frontiers | Frontiers for Young Minds

BIODIVERSITY
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WHEN MEDITERRANEAN PLANT DIVERSITY PROFITS FROM WILDFIRES

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YOUNG REVIEWERS:

DEBASISH
AGE: 15

SHREEYA
AGE: 11

SHRIYA
AGE: 13

In summer, TV and newspapers often broadcast impressive views of wildfires in Mediterranean forests. These fires are commonly seen as threats to people, their homes, and their property. However, what if wildfires are necessary to sustain the health of some forest plants? Might some plants even *need* wildfires? Scientists studied this strange issue by examining the types and amounts of plant species that exist after wildfires. The results were surprising. The highest biodiversity of flowering plants in the forest was found right after a wildfire. The older the forest, the more trees grow and prevent smaller plants from surviving. Trees could prevent the growth of flowering plants through competition for resources, including light, water, and nutrients. These results make it possible to come up with solutions

that will allow forests to maintain high levels of plant biodiversity while still protecting humans from the threat of wildfires.

MIGHT WILDFIRES BE USEFUL?

Imagine that you are walking through a hilly Mediterranean forest in summer, surrounded by valleys containing vineyards. Flames suddenly appear, progressing quickly and destroying everything in their path! Firefighters struggle to put out the flames. Forests of this type occur in Mediterranean France, Spain, Portugal, Greece, Israel, California, Chile, and Australia. These regions share similar climates and vegetation and are characterized by hot, dry summers that often favor wildfires. Wildfires are known threats to people, their belongings, and their homes. These fires can also release **greenhouse gases** and polluting soot particles.

But what if this burning is also *useful* for forests? Is it possible that forests might *need* wildfires? Today, wildfires are generally caused by humans, either accidentally or as a criminal act. But for millions of years, well before the first humans, wildfires were naturally started by lightning [1]. Unlike many animals, plants cannot escape the flames of wildfires. If wildfires destroy everything in their paths, do they leave a lifeless, desolate landscape behind them? Will the plants bloom again, and will the trees grow back? Can the forest **ecosystem** recover from fire? Scientists answered these questions by studying how Mediterranean vegetation recovers after wildfires.

STUDYING A FOREST'S RESPONSE TO WILDFIRE

Observing a burnt forest until tall, old trees return is time consuming—the regrowth process takes 100 years, at least. A solution is to study forests that burned on different dates, and therefore are each at a different stage since the last fire—some young, some middle-aged, and some older [2].

To estimate the number of plant **species** (known as richness) in the forest **understory** and their abundance (which together are known as **biodiversity**), the scientists put large frames over certain areas of the forest floor (Figure 1A). Then they identified and noted the plants present in the frames (Figures 1B,C). Once back in the laboratory, they transferred the list of species and their abundances to a computer to make complex calculations of biodiversity (Figure 1D).

To know the ages of the forests, scientists used two methods (Figure 2). If the wildfire happened after 1970, scientists looked up its date in public records. When wildfire happened before 1970, scientists measured the ages of the oldest Aleppo pines [3]. Because most of

GREENHOUSE GASES

Gases that prevent heat from escaping into space. The most relevant greenhouse gases are water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

ECOSYSTEM

An ecosystem contains a specific set of organisms adapted to the biological, physical, chemical, and geological characteristics of a region.

SPECIES

A group of organisms that can reproduce with each other and produce fertile offspring.

UNDERSTORY

Herbs, flowering plants, shrubs, and small trees growing in forest under the canopy.

BIODIVERSITY

The number of species that exist in an ecosystem. The more species, the more biodiverse the ecosystem.

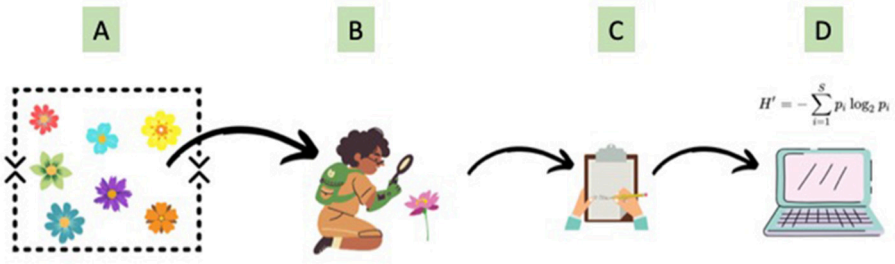

Figure 1

Method used to assess plant biodiversity in forests. **(A)** Scientists place frames over a given area on the ground. **(B,C)** The plants present in each frame are identified, counted, and carefully noted. **(D)** The information collected in the forest is transferred to a computer for calculations of biodiversity.

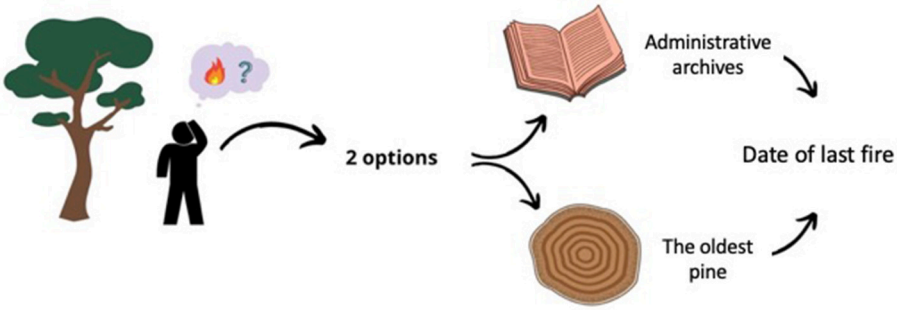

Figure 2

Scientists use two methods to determine the date of a past wildfire. If the fire happened after 1970, then its date and location were noted by firemen or foresters and this information can be found in administrative records available online. If the fire happened before 1970, the date is obtained by dating the oldest trees, based on counting the tree-rings. Samples of the wood are removed from surviving trees with a device like a huge syringe. If a trunk has 75 tree-rings, it is thus 75 years old.

these pines started growing after a wildfire, counting the **tree-rings** of these pines could be used to estimate the wildfire date ([4]; Figure 2). As mentioned, forests take a long time to recover after wildfires. Tall trees take more than 100 years to mature. The return of the forest occurs in several steps (Figure 3).

THE EARLY STAGES: 0 TO 20 YEARS AFTER A WILDFIRE

Right after a wildfire, most plants are burned or scorched, and the ground is covered with charcoal and ashes. Few tall trees survive, usually only those located at the edges of the fire. One or 2 years later, we can observe many species of herbs, flowering plants, and shrubs. Species are much more numerous than before the wildfire! How can fire result in such high species richness?

Actually, wildfires do not suppress plants. Below the ground, there are many seeds, roots, stems, and bulbs that were protected from the fire's heat thanks to the insulating properties of the soil. These dormant plants benefit from the death of the trees that previously captured the light crucial for the growth of smaller plants. The newly growing plants no longer have to compete with trees for the first rain that falls after the fire, and they also benefit from the ashes, which contain many nutrients. Removing the tree **canopy** allows more light to reach the ground, so plants can germinate, grow, and flower profusely. Thus, when the forest is young, the most resources can be gathered, which makes plant species richness the highest.

TREE-RING

The combination of a darker and lighter ring in a tree trunk represents a single year's growth.

CANOPY

The upper layer of a forest, mainly composed of the foliage and branches of dominant trees.

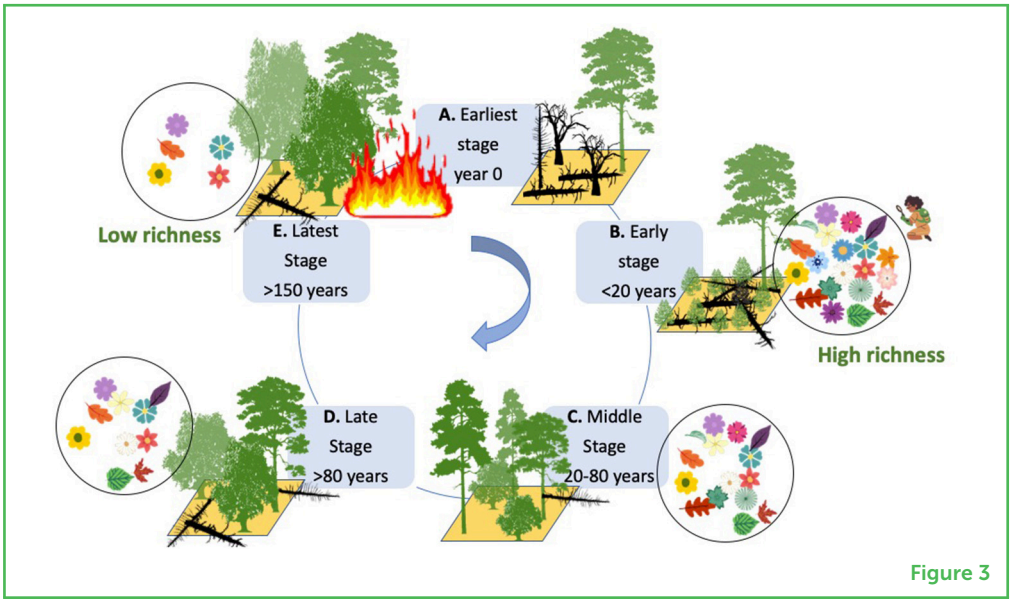

Figure 3

Figure 3

Changes in plant richness after a wildfire. **(A)** Wildfires result in the death of most trees, shrubs, herbs, and flowering plants, leaving ashes and charcoal. **(B)** Aleppo pines germinate abundantly; oaks resprout from burned stumps; plant richness is the highest. **(C)** Pines have grown to dominate the canopy; the understory contains small oaks, shrubs, herbs, and flowering plants; biodiversity remains high but is starting to decrease. **(D)** Oaks become more dominant; plant richness has significantly decreased. **(E)** Oaks dominate the canopy; plant richness is at its lowest since the fire; very few plants and trees can germinate.

RESPROUTING

A mechanism by which woody plants (shrubs and trees) regenerate after a wildfire by producing new stems.

Early after a wildfire, we found small plants like thyme, rosemary, cistus, euphorbias, and orchids, as well as seedlings of Aleppo pines, mixed with grasses. These seedlings grew from seeds released by Aleppo pines that survived on the edges of the wildfires. In 15 years, the Aleppo pines will grow taller than the average human adult. Other trees and shrubs, like oaks, maples, Saint Lucie cherries, and pistachios, produce vigorous new stems from scorched stumps in a process called **resprouting**.

THE MIDDLE STAGES: 20 TO 80 YEARS AFTER A WILDFIRE

After 30 years, pines dominate the understory. Some pines are as tall as a house, and their canopies capture most of the sunlight. Belowground, the roots of Aleppo pines take up so much water and nutrients that it is difficult for other plants to stay alive—the competition from trees is too strong for many understory plants. The most competitive plants survive while the others perish.

Under the pine canopy, we found two species of oak trees, the white oak (which loses its leaves each autumn) and the holly oak (which is evergreen). These oaks remained smaller than the pines even though they regrew immediately from scorched stumps or trees. They grow slowly because they exist in the shadow of pines and therefore get less light.

LATE STAGES: 80 TO 130 YEARS AFTER A WILDFIRE

The story of oaks and pine is similar to that of the tortoise and the hare. The pine is like the hare because it grows rapidly and dominates

the early forest stages. The oak is like the tortoise, taking time to grow but finally taking over. Aleppo pines do not live for long, often due to fungi that rot their trunks. As the pines die, the oaks' competition is reduced. Oaks ultimately dominate the canopy about 100 years after a wildfire.

The foliage of oaks, especially holly oaks, is like an umbrella that captures most of the light and creates a dark shadow that prevents the growth of more pines. Oaks also have efficient root systems that are good at finding water, even during drought. Competition with oaks is too much for most understory plants—at this stage, there are few species able to grow in the understory. Thus, in old oak forests, the number of plant species is the lowest. Interestingly, most plants growing in the understory of late-stage forests were also present in the earliest stage. The plants that disappeared are still present under the soil, in the form of seeds, bulbs, roots, and stems. These plants are waiting for a new wildfire event to germinate and grow.

HOW CAN WE HELP FORESTS REMAIN DIVERSIFIED?

So, we have seen that wildfires allow many plants to germinate or grow—plants that are inhibited or outcompeted in old forests. Thus, wildfires in Mediterranean forests are useful for plant species richness and growth. But wildfires are also dangerous for people, their homes, and their possessions. So how do we balance the need to protect humans with the need to preserve forest biodiversity and its associated benefits? For instance, pollinator insects like bees are favored by wildfires [5], thanks to the species richness of flowering plants a few years after the fire. One solution could be to let wildfires spread spontaneously in areas where there are no humans and where burning can help forest biodiversity.

Remember that fire is a natural process in fire-prone ecosystems like in Mediterranean climate regions worldwide. Species and ecosystems have co-evolved with fires and many species exhibit traits that make them able to cope with fires, such as trees that reproduce early; methods to protect seeds and stems from burning, like thick bark and the ability to resprout from stumps or roots, or rapid growth immediately after fire [6]. At the ecosystem level, a reasonable frequency of fires is needed to preserve biodiversity. If fires are too rare, biodiversity will decrease; but if fires are too frequent, plants might not recover.

In late-stage forests, there are a few rare plants, mosses, fungi, and animals that are not present in the early forest stages. This biodiversity in late-stage forests remains poorly understood because late-stage Mediterranean forests are uncommon. It seems that, to some extent, old forests *also* contribute to biodiversity because they have specific conditions that are important for rare species, and

ultimately important for the environment [7]. Therefore, we need *all* types of forests, from the young and biodiverse forests that result from wildfires and other natural disturbances to old forests with limited but unique biodiversity. The healthiest landscapes are balanced, containing all types of ecosystems. The benefits of wildfires for forests must be balanced with their risks for people. The balance between advantages and threats can help us to conserve all species in the forest landscape, including humans.

ORIGINAL SOURCE ARTICLE

Fournier, T., Fèvre, J., Carcaillet, F., Carcaillet, C. 2020. For a few years more: reductions in plant diversity 70 years after the last fire in Mediterranean forests. *Plant Ecol.* 221:559–76. doi: 10.1007/s11258-020-01034-z

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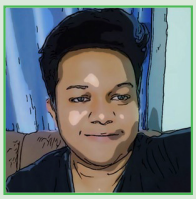
YOUNG REVIEWERS



DEBASISH, AGE: 15

I am a young lad with curiosity to learn and innovate. I am highly interested in reading science fictions. I love to watch sci-fi movies. Cricket is also something I enjoy playing.

SHREEYA, AGE: 11

Hi my name is Shreeya. I live with my sister and my parents. In my free time I like to walk with friends, play board games, and do karate. During this time, I have been keeping myself busy by talking with my friends, reading Harry Potter books, and finishing a 3D Hogwarts Puzzle.

SHRIYA, AGE: 13

Hi, my name is Shriya. I live in the U.S. I am in eighth grade, and my favorite subjects are science and math. In my free time, I like to dance and do art. I just started working with Frontiers for Young Minds, and am very excited to continue!

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