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POnTE Project findings and achievements

New species of *Phytophthora* in forestry

What is *Phytophthora*?

The organisms of the *Phytophthora* family are very well-known threats to many plant species. The name itself means plant (phyto) decay (phthora) or 'plant destroyer'. *Phytophthora infestans*, for instance, is the microorganism that causes the disease known as late blight or potato blight, whose epidemics brought devastating famine in Ireland and other European countries in the XIX century. *Phytophthora* are essentially water molds and fungi-like organisms. As such, they usually spread in soil but can also be airborne.

In recent years, scientists observed an increasing number of new emerging diseases affecting forest trees caused by several *Phytophthora* species. These lead to significant economic losses and pose considerable risks to natural ecosystems. The knowledge of the *Phytophthora* family is still limited, and some hybrid species are still evolving, potentially increasing the risk of colonization of new forest hosts. This is why plant scientists all over the world include new species of *Phytophthora* in forestry among the priorities for research.

New *Phytophthora* species

New exotic *Phytophthora* species affecting broadleaf (for instance: beech and oak) and conifer (for example, larch) trees in forest ecosystems are appearing around Europe, posing serious threats to the continent's woodlands. One example is *Phytophthora ramorum*, known to be the main agent of the sudden oak death disease. Once confined in California and Oregon, *P. ramorum* was detected in Europe at the beginning of the 1990s. In 2009, it was found in new trees species in the UK. *Phytophthora quercina*, a causal agent of Oak root rot was first isolated from mature oak stands in the eastern part of Austria during surveys carried out in 1999 and 2000. The pathogen has been reported in Germany, Italy, Hungary, France and Turkey.

Credits: Forest Research, UK

Larch affected by *P. ramorum*

The POnTE Project

The 2015–2019 POnTE Project is one of the most integrated responses of European research to the emerging threat of aggressive 'alien' plant pests, meaning the pathogens from other parts of the world establishing in Europe. Financed by the European Union Horizon 2020 program, the Project relies on the 'know thy enemy' principle, bringing together 25 partners, 120 researchers and 13 countries from Europe, the Near East and Latin America with expertise in plant science, agro-engineering and economics. The goal is the development of early detection and surveillance tools, state-of-the-art knowledge and practical solutions against the spread of new species of *Phytophthora* attacking forestry plant species, and other emerging plant pests. The POnTE Project has supported the intensification of research to find the most effective prevention, control, mitigation and management measures for these pests, covering phytosanitary as well as socio-economic dimensions.

POnTE and Phytophthora species in the forest: main findings and results

Within the POnTE Project, researchers monitored emerging *Phytophthora* species to understand why these organisms may be harmless in some areas and devastating in others. Firstly, also thanks to previous research, scientists could confirm the existence of a number of unknown species of *Phytophthora*. Secondly, a particular focus was dedicated to determining a baseline of which *Phytophthora* species were present both in 'disturbed' sites (with frequent introduction of plants, soil movement and frequently visited by the public) and sites with very little disturbance, i.e. 'natural' ecosystems in Britain. In Serbia and Austria, scientists carried out *Phytophthora* surveys on specific declining woodland species.

Credits: Forest Research, UK

Bleeding on trunk of Acer caused by *Phytophthora plurivora*

Some of the species investigated proved to be highly adaptable. One *Phytophthora* specimen was found in the soil of a site where the disease had been eradicated nine years before.

The POnTE Project helped to highlight some characteristics of this organism, in particular:

- Different *Phytophthora* species have been identified associated with specific tree declines in Europe.
- The combination of various state-of-the-art testing methodologies allowed the detection of up to 34 *Phytophthora* species.
- The abundance and high diversity of both known and new *Phytophthora* species discovered thanks to the POnTE Project are an alarm ring for European forests, agriculture and horticulture.
- Furthermore, it has been shown by these studies that **Southeast Asia is the center of origin of highly invasive wide-host-range *Phytophthora* species** like *P. cinnamomi* and *P. ramorum* which cause currently devastating forest epidemics in Europe and North America. This suggests that extensive host-range testing among European forest tree and horticultural crop species is urgently required to assess the **potential threat posed by the import of living plants from Southeast Asia**.
- Both natural and 'disturbed' ecosystems in Europe are likely to unravel the presence of previously unknown *Phytophthora* species. Thus, additional research is needed to better understand the biological and epidemiological significance of these findings and the potential impact of the *Phytophthora* subspecies on European forests.

The research on the ground

Between 2013 and 2019, within the frame of several projects – including POnTE – aiming at unravelling global diversity and biogeography of the genus *Phytophthora*, surveys were performed in natural ecosystems of Japan, Taiwan, Vietnam, Indonesia (Borneo, Java, Sulavesi and Sumatra), Chile, Nicaragua, Panama, Curacao, Egypt and eight countries in Europe. In total, 320 forest sites, 410 forest streams, 9 mangrove forests, 6 lagoons and 5 other marine sites were sampled. Baiting assays and direct plating of necrotic plant tissues were used for isolating *Phytophthora* species from forest streams, forest soils and woody plants. Overall, **13.242 isolates were obtained, which could be assigned to 65 known and 101 previously unknown species of *Phytophthora***.

These surveys contributed to pin down the origin of several invasive aggressive *Phytophthora* pathogens, including *P. cinnamomi*, *P. xcambivora*, *P. lateralis*, *P. ramorum* and the *P. citricola* complex.

Scientists at work
Credits: Forest Research, UK

In Serbia, some *Phytophthora* diseases were recorded for the first time, both in woodlands and in nurseries. From forest streams and soils, nine different species were isolated, including *P. gonapodyides*, *P. lacustris*, *P. chlamydospora*, *P. plurivora*, *P. ×cambivora*, *P. gallica*, *P. europaea* and two undescribed taxa *P. sp. organica* and *P. sp. Kelmania*. From nurseries, the most frequent species were *P. plurivora*, *P. ×cambivora* and *P. cactorum*, but also *P. gregata* was isolated for the first time from Magnolia seedlings. In different pathogenicity tests, various *Phytophthora* species were aggressive to their respective hosts, like *P. cactorum* and *P. sp. Kelmania* to *Picea omorika*, or *P. pini* and *P. plurivora* to poplar plants in soil infestation tests; or *P. plurivora* to maple and poplar, *P. ×cambivora* to wild cherry and cherry laurel, or *P. ×serendipita* to wild pear plants in underbark stem inoculation trials, respectively

In Britain, in recent years, diseases caused by *Phytophthora* species have consistently been in the top ten reported problems on trees at the Tree Health Diagnostic and Advisory Service (THDAS). A total of 227 *Phytophthora* reports have been submitted to THDAS since 2015 on 26 different tree genera. *Phytophthora* was isolated from these hosts and where possible was identified to species level by sequencing their ITS region with the primers TS4-ITS6. In 195 cases, *Phytophthora* was identified to species level, and in 32 cases, confirmation was only based on the positive result of a lateral flow device (LFD). In total, 19 different *Phytophthora* species were identified, of which three were the first records for Britain, *P. foliorum* on Rhododendron, *P. siskiyouensis* on *Alnus incana* (grey alders) and the hybrid *P. gonapodyides x P. chlamydospora* on *Fagus sylvatica* (common beech). The five most common identified species were *P. plurivora* followed by *P. austrocedri*, *P. cinnamomi*, *P. pseudosyringae* and *P. cambivora*. *Phytophthora plurivora* was recorded in 48 cases, 24 of which were identified on bleeding lesions on *Tilia* (lime tree); *P. austrocedri* was mainly recorded on roots of juniper; *P. cinnamomi* was mainly detected on roots/soil of *Castanea sativa* (sweet chestnut) and *P. pseudosyringae* was primarily detected on bleeding lesions of beech.

Bleeding on the trunk of a beech tree caused by *P. pseudosyringae*

Credits: Forest Research, UK

In Austria, scientists assessed the *Phytophthora* species role in declining of alpine green alder in the Austrian and Northern Italian Alps. This was performed by direct isolation from stem and root bark necroses onto PARNPH-medium, furthermore by soil baiting and direct isolation from symptomatic leaves of *A. viridis* and other plant species collected from nearby streams, onto PARNPH- medium. In addition, neighboring grey alder sites were checked by the same method in order to compare the spectrum of *Phytophthoras* present. A number of species were identified, among them *P. pseudosyringae* as a species well adapted to cold climates and a mutual pathogen of *Vaccinium myrtillus*, a shrub widespread in the Alps. Similarly, the presence of *P. plurivora* as a pathogen with a wide host range was confirmed.

From data collection to concrete actions on the ground

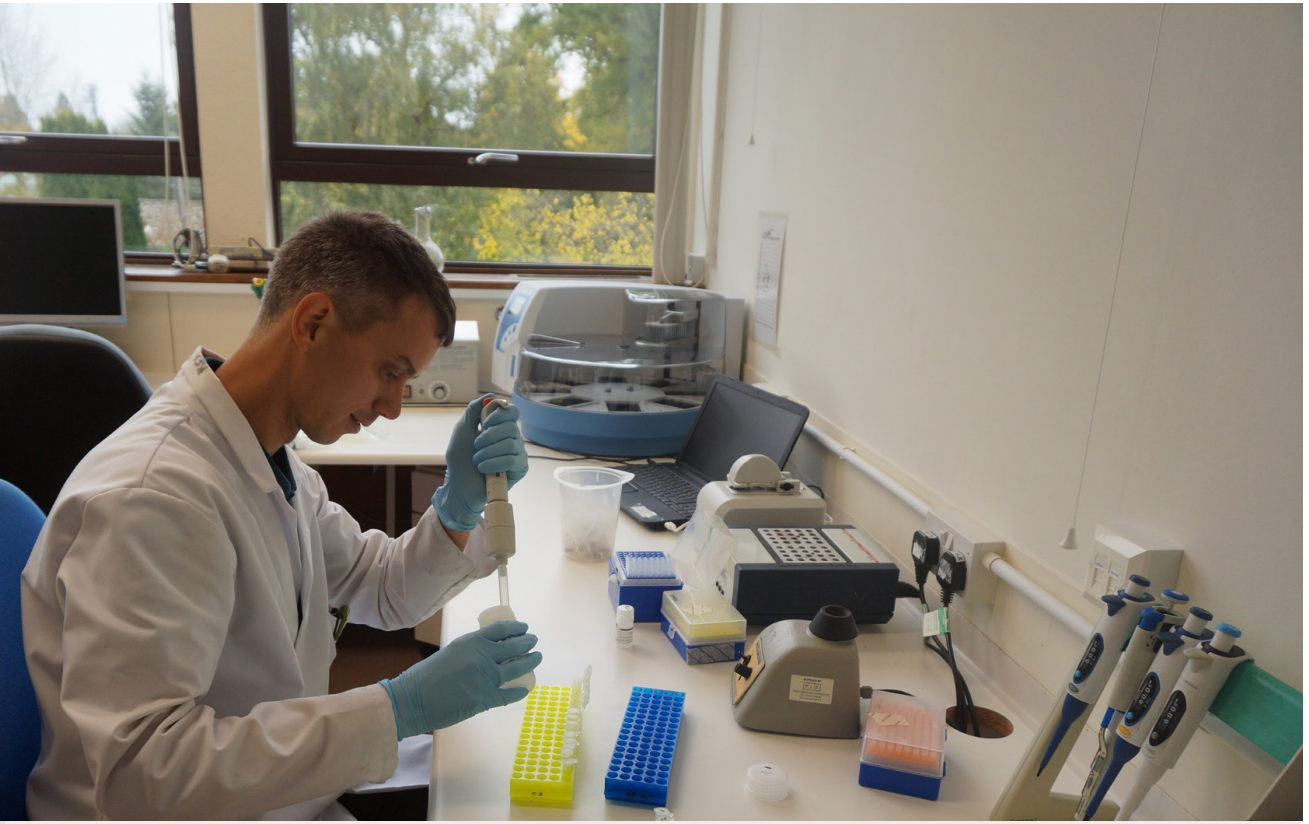
The combination of traditional microbiological and molecular techniques is an essential first step for building knowledge on the invasive alien plant pests and to design future strategies of prevention, management and control of the infection. In the case of *Phytophthora*, the sequencing contributed to highlighting connections among various species allowing to infer the place of origin of some of the most threatening *Phytophthora* species in the world. The forests and rivers of Southeast Asia harbor an extremely high diversity of both known and new *Phytophthora* species and other fungi belonging to the same class of oomycetes. **Two of the most damaging invasive *Phytophthora* species of the world, *P. cinnamomi* and *P. ramorum,* are most likely native to Southeast Asia**. The results of the POnTE Project also provided strong evidence that known *Phytophthora* species not yet present in Europe pose a serious threat to forests in Europe because of the possible recombination with local species and the high level of aggressiveness and adaptability to different hosts and climatic conditions. These findings are a key element of any prevention strategy, with particular attention to the living plants arriving in Europe from Southeast Asia.

Credits: Forest Research, UK

Sporangia and encysted zoospores of *Phytophthora*

Also, the findings highlightened the role of **climate change**. The finding of *P. cinnamomi* causing collar rot of a 30-year-old *Araucaria* tree in a landscape planting in Germany is alarming since it indicates that climate warming triggers the establishment of this frost-sensitive pathogen in Central Europe with severe implications for tree and forest health in the future. Similarly, the severe collar rot and dieback of beech trees in a mature natural forest in the Bavarian Alps caused by *P.* x*cambivora* are most likely triggered by climate change.

Moreover, the data, also collected within the POnTE Project, are crucial to minimize the risk of spreading *Phytophthora* species, under condition that they are taken up by nurseries and authorities, to release up-to-date international management guidelines. An accreditation scheme for the production of *Phytophthora*-free plants in nurseries is under development in the UK. The guidelines and requirements to avoid the introduction and spread of *Phytophthora* species into production fields and forest nurseries are being implemented in Austria and plant growth media are being screened in Norway. Considering the spectrum of nurseries in Europe with respect to dimension, and financial potential, but also the availability of irrigation sources as well as infection risks by specific environments, international management guidelines should provide certain flexibility to achieve *Phytophthora*-free plant production.



Credits: ***Forest Research, UK***

Scientists at work

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