Generation Climate Europe

Europe’s Living Forests

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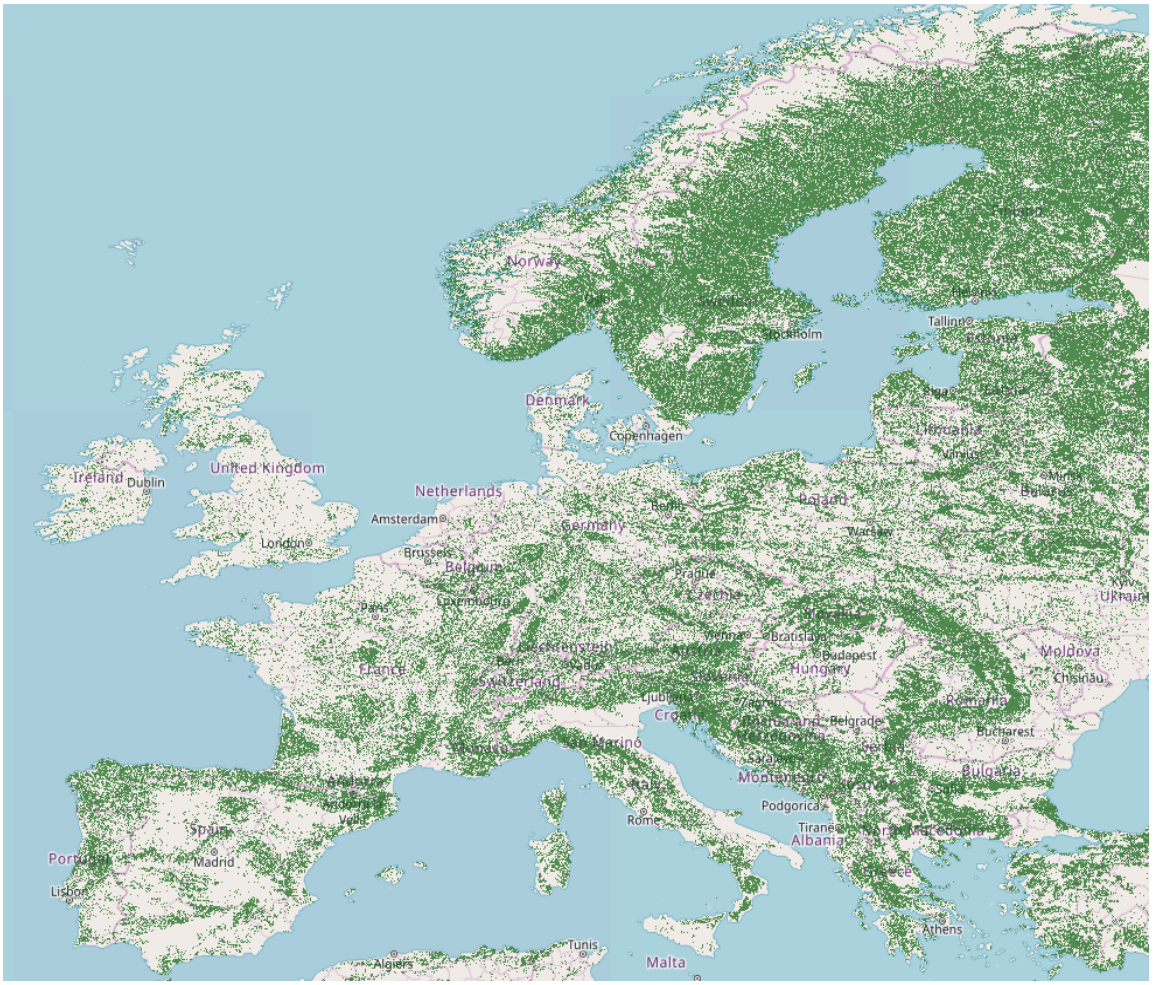
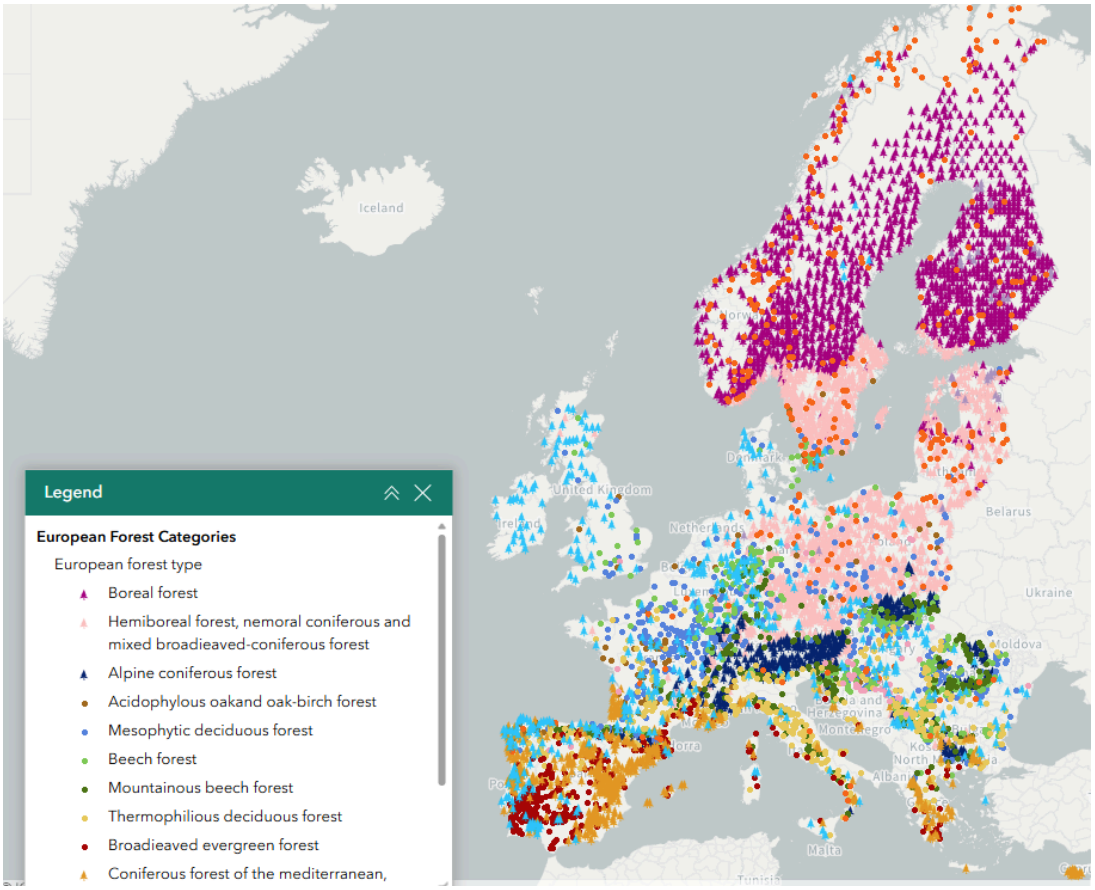
Introduction

Do you know how much of Europe's land surface is covered by forests? Covering an area of **227 million hectares,** forests make up about 35% of European territory!

European forests are **highly diverse** and consist of different types of forest with varied characteristics. According to Forest Europe, 46% of our forests are coniferous (i.e. evergreen), 37% are broadleaved, and the rest are mixed. Trees are present in every European country, but almost 70% of Europe's forest area is located in only six countries. Take a look at the maps below, and see if you can guess what those six countries are!



Source: Global Forest Maps for the year 2020. Global Forest Mapping and Monitoring. https://forest-observatory.ec.europa.eu/forest/rmap



Source: Forest Information System for Europe (2023).
https://forest.eea.europa.eu/topics/nature-biodiversity-and-ecosystems/ecosystems

Could you guess the six European countries with the greatest forest area? They are Sweden, then Finland, Spain, France, Norway and finally Turkey. In the Nordic countries, forests represent more than 60% of their total land areas.

Forests are a **huge source of biodiversity**, and they also provide a wide range of societal, health and economic benefits. More than 95% of Europe's forests are managed by humans and are affected by our activities, with management ranging from strict protection for biodiversity conservation to monoculture forests which are managed intensively for biomass or paper production. 70% of European forests are accessible to the public for recreational purposes. Europe is also the main roundwood producer in the world, with a forestry sector that employs more than 2.6 million people and represents 0.7% of Europe's Gross Domestic Profit (GDP). The wood provided by Europe's forests is used for heating (as wood energy covers 6.4% of total energy consumption), in the building sector, and for industrial processes. Our forests are also a source of food and other materials such as chestnuts, wild meat, honey and christmas trees. The markets for these 'non-wood' products were collectively valued at €4 billion in 2015. Finally, forests play a **huge role in the global carbon cycle**. Europe's forests sequester about a tenth of overall CO2 emissions, which equated to an annual average of 155 million tonnes between 2010 and 2020.

The area of Europe's forest has increased by 9% since 1990, increasing their carbon storage potential. Species diversity is also improving, and populations of common

forest bird species have now been stable for 40 years. While this improves the resilience of forests to climate change, these ecosystems still continue to face threats and large-scale disturbances from extreme droughts, heatwaves, and diseases. Although wood is often considered a renewable energy source, this risks increasing overall demand, and requires long-term resource planning to ensure harvests remain sustainable.

Interesting groups of forest species, such as bioindicators, invasive species, and ecosystem engineers, can help us to better understand the current state of European forests. Have you ever heard of the European spruce bark beetle, the Lung lichen, or the Asian longhorn beetle? Let's discover them together.

The European spruce bark beetle: tiny, hungry, and surprisingly influential

European spruce bark beetle (*Ips typographus*)

- **Size:** 4 - 5.5 mm
- **Lifespan:** Several months
- **Habitat:** Europe and northern Asia, mostly on Norway spruce (*Picea abies*), weakened or damaged coniferous forests
- **Role:** Ecosystem engineer, natural decomposer
- **Why it matters:** Key species for understanding forest resilience and disturbance dynamics.

Source: NaturePhoto Foto ID 19063 © Jiri Bohdal
https://www.naturephoto-cz.com/european-spruce-bark-beetle-photo-19063.html

The European spruce bark beetle (*Ips typographus*) is a member of the bark beetle group. Bark beetles are found almost everywhere that trees grow and they are major herbivores of conifers. At low population levels, they quietly help forests by removing old or weakened trees, but when their numbers explode, these massive outbreaks can overwhelm and kill millions of trees, including healthy ones. These outbreaks can be influenced by factors such as forest structure, the availability of host trees, and climatic events like windstorms and drought. In other words: most of the time these beetles are discreet forest janitors, but under the right conditions they can turn into a tiny, well-organised demolition crew.

Native to Europe, *Ips typographus* is found throughout the natural range of the Norway spruce tree (*Picea abies*). It also occurs across Northern Asia and has spread into spruce plantations in Western Europe, outside the natural range of its host tree. The

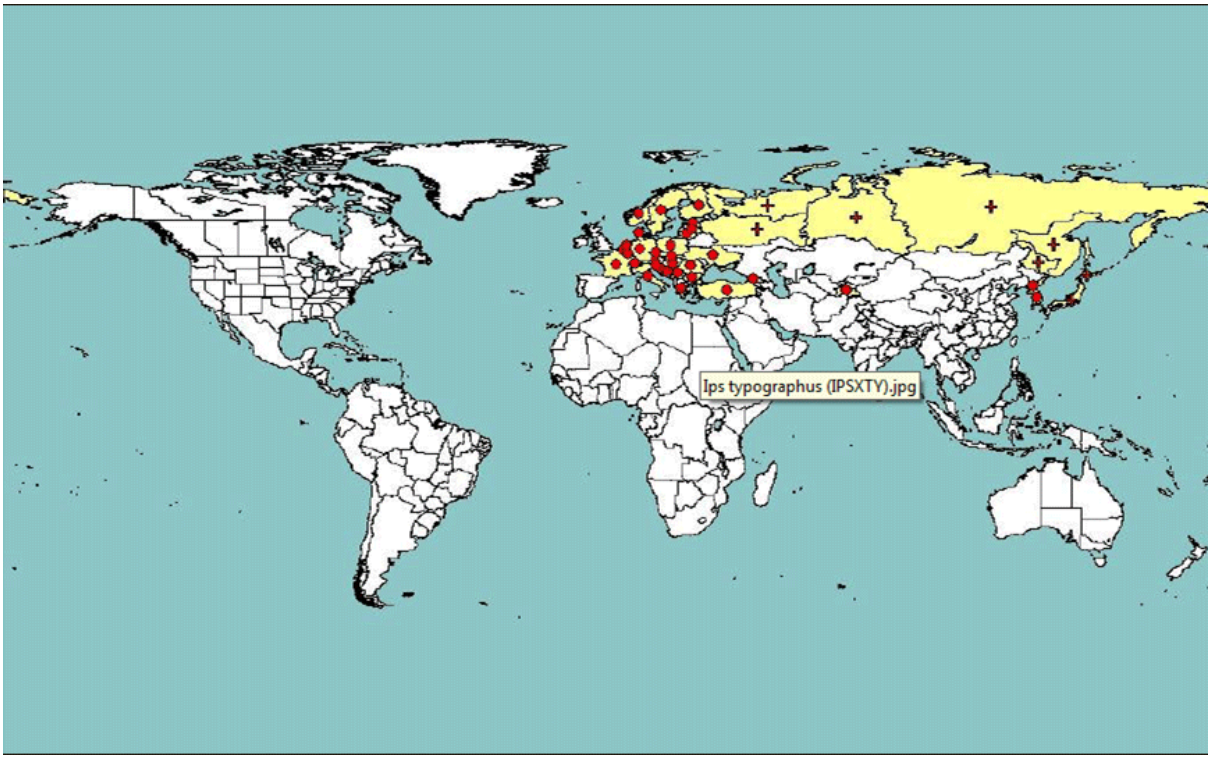
beetles are strong fliers and can disperse over long distances, with wind helping them travel up to 43km - impressive for an insect that could comfortably sit on your fingernail. Like other bark beetles, *Ips typographus* feeds on the inner bark, or "phloem", of spruce trees. As they tunnel, they create entry points for fungal spores, which begin breaking down the tree's nutrients and can even interrupt water transport within the tree. The bore dust and frass produced by their tunnelling is quickly colonised by microorganisms and fungi, and by loosening bark, the beetles also create openings for a range of fungi, microorganisms, and other insects. In summary, bark beetles can help to turn a tree into a bustling micro-city of decomposers! Sheltering under the bark of the tree, bark beetles are shielded from many predators and environmental hazards. However, they still serve as food for a number of other species. This includes woodpeckers, which are able to extract bark beetle larvae directly from the wood and rely on these insects for up to 99% of their winter diet.

Ips typographus earns the title of **"ecosystem engineer"** because its **activity reshapes forest structures in ways that influence biodiversity**. By killing trees and creating patches of deadwood, bark beetles open canopy gaps that allow more light to reach the forest floor, increasing soil moisture and accelerating nutrient cycling. These gaps host more diverse tree assemblages, including new species and snags in various stages of decay, each supporting different tree-related microhabitats. After an outbreak, forests experience a surge in herbaceous plants, pioneer tree species, fungi, insects, and cavity-nesting birds, all taking advantage of the newly available habitat. Woodpeckers feeding on bark beetle larvae create nest cavities that later house birds, bats, rodents, and even amphibians. Although large outbreaks temporarily reduce the forest's carbon storage, surviving trees and new growth can compensate for this within one or two decades. In short, the beetle unintentionally runs a full forest renovation programme, which can seem chaotic at first, but is ultimately beneficial for biodiversity.

Despite their destructive reputation, bark beetles face their own difficulties. Climate change is increasing the frequency of droughts and warm periods, which can both stress forests and expand the beetles' suitable climate range, potentially increasing the severity of an outbreak. Forests in Europe have also experienced catastrophic storms in recent years, followed by bark beetle infestations that caused high natural losses and forced increased timber removals. While storms and droughts create ideal conditions for beetle population growth, they also destabilise forest ecosystems. In the long term, this poses a threat to bark beetles, which depend on a delicate balance of forest disturbance, and available host trees.

Humans and *Ips typographus* are linked through both **conflict and ecological interdependence.** Severe outbreaks of bark beetles can impact the ecosystem services that we depend on forests for, such as timber production, protection from natural hazards, and recreation. Outbreaks also force costly timber removals and disrupt forest management. At the same time, the habitats created by bark beetle activity support a wide range of organisms, including birds, bats, rodents, carnivores, amphibians, invertebrates, and fungi, which are essential to healthy and functioning forests. So while humans often see *Ips typographus* as a pest, this beetle is also a **key**

player in maintaining forest biodiversity. However, climate change is increasing the likelihood and severity of beetle outbreaks, creating a damaging feedback loop with consequences for human economies, forest habitats, and even the bark beetle itself.



Distribution map of *Ips typographus*. The circles represent national records and the crosses represent sub-national records of its presence. (EPPO PQR database)
Source: Department of Agriculture, Environment and Rural Affairs of Northern Ireland. (n.d.). *Eight-toothed spruce bark beetle (Ips typographus)*. https://www.daera-ni.gov.uk/articles/eight-toothed-spruce-bark-beetle-ips-typographus

Take a deep breath with the lung lichen, an important bioindicator!

The lung lichen (*Lobaria pulmonaria*)

- **Size:** 5 - 15cm
- **Lifespan:** several decades to over a century, growing very slowly
- **Habitat:** humid, old-growth, temperate forests, broadleaved trees in clean, unpolluted air
- **Role:** Bioindicator, sensitive to air pollution and microclimate changes
- **Why it matters:** Its presence signals healthy stable forests. Also a 'nitrogen fixer' (i.e. something that draws nitrogen from the air) and a moisture regulator.

Source: L S, alguns direitos reservados (CC BY-NC), http://www.flickr.com/photos/27632962@N04/3836101271 to find here: https://www.biodiversity4all.org/guide_taxa/1442894

The lung lichen or lungwort (*Lobaria pulmonaria*) is a large, 'foliose' (leafy) lichen. This species is widely distributed across Europe, Asia, North America, and Africa, with a preference for humid, rainy environments. It typically grows on the bark of broad-leaved trees such as oak, beech, chestnut, and maple, but can even make itself at home on rocks. When moist, the body of the lichen (the thallus) is bright green; when dry, it changes to a brownish colour.

Lung lichen is formed through a complex **three-partner symbiosis:** the interaction between an ascomycete fungus, green algae, and a cyanobacterium. This association spans three kingdoms of life and allows the lichen to switch between oxygen-producing photosynthesis (via the algae) and nitrogen fixation (via the cyanobacteria) that enriches the surrounding ecosystem with bioavailable nitrogen.

As a lichen, *Lobaria pulmonaria* does not "eat". Instead:

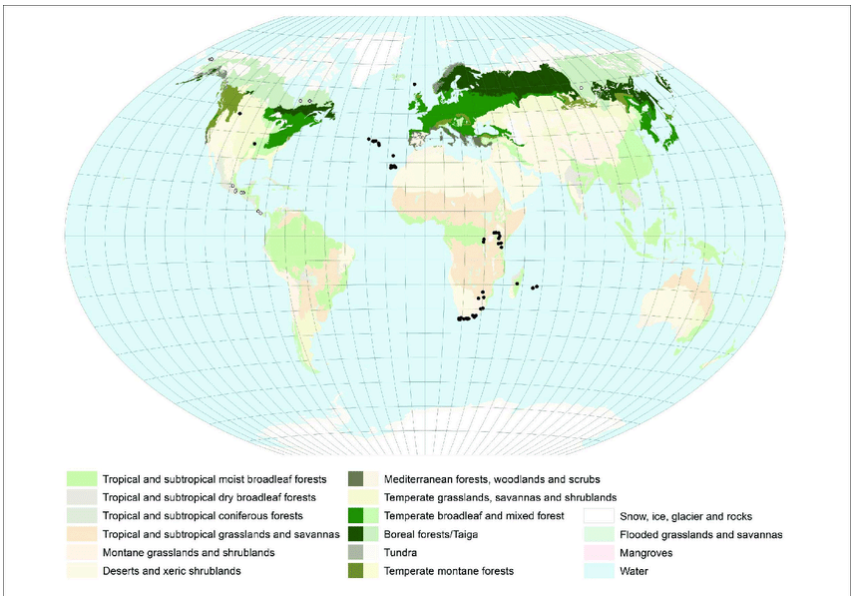
- **Green algae** performs photosynthesis, transforming carbon dioxide into sugars and oxygen.
- The **cyanobacterium** 'fixes' atmospheric nitrogen, drawing nitrogen from the air to enrich the lichen and its surrounding environment.
- The **fungus** provides structure, water retention, and protection for the other partners.

In this way, the lung lichen contributes significantly to **forest ecosystem functioning and carbon cycling**. It also plays a key role in forest food webs, serving as food for snails and slugs, providing microhabitats for small invertebrates, and even offering shelter, moisture retention, and substrate for parasitic fungi.

Humans have interacted with the lung lichen for centuries. The name "lungwort" dates back centuries and reflects the historical belief that the lung-like appearance of this species meant it could treat respiratory ailments. The lichen has also been used to treat eczema, coughs, and wounds, and its extract has been proven to possess anti-inflammatory, ulcer-preventing, antioxidative, and gastroprotective properties. In some cultures, the lichen is even used for the production of orange dyes for wool and leather, tanning, perfume making, and brewing.

Lobaria pulmonaria is also widely recognised as an **excellent bioindicator species**. Indeed, its presence signals ancient woodland and high ecological continuity. It is also highly sensitive to air pollution, forest management, microclimate changes, and habitat fragmentation, making it a reliable indicator of forest health. It also serves as a proxy for the biodiversity of the entire *Lobarion* lichen community, meaning it indicates the health of other lichens too. Because of these qualities, researchers recommend that the lung lichen is included in large-scale and long-term forest monitoring programmes.

Unfortunately, *Lobaria pulmonaria* has undergone a **marked decline across Europe** and is now considered rare or threatened in many regions, especially lowland areas. The main drivers of this are: air pollution (particularly acid rain), industrial forestry, and habitat fragmentation. The same sensitivity that makes lung lichen a great bioindicator also makes it highly vulnerable to these threats. Because of these persistent pressures, the lung lichen is now red-listed in several European countries. However, despite its unassuming appearance, *Lobaria pulmonaria* is increasingly considered a **flagship species for environmental education**, and it is helping to raise awareness about sustainable forest management, air pollution, and biodiversity conservation. The unexpected charisma of this impressive lichen will hopefully help to secure its future, and the protection of the forest ecosystems it depends on.



Distribution map of L. pulmonaria created with ArcGIS 10. Colors indicate the different vegetation zones. Strongly colored areas -general distribution regions.
Source: Braun, Maria et al. (2021). The Lichens' Microbiota, Still a Mystery? *Frontiers in Microbiology*, vol.12.
https://www.researchgate.net/publication/350494712_The_Lichens'_Microbiota_Still_a_Mystery

Noticed a yellow insect in your forest? Watch out for the Asian longhorn beetle!

Asian longhorn beetle (*Xylotrechus chinensis*)

- **Size:** 12 - 25 mm
- **Lifespan:** 18 - 23 days
- **Habitat:** Native to East Asia, primarily mulberry trees, larval habitat
- **Role:** Invasive species, weakens trees, can kill hosts
- **Why it matters:** Severe damage to trees leads to tree mortality and landscape degradation

Source: Préfet de la région Occitanie. https://draaf.occitanie.agriculture.gouv.fr/xylotrechus-chinensis-ou-longicorne-tigre-point-de-situation-decembre-2024-a9351.html

The Asian longhorn beetle (*Xylotrechus chinensis*), also known as the tiger longicorn beetle, is relatively large for a beetle, measuring 15–25mm, with short, widely separated antennae and striped elytra, that make it look like a wasp trying to get into a costume party. The species was first reported as **established in Europe in 2018,** though it likely arrived around 2012 or earlier. Adults emerge between May and August and live for 18–23 days. Females lay about 80 eggs on tree bark during this time.

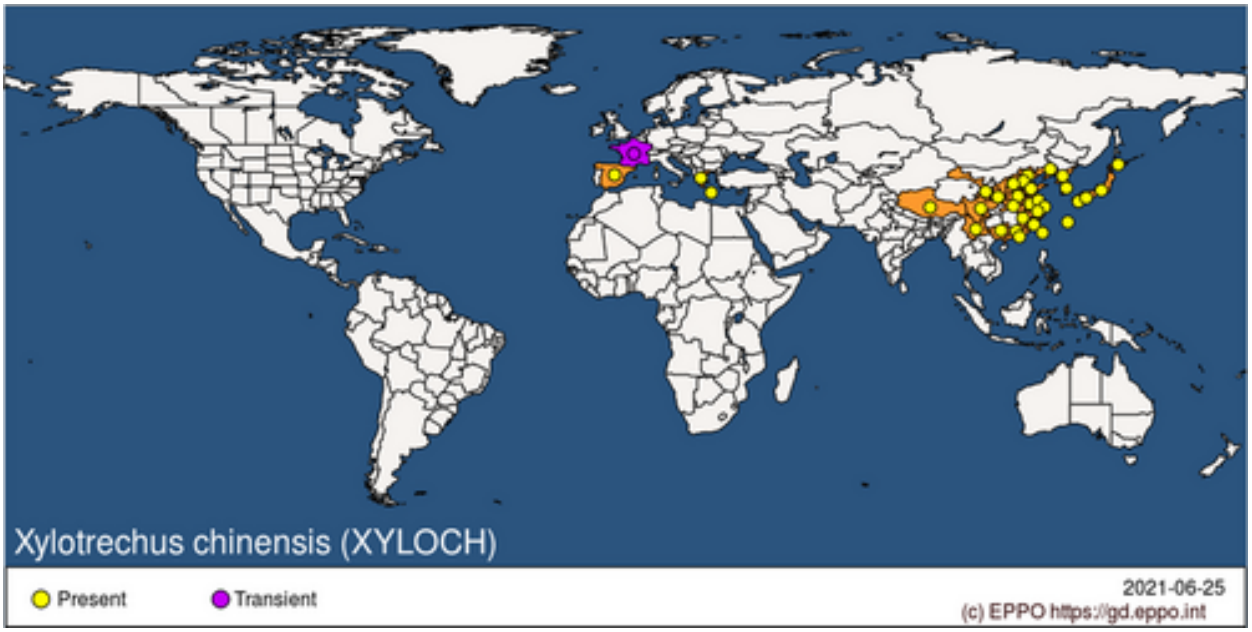
The larvae of the Asian longhorn beetle are 'xylophagous' (they eat wood), and their favourite buffet is **mulberry trees (*Morus spp.*)**, which they can kill if left unchecked. In Asia, they also feed on apple trees (*Malus domestica*), pear trees (*Pyrus spp.*), and grapevines (*Vitis vinifera*). Larvae start by feeding in the phloem and cambium of the tree, then tunnel deeper into the xylem to pupate. Their feeding creates slits, galleries, and round exit holes - the beetle equivalent of leaving a huge mess in someone else's house.

The Asian longhorn beetle is native to East Asia, specifically China, Japan, Taiwan, and the Korean peninsula. However it has now settled in Spain (Catalonia, Valencia), Greece (Athens, Crete), and France (Hérault, Gironde). It was introduced accidentally, concealed within wood-packaging materials, pallets, plants for planting, and through the bonsai trade. Given the climate across Europe, experts warn that this species **could establish itself in most of the EU territory**. In its new European life, *Xylotrechus chinensis* prefers urban and peri-urban environments that are full of mulberry trees — parks, avenues, gardens, and anywhere that people thought "mulberries would look nice here". But this hardy beetle can even thrive in piles of cut logs.

Xylotrechus chinensis is considered **invasive** because it spreads easily, kills living trees, and is difficult and costly to detect and eradicate. Once established, it causes significant damage. In their native habitats, longhorn beetles play an important ecological role by helping to recycle dead wood, but invasive species like *Xylotrechus chinensis* disrupt European ecosystems. Infested trees become structurally weak, increasing the risk of falling branches in public parks and avenues. Fewer trees also means fewer possibilities for people to enjoy their mental and social benefits, especially in cities. A 2021 study found that, out of 200 mulberry trees infested with Asian longhorn beetles in Crete, 15% had already died. The same study also found that 23% (300 out of 1,300) infested mulberry trees in Athens were already dead. The beetle spreads locally by flight, allowing it to expand its range steadily. In 2018, the European and Mediterranean Plant Protection Organization (EPPO) added *Xylotrechus chinensis* to its Alert List, signalling its high risk and the need for rapid reporting and eradication efforts. In 2021, the European Food Safety Authority (EFSA) later concluded that this species meets all the criteria to be considered a **potential Union quarantine pest.**

Although *Xylotrechus chinensis* is spreading successfully, it does face some obstacles — mostly because humans are not thrilled about losing their mulberry trees. Control methods themselves are not exactly glamorous: they include catching adults, injecting insecticide into larval cavities, or even killing larvae with metal wires, a technique that feels surprisingly medieval but is still used. In China, blocking emergence holes with mud after injecting insecticide is also considered effective.

Xylotrechus chinensis is **notoriously difficult to control once established**, and the economic consequences are substantial, as cities must remove dead trees, monitor infestations, and apply treatments. **Climate change gives this invasive species a further advantage**, as rising temperatures extend the beetle's flight season, giving it more time to reproduce and spread. This means insecticide treatments must be adjusted to match its longer activity window, further increasing costs. In short, humans accidentally brought the Asian longhorn beetle to Europe, have driven the climate change that is helping it to thrive, and are now dealing with the consequences.



Global distribution of *Xylotrechus chinensis* (Source: EPPO Global Database accessed on 25 June 2021) https://efsa.onlinelibrary.wiley.com/doi/10.2903/j.efsa.2021.7022

Conclusion

After wandering through Europe's forests together—from the quiet, lichen-covered branches hosting *Lobaria pulmonaria* to the dramatic invasions of the Asian longhorn beetle and the chaotic engineering feats of *Ips typographus*—one thing becomes clear: forest ecosystems are anything but static. They're more like a long-running drama where every species has a role, whether it's the gentle air-quality-loving lichen, the wasp-cosplaying tree assassin, or the tiny bark beetle that can accidentally remodel an entire landscape. What ties them all together is the delicate balance between resilience and vulnerability: forests thrive thanks to complex interactions, yet a single newcomer or a warming climate can flip the script. And despite the occasional chaos, these ecosystems keep adapting, reshaping, and surprising us. If anything, studying them reminds us that even the smallest organisms can have a huge influence, and that protecting Europe's forests means understanding not just the trees, but the quirky cast of characters living on, in, and around them.

So, pay attention during your next forest trip, and you might see one of the species you've just learned about!

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