News and Views

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Clonal differences in susceptibility to ash decline have been observed in several studies, although no clones seem to be fully resistant to the disease. Photo: Thomas Kirisits

New light on causes of ash decline

The accelerating decline of *Fraxinus excelsior* in Europe has been a mystery. The fungus responsible for the disease has now been disclosed as coming from the Far East. It still remains a challenge for science to find methods to save the ash from extinction. The SNS-supported project "Decline of *Fraxinus excelsior* in northern Europe" took a firm grip on the issue from a scientific viewpoint.

The project, which ran over the period 2010–2012, assembled research teams from six Nordic-Baltic countries. In addition, intensive international collaborations and networks were established, including the launch of COST FP1103 Action FRAXBACK ("*Fraxinus* dieback in Europe: elaborating guidelines and strategies for sustainable management") that currently involves 37 countries and over 150 participants. A total of 11 scientific articles in peer-reviewed journals and two PhD theses were also outcomes of the project.

The SNS-project produced new information on the genetic, ecological and silvicultural aspects of ash dieback, but also identified research gaps that need to be filled. Europe provides a giant field experiment with countries in different stages of invasion of the disease. This, together with the competences built up during the project, lays a good foundation for further research.

The final report is published on SNS's website. Some important findings are listed here:

The spread

Severe dieback of *Fraxinus excelsior* has been observed in most European countries, including the Nordic-Baltic states. It is an emerging disease, which results in massive tree mortality, and currently threatens the existence of ash over large parts of Europe. The dieback was first observed in Lithuania and Poland in the mid-1990s and spread northwards from there into Latvia, westwards towards Kaliningrad and southwards in Belarus. Since 1998, the dieback has spread all over Poland, and was recorded in northeastern Germany for the first time in 2002.

In 2002, the disease had only been observed locally in southern Sweden, but in summer 2004 it also emerged into the western and central parts of the country. In 2003–2004, the first symptoms were recorded in Denmark, and the causal pathogen spread rapidly across the country during 2005–2008. In 2007–2008, ash decline appeared in Norway and Finland.

Between 2006 and 2010, ash dieback became established in France,

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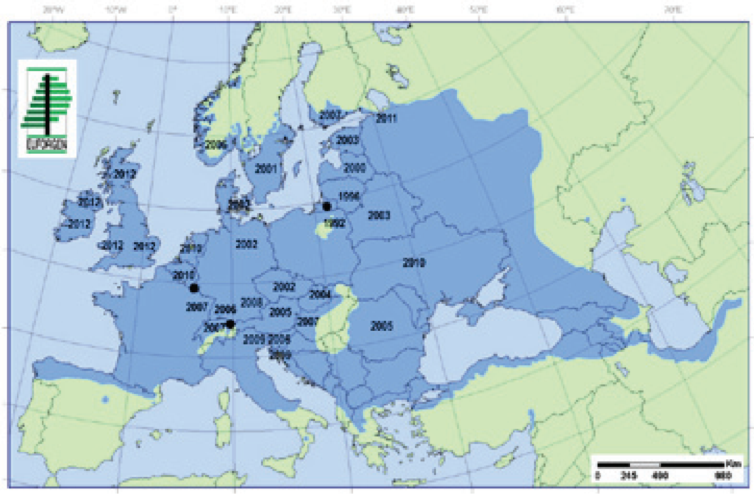
the Netherlands, Italy and Croatia. The first symptoms in Ukraine were found in 2010; it was detected in 2012 in the UK and Ireland.

The mystery of the pathogen

Initially (2006–2010), studies carried out in central Europe (Poland and Switzerland) suggested that the ascomycetous fungus *Hymenoscyphus albidus* was the causal agent of the dieback. This was very surprising, since *H. albidus* is common, native to Europe and a widespread saprotrophic fungus, known to decompose the petioles of shed ash leaves in forest litter. The commonly asked question was: why is an indigenous, common, widespread and, until now, seemingly harmless saprotroph causing such a catastrophe? The mystery was solved in 2012 when it was proved that the causal agent of ash dieback is not *Hymenoscyphus albidus*, but a related and morphologically almost identical fungus, which was then described under the name of *Hymenoscyphus pseudoalbidus*. Its origin remained unknown until more recently, when it was demonstrated that *H. pseudoalbidus* is native to the Far East, where it fulfils a similar ecological function on Mandshurian ash (*Fraxinus mandshurica*) as *H. albidus* does on European ash in Europe: saprotrophically decomposing shed leaves and petioles. Currently, it is generally assumed that the pathogen reached Europe on saplings of Mandshurian ash imported from China for planting and became established in one or more nurseries in eastern Poland. From there, the fungus spread in all directions, causing massive dieback of ash, thus proving to be a classical example of a very aggressive and invasive alien species.

A study from Denmark indicates that the saprotroph *H. albidus* has been replaced by the pathogen *H. pseudoalbidus*. In herbarium samples collected before 2005, only *H. albidus* were found. In 2005, the first evidence of *H. pseudoalbidus* appeared, at the same time as the first symptoms. In a collection from 2010, all fungi were identified as *H. pseudoalbidus*. The original species seems to be excluded from its niche, and is perhaps already locally extinct.

Genetic mapping of both *H. pseudoalbidus* and *H. albidus* has revealed that the two fungi differ genetically. Although they share the same habitat and are morphologically very similar, they do not share a recent common ancestor. Moreover, the asexual (anamorphic) stage known as *Chalara fraxinea* is characteristic only for *H. pseudoalbidus,* so both names are valid for the ash dieback pathogen. An asexual stage of *H. albidus* is not known and probably does not exist.



The shaded area shows the distrubution range of *Fraxinus excelsior*. The first records of symptoms of ash dieback demonstrates the accelerating spread of ash decline in Europe. No first record is known for the Kaliningrad Oblast of Russia, Liechtenstein and Luxemburg where the disease also occurs. The distribution map of ash was kindly provided by EUFORGEN (2009). The map was compiled by Thomas Kirisits as part of the EU-funded projects FORTHREATS, ISEFOR and FRAXBACK.

The project

SNS-109 Decline of *Fraxinus excelsior* in northern Europe

Project period: 2010–2012.

Support from SNS: €150 000.

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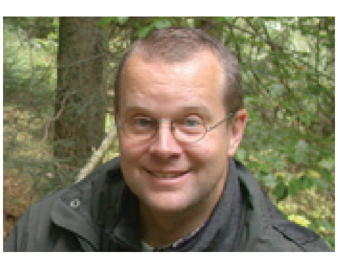
Other participating organisations: Forest & Landscape, University of Copenhagen (prof. Erik Dahl Kjaer), Norwegian Forest and Landscape Institute (prof. Halvor Solheim), Finnish Forest Research Institute (prof. Jarkko Hantula), Latvian Forest Research Institute (Dr. Talis Gaitnieks), Institute of Botany, Vilnius (Dr. Vaidotas Lygis).



The network coordinator Rimvydas Vasaitis. Photo: Thomas Kirisits.

The countermeasure – breeding

Dieback resistance of common ash has been found to be strongly genotypically controlled. A clonal test in Sweden demonstrated clonal variation in susceptibility, although no ash clones were completely resistant. The most susceptible clones were also those with a prolonged growing season. The study indicates that there is good scope for breeding of less susceptible trees in the future.

Progeny tests in Denmark also showed the presence of genetic variation in susceptibility, although only a small portion of the trees had low susceptibility. Only around 1% of

Fruiting bodies (apothecia) of *Hymenoscyphus pseudoalbidus*, the sexual stage of the ash dieback pathogen, on blackish, pseudosclerotial leaf petioles in forest litter. The wind-dispersed ascospores produced in these fruiting bodies cause infections on ash trees, and they facilitated the rapid geographical spread of the pathogen across Europe.
Photo: Thomas Kirisits.

all trees have the potential to produce offspring with less than 10% crown damage under the current disease pressure.

Lithuanian progeny trials predated the results from Sweden and Denmark. In this study, genetic variations in resistance were found at both a population and a family level. It was also found that introduced populations were slightly more susceptible than native ones, indicating that the introduction of new populations to a diseased area is an inappropriate option.

The regeneration

Self-generation of ash in diseased stands is poor, and it seems that stands previously dominated by ash will be replaced by other species. A study of 20 clearcuts in Lithuania, where the stands were originally dominated by ash, demonstrated that ash regeneration was scarce. Of all observed regenerated ash trees, less than a third were healthy. The ash saplings are also slow growing, and will be out-competed by grey alder and birch.

The disease is also found in seeds of ash. Seeds were collected from ash stands in Latvia and in Sweden in 2011. *H. pseudoalbidus* was found in about 8% of the seeds from Latvia, but in none from Sweden. The presence of the fungi in seeds indicates the need for phytosanitary actions to prevent spread via the seed trade.

The ecological relationships

Despite numerous field surveys of ash dieback in Europe, it has remained unclear how the disease is related to ecological site conditions and also to phenology. One study in Denmark compared dieback in stands of varying density. It was found that the disease was more severe in dense stands, which were not thinned. Late-flushing trees were also more severely affected.

Another study examined the wood-inhabiting fungi in affected ash stands. Secondary damage by rot fungi such as *Armillaria* is commonly observed in damaged stands. The question was whether the rot affects the ash decline in itself and the regrowth. The results from the Lithuanian study showed that rot in the roots and stumps of ash has a negative impact on sprout production, but not on the subsequent phytosanitary condition of the coppice. The study demonstrated that the disease is, therefore, primarily caused by airborne *Hymenoscyphus pseudoalbidus*, but that in older trees dieback may also be made worse by secondary attacks of *Armillaria* root rot.

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Nordic workshop on bioeconomy

Uppsala in Sweden is welcoming participants to a Nordic workshop "The forest sector in the biobased economy – perspectives from policy and economic sciences", 28–29 August 2013. The workshop has been organised by a joint team from Sweden, Norway, Finland and Denmark with economic support from SNS.

Professor Anders Roos, Swedish University of Agricultural Sciences, is one of the organisers. He estimates that some 40 people will attend the workshop, originating from a broad spectrum of research fields.

– We look forward to a good orientation over the forces and actors needed to achieve a biobased economy: consumers, innovators, corporate strategists, economists and environmental policy advisors, he says.

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Anders Roos: We look forward to a wide range of contributions. Photo Mats Hannerz

What is bioeconomy?

The term "bioeconomy" is relatively new, but has evolved into one of the top hits in recent policy documents. It entered the policy discussion in Europe as late as in the middle of the 2000s. The recognisability of the term is illustrated by a doubling of hits on Google searches from 2007 to 2013.

The high level of political interest in bioeconomy is based on a number of potential benefits: reduced greenhouse gas emissions, decreased dependence on fossil resources and improved food security. A boost in bioeconomy is also expected to generate employment, and to create new non-food markets, thus benefiting rural development.

The technical potential for bioeconomy is impressive. It has been estimated that over 90% of oil-based products could be replaced by bio-based alternatives. The challenge is rather to increase the scale of activities.

The term in itself is not precisely defined. The content of bioeconomy depends on the perspective of the user and the context it is used in. It is therefore not surprising that policy documents, as well as scientific articles, devote a mass of space to discussing what it means.

One source defines it as "an economy where the basic building blocks for materials, chemicals and energy are derived from renewable biological resources". The concept of bioeconomy, also known as "bio-based economy" or "knowledge-based bio-economy" usually refers to an economy founded on biomass instead of fossil fuels. It originated in the life sciences and biotechnology spheres, but has expanded to incorporate other ideas such as the biorefinery concept.

Bioeconomy can also be considered from two contrasting perspectives. One is the life sciences vision, where genetic engineering and technical development make the conversion of biomass to energy or other products more efficient, thereby boosting industry and export. The alternative vision is the agro-ecological vision, which involves the utilisation of agricultural waste to produce energy on-site.

Some bioeconomy terms:

Biofuels are liquid and gaseous fuels derived from biomass and used for transport.

First generation biofuels are made from food crops, **second generation biofuels** are based on non-food biomass, such as lignocellulosic materials, and **third generation** biofuels are derived from algae.

Biorefineries involve the integrated production of energy, fuels, chemicals and other products derived from biomass. The biorefinery concept aims to replace petroleum-based refineries.

White biotechnology (Industrial biotechnology) uses enzymes and micro-organisms to make bio-based products, including chemicals, food and feed, bioenergy, paper and pulp, and textiles.

Grey biotechnology encompasses technological solutions created to protect the environment, such as in the case of oil spills and purifying sewage water.

Green biotechnology refers to agricultural processes for instance to develop genetically modified crops or improve plant breeding techniques.

Blue biotechnology refers to marine and aquatic applications, and red biotechnology relates to the health sector.

Source: (free interpretation from McCormick, K. & Kautto, N. 2013. The bioeconomy in Europe: An overview. Sustainability 5, 2589-2608.)

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