgia after the summer heat, spring is the season of rebirth after the darkness and cold of winter. The transformative passing of seasons has historically represented a powerful mental image, rich in symbolism. The seasonal timings of biological events are also an essential aspect of plant adaptation and can also be of crucial economic relevance.

However, as forest ecologists, we have observed that climate change has been modifying the timing of recurrent plant life-cycle events, thus critically affecting the ecosystem.

The plant's clock

In spring, flowers bloom. In summer, fruits ripen. In autumn, leaves change colour and fall. In winter, plants rest. This is phenology—the study of the timing of recurring life-cycle events.

So how do plants recognize the passage of time and the right moment to accomplish growth and reproduction? Like people, plants have their own calendar. A plant's clock is represented by cycles in the environmental conditions, and the timing of phenological events is controlled by climate .

Specifically, plants use a set of triggers to synchronize the timings of growth and reproduction with favourable environmental conditions.

Depending on the species, phenological events are triggered by temperature (autumn and winter chilling and spring warming), photoperiod (length of day), precipitation or, often, a combination of these.

If climate changes, phenology changes

Phenology is one of the most sensitive biological indicators of the changing climate. Under the progressive rise in temperature experienced in the last century and the variations in seasonal distribution of rainfall events, the environmental triggers usually occur earlier and earlier.

This is why phenological shifts have been observed worldwide, and contextually, it seems that phenological events are occuring earlier year by year.

Japan's *Sakura* or cherry blossom season is one of the most evident proofs of this shift. Dating back to the ninth century, the date of flowering, which defines the festival's timing, has been anticipated in the last century by the rise in average temperatures.

What is the problem? Spring is cool, right?

American poet Anne Bradstreet said, "If we had no winter, the spring would not be so pleasant." While this is hyperbolic, we still need to consider that the timings of flowers blooming, fruits ripening and other such phenological events result from a long-lasting adaptation of each species to its surrounding environment.

The timing of phenological events are calibrated to ensure the perfect environmental condition needed to accomplish the annual cycles of a plant's life while minimizing the risk of damage. Changes in these conditions can have ecological as well as economic consequences as they can affect the quantity and quality of agriculture and forestry products.

At the end of the growing season, plants develop dormant buds to protect the sensitive meristematic cell layer—tissue in which cells maintain the ability to divide throughout the life of the plant—and suspend activity. Dormancy is an adaptation mechanism evolved in climates with seasons to escape harsh winter conditions.

Warm spring temperatures (called forcing), the increase in day length during spring (photoperiod), and the length and intensity of winter temperatures (chilling) reactivate the growth of the apical buds—the buds located at the top of the plant—in the spring. Clearly, temperature has a central and leading role in this process. For this reason, warming can trigger an earlier reactivation in spring and a delayed cessation in autumn, or both, lengthening the growing season.

Some believe that a longer growing season could enhance carbon uptake and, therefore, the productivity of forests. In some places, such as regions in the northern latitudes or elevated altitudes, trees have profited from a longer growing season and, more generally, more favourable climatic conditions under global warming.

However, an earlier growth reactivation increases the risk of damage due to late spring frosts, and lengthening of the growing season increases the risk of damage by early autumn frosts.

If trees cannot adapt, or re-adapt, their phenology with the new climatic conditions, the fitness and growth performance of local populations could be dramatically affected.

If phenology changes, species interaction changes

Ecosystems are generally complex and the species within them interact with each other as well as their surrounding environment. Different species can react differently to the changing climatic conditions, potentially leading to dangerous new phenological matches or mismatches.

For example, current climatic conditions create new phenological matches between prey and predators. Black spruce may become a key host for the spruce budworm given that the timing of maximum larvae

activity could be better synchonized with the timing of yearly shoots development, which increases the risk of severe defoliations for one of the most profitable boreal species in North America.

Climate change can also cause mismatches between plants and their pollinators. Bumblebees represent one of the most important pollinators for several wild species and many varieties of enormous agricultural interest. Bumblebees, given their low heat and cold tolerance, are particularly sensitive to environmental conditions. For this reason, the projected climatic risk for this species is extremely high.

The mutually beneficial plant-pollinator relationship is an essential ecosystem service, specially considering that the pollination done by insects contributes to 9.5 percent of global food production.

Action must be taken

As the climate continues to change, affecting all kinds of ecosystems in the process, we need to be aware of plant phenology and think about how these shifts may directly affect our lives and businesses.

Scientists, today, use observational data to determine how species, populations and communities are vulnerable to these ongoing and projected future changes in climate. This research can be the foundation for essential human intervention, which may influence plant distribution through assisted migration, which is the human-assisted movement of species to areas far outside their established range. This will help tree species resynchronize their phenology to the current climatic condition.

Plant phenology is the result of an adaptation. However, adaptation requires time, an amount of time we do not have given the magnitude and rate at which we are observing climate changes. Constantly monitoring the phenological shifts worldwide will allow us to develop

sound strategies to protect the most vulnerable ecosystems as well as our businesses.

Besides, we are like autumn leaves on branches, but at least we should try not to fall!

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