



HI FOREST, HOW ARE YOU DOING?

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YOUNG REVIEWERS:



BERNARDA

AGE: 9



BESHR

AGE: 14



RETA

AGE: 14



TAYM

AGE: 14

Forests are much more than just a group of trees: they are complex ecosystems where plants, animals, insects, fungi, and microorganisms all work together to keep everything in balance. Each organism has an important job to do. But forests can get sick, just like people. Climate change, pollution, pests, or a mix of these can cause problems. That is why scientists keep an eye on forests to make sure they are healthy and continue to provide us with clean air, water, and valuable resources for the future. This is called forest monitoring, and it involves checking biodiversity, tree growth, and the presence of certain species that can tell us a lot about forest health. Studying soil and water also helps identify anything out of balance that might

harm the forest. This article shows how scientists monitor forests and why it matters!

THE RECIPE FOR A FOREST

Forests are not just trees, they are entire ecosystems where plants, animals, insects, fungi, and tiny microorganisms all live and rely on each other. All these organisms work together to adapt and respond to changes, including drought, storms, or pollution. By collaborating in many ways, they help each other survive, stay balanced, and keep the whole forest strong, even when the environment around them is changing. While trees are the most visible part, forests also include shrubs, ferns, herbs, mosses, lichens, algae, and mushrooms (many of which grow underground). The soil provides water and nutrients to trees and other plants.

Forests help clean the air, give us fresh water, and are home to many species. They also produce the oxygen we breathe and absorb carbon dioxide (CO₂), a gas that causes **climate change**. By storing CO₂ in their wood, roots, and soil, forests help keep the planet's climate stable.

Forests, together with plants in the oceans, are our allies in the fight against climate change, because, for example, they can cool the climate. Forests also give us important resources like wood, fruits, and medicines. However, forests are also vulnerable to many unfavorable conditions caused by human activities. To protect and manage forests appropriately, we need to understand how they work and check their health regularly.

HOW DO WE MONITOR A FOREST'S HEALTH?

When someone asks us how we are doing, we can think about different things to create our answer: whether we are in pain, how our mood is, or if something around us is making us feel stressed.

Forests, of course, cannot talk, but there are cool ways to figure out how they are doing—for example, by observing how trees grow, how many leaves they have and of which color, and how they take up nutrients, transfer water from the soil to the atmosphere, and interact with neighboring plants [1]. We can check if the soil is healthy and if there are many insects and animals living in the soil. We also monitor the **biodiversity** of forests; how forest plants absorb CO₂ through their leaves and store it in their trunks, branches, and roots; and whether the vegetation is affected by pests, diseases, pollution, drought, or flooding. We can do all of this using our eyes or equipment that ranges from homemade tools to high-tech **sensors** that can measure temperature, humidity, and other parameters—similar to how we use

BIODIVERSITY

The variety of all living things, including plants, animals, fungi, and microorganisms, in a particular area or on Earth.

SENSORS

Tools that detect changes in the environment—like heat, light, sound, or movement—and turn them into data we can measure, study, or use to control things.

FOREST MONITORING

Observation and recording of forest changes—like tree growth, wildlife, and health—along time or in relation with particular events (i.e., fire, pollution, human activities).

a thermometer to measure a fever. This process, known as **forest monitoring**, provides us with valuable information about forest health and status. Monitoring forests usually does not hurt them. We mostly just look, take notes, and use special tools that do not damage trees or plants. Sometimes, to better understand what is going on, we need to take tiny pieces of a plant, a lichen, or other forest parts—but only little pieces, and very carefully. For animals like insects, small traps are used, and a few insects might be lost. But bigger animals, like birds and mammals, are usually just caught for a short time, checked to see if they are healthy, and then released safely.

When we monitor forests in many places around the world, we can better understand how they function and see the big impacts of global changes such as climate change. Some forests are more affected than others, depending on where they are in the world. For example, forests in dry or very hot places may suffer more from climate change, and forests near cities might be more polluted. We can give priority to forests in special situations, like those that are very important for animals, people, or clean air, or forests for which there is little data available, or at-risk forests that need to be saved from imminent destruction.

TREE AND PLANT HEALTH

Trees can get sick, too. Like doctors finding out why people are ill, we try to understand why a tree is not healthy and how to help. Tree illnesses come from pests and diseases that can damage their leaves, bark, wood, or roots, and sometimes even kill them (Figure 1). Pests are small animals like insects or fungi, while diseases are caused by tiny microorganisms like bacteria or viruses.

Figure 1

(A) Healthy vs. (B) sick Scots pines in Kampinos National Park (Poland). (C) Healthy vs. (D) sick Aleppo pines in Sani, Chalkidiki (Greece), where the sick trees are affected by the bark beetle. (E) Healthy vs. (F) sick Holm oak trees in Tres Cantos (Spain), where the sick trees are affected by a fungus.

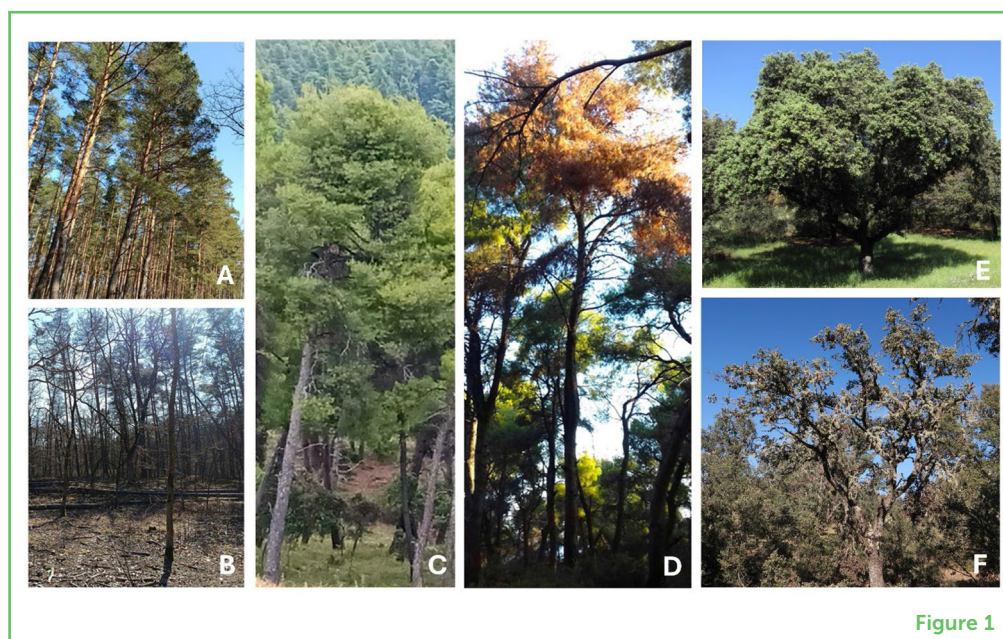


Figure 1

Trees can also get poisoned with substances coming from the air, water, or soil. Air pollutants can be transported very long distances and can arrive in remote areas, disturbing forest health.

When trees are unhealthy, they might grow slower, lose leaves, or change in appearance. We check for unusual signs like spots, holes, or strange colors. Photos can be taken with simple tools like cameras or phones to track changes. If needed, samples of affected parts can be examined in a lab.

Setting traps for insects, using collectors for pollutants, and measuring tree growth help us find problems early. Traps reveal which insects live in the forest and if pests are spreading. Measuring growth shows if trees are healthy or struggling. Studying these clues across regions helps us see patterns, track problems, and act quickly to protect forests. This approach works similarly for other plants besides trees.

BIODIVERSITY

Biodiversity means the variety of trees, other plants, and animals living in a forest. It shows how healthy a forest is, since a healthy forest supports lots of life. Organisms live everywhere in forests, from the soil and rocks to the treetops. Some, like soil organisms, are too small to be visible with the naked eye, so we study them under a microscope. Bigger organisms, like birds and bats, are easier to spot or hear using microphones and computers to identify their sounds. Collecting biodiversity data worldwide helps us understand how plants and animals handle changes in climate and pollution.

Biodiversity also gives us clues about the forest environment and how species cope with climate change [2]. **Lichens**, for example, are cool growths that live on rocks, soil, and trees (**Figure 2**). They belong to different groups, each with unique skills that help them adapt to their surroundings. Some lichens can survive strong sunlight, dryness, or pollution. If you find pollution-sensitive lichens in a forest, it means the air is clean since they would not survive otherwise. Similarly, **lichens** that need lots of moisture tell us the forest is humid without needing special tools.

We can monitor lichens over time to see how a place changes or we can compare different areas to find out how things like industries or busy roads affect nearby forests. This kind of monitoring works not just for lichens but also for other organisms, helping us better understand and protect forests.

Figure 2

(A) Examples of lichen species growing on bark (Shennongjia National Park, China).
 (B) Grid for sampling lichen diversity on trees (Leiria pine forest, Portugal).

**Figure 2**

NITROGEN

A chemical element essential for plants to build strong leaves, roots, and stems. In nature, nitrogen moves in a cycle through the air, water, soil, plants, and animals.

AIR, SOIL, AND WATER QUALITY

All living things need nutrients to survive. Just like we eat food, trees and plants absorb nutrients from the soil through their roots and CO_2 from the air. In some forests, the soil does not have enough nutrients, making plants weak and more likely to get sick. In other places, there can be too much of one nutrient, like **nitrogen**. If trees absorb too much nitrogen but lack other nutrients (e.g., phosphorus), their growth slows down.

Nitrogen is released in the atmosphere by burning fossil fuels, by industries, and by agricultural practices. Excess nitrogen can get washed into forests, rivers, and lakes, polluting water and harming plants and wildlife. To measure pollution, scientists collect rain in bottles and air in tubes, then test them in a lab to find the chemicals. They also check tree leaves for nutrients. Sampling water from soil and rivers help us to track nitrogen levels and understand its impact on nature globally.

FOREST GROWTH AND ENVIRONMENTAL STRESSES

Forest trees live for decades—starting as seeds, growing into seedlings, and getting taller and thicker over time. They grow by taking in water, sunlight, nutrients from the soil, and CO_2 from the air. This process, called forest tree growth, depends on the tree species, soil, climate, and environmental stresses.

Nowadays, forests face challenges like long, hot, and dry summers or heavy floods. Unlike humans, trees cannot move away, but they have survival tools. They can tilt their leaves away from the sun, limit water loss through their leaves, grow deep roots to find water, or adapt to low oxygen in soil when flooded. These remarkable responses are

understood by monitoring forests over many years, enabling better planning for their management [3].

We use sensors placed on trees, in soil, or on tall towers above the forest (Figure 3). For instance, sensors on tree trunks measure yearly growth and water movement, while soil sensors track temperature and moisture. Data from these sensors help us analyze and predict how forests respond to climate change.

CAN I HELP?

Everyone can help in forest monitoring! Scientists are building networks for monitoring forests around the globe (e.g., Cleanforest COST action, <https://cleanforest.eu/>; eLTER, <https://elter-ri.eu/>; ICOS, <https://www.icos-cp.eu/>; ICP Forests, <https://www.icp-forests.net/>), but this may not be enough. You can participate in projects to observe forests, take photos, and collect data about tree health, animals, and environmental conditions [4]. Some projects look for citizens who want to collaborate and use easy apps to report

Figure 3

(A) Tools to measure air pollution and check temperature and humidity. (B) Containers to collect rainwater that falls under the trees. (C) Instruments to watch how much water is in the soil and test how clean it is. (A, B and C from Tres Cantos Holm oak monitoring station, Spain.) (D) Boxes called stem chambers (white arrows) placed on different parts of a tree's trunk, helping scientists measure gases that enter and exit the tree. (From ecosystem station Stitna nad Vlari, White Carpathians, Czech Republic). (E) Sensors (white arrow; enlarged in upper right corner) measuring wind speed and direction, solar radiation, and CO₂ and water concentration in the air (Sani Environmental Observatory, Chalkidiki, Greece).



Figure 3

things like tree growth, pests, biodiversity, or pollution [5]. By getting involved, you can help scientists gather more information about forests and be part of protecting and understanding these beautiful and important ecosystems.

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YOUNG REVIEWERS

BERNARDA, AGE: 9

Hi everybody! I live in Ecuador. Since I was little, I have loved pandas because they are so cute and cuddly. When I grow up, I want to be a vet and take care of pandas. I would love to be with them all day and night, even if I have to wear a panda costume to look like one! My favorite country in the world is definitely China. And my favorite music group is BTS!



BESHR, AGE: 14

My name is Beshr. I am 14 years old, and I am currently in 9th grade. I want to become an ornithologist because I like birds. Also, I want to study other fields like paleontology and botany if I get the chance. I like to learn about different things whatever I find interesting. My hobbies include swimming and robotics, I like keeping pets and plants.



RETA, AGE: 14

Hi my name is Reta. I am 14 years old and currently in ninth grade. I have a passion for science, reading, drawing and writing poetry. I love exploring new ideas. In the future I want to be a Neurologist. I believe that there is something difficult but there is nothing impossible and the knowledge is the key to success.





TAYM, AGE: 14

I am Taym. I am 14 years old. I have a deep passion for biology and believe that a better future depends on dedicated biologists—I am committed to becoming one of them. In addition to my interest in science, I have a strong appreciation for nature and enjoy staying active, especially through football. In my free time, I also like to unwind by playing virtual games whenever I get the chance.

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