Early green, early brown: Climate change leads to earlier senescence in alpine plants

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Alpine plants that start to grow earlier also start to age earlier. As is the case with the alpine vegetation in these containers, which were exposed to summer weather several months before the snow melted (photograph taken in July). Credit: Patrick Möhl, University of Basel

Global warming is leading to longer growing seasons worldwide, with

many plants growing earlier in spring and continuing longer in autumn thanks to warmer temperatures. Now, however, plant ecologists at the University of Basel have been able to show that this is not the case for the most common type of alpine grassland in the European Alps, where an earlier start leads to earlier aging and leaves the grassland brown for months.

Spring 2022 was extremely warm, giving many plants an early start to the growing season. And the Swiss Alps were no exception, with the snow cover melting early and the underlying vegetation being quickly roused into growth. Researchers at the Department of Environmental Sciences at the University of Basel have investigated how such an early start affects the plants' further development.

For their study, they removed intact blocks of alpine grassland and placed them in walk-in climate chambers at Basel's Botanical Institute. Here, they left the vegetation to overwinter artificially in cold darkness, and then switched some of the blocks to summer conditions in February.

A second group was left in the cold dark until April, before summer was introduced here as well. The researchers compared the growth and aging of these plants with their neighbors growing naturally at an elevation of 2,500 meters, which did not emerge from the snow until late June.

A predetermined program

The study, published in *Nature Communications*, shows how the majority of these alpine plants stopped growing and began the aging process after around five to seven weeks, regardless of when they had been roused.

"We were amazed at how stubbornly the dominant plant species, an alpine sedge, started aging and turned brown after just a few weeks," says Dr. Erika Hiltbrunner, a scientist in Professor Ansgar Kahmen's

research group at the University of Basel and head of the Alpine Research Station ALPFOR on the Furka Pass.

Once the snow had melted at the end of June, the blocks were returned to their alpine location.

"By the time the natural vegetation was in full growth, the plants with the earliest start to the season had already turned brown," adds doctoral student Patrick Möhl. A period of growth and aging with a predetermined length is advantageous in an alpine environment with a very short growing season. This autonomous control mechanism prevents the plants from remaining active any longer than this, even if the weather is exceptionally favorable. Winter, with its freezing temperatures and snowfall, can set in at any time from August onward.

In addition to leaf growth and the "greening" of the vegetation, the researchers also studied root growth. They regularly inserted a digital camera into clear tubes below the ground to scan the root system with high precision. A new machine-learning algorithm detects the roots in the images, and traces the otherwise hidden root growth in high resolution. The analysis revealed that the growth dynamics of the roots followed that of the leaves: root growth diminished after the initial two months, despite ongoing warm root temperatures.

Brown alpine grasslands in summer

A few plant species remained longer active under favorable conditions, meaning that their internal clock is less strictly fixed to a certain length of the growing season. Such species could potentially become more common in the future, and displace today's dominant species.

However, changes in the species composition of closed, alpine grasslands are likely to take decades or longer. Alpine grassland species reproduce

primarily by vegetative means (clonally) and produce genetically identical relatives, which slows down the process of adapting to new environmental conditions through genetic change.

In addition, the alpine sedge (Carex curvula) forms an extremely dense root system that leaves little space for shifts in species composition. As long as the existing vegetation is not displaced by more flexible species, alpine grasslands will therefore appear increasingly brown even in summer.

More information: Patrick Möhl et al, Growth of alpine grassland will start and stop earlier under climate warming, *Nature Communications* (2022). DOI: 10.1038/s41467-022-35194-5

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