Future Forest Health

Early detection and mitigation of invasive pests and diseases in Nordic Forests

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Hótel Örk, Hveragerði, Iceland
17-18 September 2019

Program - Abstracts - Participants

Future Forest Health: NordGen conference

Early detection and mitigation of invasive pests and diseases in Nordic forests

Iceland, Hótel Örk, Hveragerði, 17-18 September 2019

Program Tuesday 17 September

08:00-08:30 **Coffee and registration**

08:30-08:50 **Conference opening: NordGen**

08:50-09:30 **How can we combat international movement of pests by trade?***by professor Hugh Evans (Britain)*

09:30-10:10 **Screening potential pests of Nordic coniferous forests associated with trade of ornamental plants**
by Juha Tuomola, Finnish Food Authority

10:10-10:40 Coffee

10:40-11:10 **The role of climate factors in association with spread of invasive forest pests with special focus on plant production**
by Anne Uimari, LUKE, Natural Resources Institute, Finland

11:10-11:40 **Invasive forest pests in Iceland**
by Guðmundur Halldórsson, Soil Conservation Service of Iceland

11:40-12:10 **Breeding for disease resistance**
by Halldór Sverrisson, Icelandic Forest Service

12:10-12:30 **Discussions**

12:30-13:30 Lunch

13:30-14:00 **Action to mitigate threats towards forests in the Nordic countries**
by Hans Peter Ravn, University of Copenhagen

14:00-14:30 **New invasive species which may arrive in the European Union: risk analysis, prevention and management options using biological control**
by Jørgen Eilenberg, University of Copenhagen

14:30-15:00 **Susceptibility of different provenances of birch in Iceland to *Eriocrania unimaculella***
by Brynja Hrafnkelsdóttir, Icelandic Forest Service

15:00-15:30 **Discussions**

15:30-16:00 Coffee

16:00-16:40 **Climate change, forest pests and forest production in the Nordic countries**
by Edda S. Oddsdóttir, Icelandic Forest Service

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19:00 - Conference dinner

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09:20–10:00	**Geothermal heat forest in Reykir, Hveragerði**
10:40-11:20	**Hrosshagi research field.** Breeding of Black Cottonwood to increase resistance for the rust fungus, *Melampsora larici-populina*
11:45-12:20	**Friðheimar - greenhouse farming.** Use of biological control in the production process
12:20-13:00	Friðheimar **(Lunch)**
13:00	**Departure from Friðheimar**
13:45	**Þjórsárdalur (National Forest).** Presentation of the land reclamation project – Hekluskógar
14:15-16:15	**Driving through the area of Hekluskógar, close to the volcano Hekla.** Information in the bus with short stops on the way to Gunnarsholt, the main office to Landgræðslan (Soil Conservation Service of Iceland)
16:15-17:15	Gunnarsholt **(Soil conservation service of Iceland)** Coffee in the soil reclamation history museum
17:15	**Departure from Gunnarsholt**
18:00	**Arrival to Hótel Örk, Hveragerði**

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How can we combat international movement of pests by trade?

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Abstract

The past 100 years or so have seen massive increases in global trade, a growing tendency to plant exotic tree species and increasing effects from climate change. Taking such trends into account, it is not surprising that pests (to include both insects and various pathogens) have exploited these opportunities to colonise new areas across the globe. In the second half of the 20th C, global instruments (procedures) from a range of international bodies have been developed to protect the environment and reduce species loss (Ormsby & Brenton-Rule 2017). From a phytosanitary perspective, the most influential global instruments are the Wold Trade Organisation Sanitary and Phytosanitary (SPS) Agreement and the International Plant Protection Convention (IPPC). The SPS Agreement, in particular, aims to facilitate international trade and requires scientific evidence to justify the use of any measures that could be construed to be barriers to trade. This requires effective knowledge gathering on named pests along with extrapolation of knowledge to predict the biology and potential impacts of pests in new locations around the world. Whilst this is a generally effective approach in dealing with new pest incursions, it does not account for other organisms that could move along trade pathways and be missed in Pest Risk Analysis (PRA).

Whilst phytosanitary processes concentrate on 'known' pests, it is an unfortunate fact that most of the new pest infestations that are recorded internationally comprise organisms that were not previously recorded in national or international pest lists. These findings, summarised by many authors (e.g. Meurisse *et al* (2019)), confirm that both interceptions and, in many cases, establishments of pests continue to increase despite phytosanitary rules to prevent pest movements. It is also apparent that, for both insects and pathogens, a wide range of orders and families are represented many in association with particular pathways. Frequent and increasing records of pest incursions not previously included in phytosanitary lists can be regarded as 'failure of process' for current pest-based rules and there is now a trend towards commodity-based risk assessments, which will feature more prominently in the new EU Plant Health Regime from December 2019. When the records of new pest establishments are shown on a map of the world it is apparent that pests have moved in all possible directions, including between hemispheres indicating considerable plasticity in climate and environmental requirements.

Not surprisingly, efforts to combat pest movements consider how particular organisms are associated with pathways and how the pathways can be declared free from the pests. The risk profile of untreated wood (i.e. wood prepared from felled timber) varies with the degree of processing of the wood, with the highest risk of pest presence arising from green dunnage, including round wood with bark present. Since the wood on this pathway is already dead,

direct intervention using various processes such as heat treatment or fumigation can be applied to kill any organisms present. On this basis, the treatment of wood packaging material (WPM) has now been made mandatory under International Standards For Phytosanitary Measures (ISPM) Number 15. Such an approach delivers the concept of 'Manage Once, Remove Many' as described by Evans (2010). A considerably more difficult pathway to manage is live Plants for Planting which can include organisms in both the tree itself and in associated soil. Since the pathway is a living plant, the application of measures to kill pests is severely restricted, making it difficult or impossible to kill any organisms present. A systems approach is, therefore, the process of choice for this multiple-component pathway, requiring an understanding of the range of organisms that could be present, linked to the source location and environment. Reducing the presence of pests at each stage from source to sink requires greater efforts in inspection and analysis of possible pest presence with limited capacity to apply pesticides or other direct interventions.

Efforts to ensure that the pathway is pest-free are prioritised under phytosanitary regimes and are the most cost-effective in relation to long-term protection of the forest resource in the importing country. However, if the measures prove ineffective and pest incursions and establishment occur, the emphasis must move from the pathway to the pest itself. This requires detailed knowledge of the biology of the invasive pest in its new environment and development of management responses to the new incursion.

Early detection of pioneer populations of an invasive pest is key to management and for minimising impacts in the new environment but this poses the difficult question of how to survey for new pest infestations and where to allocate scarce resources. Pathway analysis for optimal surveillance has been developed for known pests (e.g. Yemshanov *et al* (2015) for Asian longhorn beetle and emerald ash borer). This provides the basis for where to locate survey resources for early detection in relation to pathway volumes and their endpoints relative to emergence and dispersal capacity of the pests. Having determined where to allocate surveillance, other procedures can be used to assess the effort and its statistical validity. In this respect, for example, EFSA provides guidance and statistically valid protocols for survey, but not where to place the survey effort. This includes general survey guidelines and open access statistical tools including RiBESS+ and SAMPELATOR (https://shiny-efsa.openanalytics.eu/). There is also guidance from EPPO as well as regulation from the EU. All have been pest-based up to now.

Surveillance employs a range of detection techniques, such as pheromone traps, visual symptoms, etc., but all require a good knowledge of pest biology under the local climate and host tree conditions. When information on the pest is limited, a more generic detection approach such as multilures for bark and wood boring beetles, remote sensing, citizen science, etc can be employed.

Management choices must include an early decision on whether eradication of a new infestation is feasible and, if not, what the longer-term strategy will be. Since there is typically a lag of several years between establishment and first detection of most pests, eradication is rarely feasible. Consequently, containment and 'living with the pest' are common options but require assessment of all available pest reduction tools and can include use of pesticides, biological control and silvicultural management as longer-term approaches.

As an example of development of a management regime for two potentially damaging pests, the work of the Euphresco PREPSYS project on emerald ash borer – EAB (*Agrilus planipennis*) and bronze birch borer – BBB (*Agrilus anxius*) includes development of a European Toolbox to both prepare for and manage the pests. Comprehensive analysis has identified both progress and gaps in knowledge from the extensive research and experience of the pests in North America. This will be illustrated in the presentation.

Conclusions on threats to our forests from international movement of pests

Pest lists have value, but many pests not on previous lists are moving and establishing globally, indicating that pathway management is not fully effective. Efforts are now concentrating on how to reduce risks generically so that both known and unknown pests are removed during pathway management. This has been done, through ISPM15, for a previously highly dangerous pathway – wood packaging – but management of plants for planting remains problematic. International cooperation and stakeholder engagement remain essential components in developing effective phytosanitary measures to keep our forests healthy.

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Screening potential pests of Nordic coniferous forests associated with trade of ornamental plants

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Abstract

Invasive pests can cause extensive ecological and economic impacts worldwide and they are introduced into new areas especially via the international trade of living plants. According to the international trade statistics, the trade of living plants, particularly that of ornamental plants, into the Nordic countries has increased in the last decades. For example, during the last 10 years ornamental plants have been traded into Finland, Sweden or Norway from more than 70 countries. The pests that may potentially spread with this trade may not only pose a threat to ornamental plants and the horticultural industry, but also to our native forest tree species.

The introduction of new pest species in the European Union and Norway is mitigated with plant health regulations. These regulations provide lists of quarantine pests whose introduction and spread are aimed to be prevented, for example, with requirements for the international trade. However, these regulations do not provide full protection against new pest threats, partly because the quarantine lists do not contain all the potentially harmful pest species that could spread in international trade. New quarantine pests and trade restrictions to prevent their introduction and spread may be added to the plant health legislation, only if the risk of the pests has been assessed according to the International Standards for Phytosanitary Measures (ISPMs). Because there are numerous potential pests worldwide and the pest risk assessment (PRA) is a time and resource consuming process, such assessments are normally done only for pests that are emerging or otherwise recognized as a potential risk based on prescreening or pest prioritization.

We used a four-step screening procedure to identify pests of Scots pine (Pinus sylvestris) and Norway spruce (*Picea abies*) that could 1) be introduced into Finland, Sweden and Norway via the trade of ornamental plants, and 2) potentially fulfil the criteria to become regulated as quarantine pest in the EU and Norway. In the first step of the process a list of all recorded pests of pine (*Pinus* spp.) and spruce (Picea spp.) was established using major pest databases, i.e. EPPO Global Database, CABI Crop Protection Compendium and Pest Information Wiki. This list was then screened to exclude pests that were considered irrelevant for the current work, e.g. pests that are already regulated as quarantine pests under the current plant health legislation, and pests already present in the area at risk. In the third step, rating criteria adopted from

EPPO's (European and Mediterranean Plant Protection Organization) approach for commodity studies were used to identify the most relevant pests. In the last step, the pests were ranked according to their risk to Nordic coniferous forests using the FinnPRIO pest risk ranking model and the hypervolume approach.

This work provides an extensive overview of the pest risks to Nordic coniferous forests that are associated with trade of ornamental plants. The final rankings of the pests can be used to decide which pests or trade pathways to prioritize for full pest risk assessments.

The role of climate factors in association with spread of invasive forest pests with special focus on plant production

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Abstract

Invasive species are ecologically and economically harmful non-native organisms introduced to new locations by multiple human action-connected pathways. Invasive forest pests include pathogens and insects inducing damage in forests and other natural and human build green areas as well as nurseries producing plant seedlings. While global trade and human movement increase the introduction of invasive species climate change affects the establishment and spreading of these new organisms. Human activity especially during the last hundred years has increased the temperature of terrestrial and marine environments. The temperature rise affects Earth's water cycle resulting increased precipitation and flooding in some areas and drought elsewhere. Thus, climate change modifies biodiversity and environment globally.

Climate change can increase, decrease or has no effect on the competitiveness of invasive pests. Agriculture and forestry invasive pests with economic and biodiversity impact are predicted to be most responsive to climate change. Winter survival, spring revival and generation number of invasive pests may be increased by modified climate. In addition, changes in the climate may accelerate pests' life-cycle and expand their host species range. Climate change also causes range sifts of species and environmental factors, such as vectors, carriers and pests, interacting with invasive organisms.

Although, invasive pests can cause large damage in wildlife they also have impact on nursery production of plants. Like in nature, without pest arrival there will be no establishment or spreading even the climate would be suitable. Introduction of invasive organisms into the plant production environment is facilitated by several pathways including human, machinery and equipment, irrigation systems, air-dispersal, seeds and most importantly plant material. In the new environment, extent of the risks and putative damage are often difficult to predict. However, once present the pests can cause yield losses, plant death and destruction of infrastructure and production environment.

Eradication of invasive organisms is difficult, thus, preventing the entry is the most effective strategy for managing biological invasions. Some of the invasive species harmful for plant production are known and preventive manners against their introduction and establishment can be applied. Unfortunately, harmful organisms can often be unknown prior establishment because being harmless in their native region. Plants in the invaded environment have not evolved alongside introduced species and thus, have not natural resistance. In addition, introduced species may not have any natural "enemies" to control population sizes and they may be resistant against plant protection products used in nurseries.

The climate change further complicates plant production by increasing the

impact of existing pests. Increased use of pesticides and deployment of new crop species and cultivars may induce pests' resistance against plant protection products and offer new hosts for invasive pests, respectively. Changed climate also modifies growing and production systems, e.g. affects the amount of irrigation. Altogether, adaption of plant production to a changing climate may alter impacts of all, native and non-native, pests in unexpected ways.

Invasive forest pests in Iceland

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Abstract

Downy birch *Betula pubescens*, Ehrh, is the only native forest forming species in Iceland (Aradóttir and Eysteinsson, 2005), while tea-leaved willow (*Salix phylicifolia* L.), woolly willow (*S. lanata* L.) and dwarf birch (*B. nana* L.) often form shrubland on substantial areas. Rowan (*Sorbus aucuparia* L.), is often found as single trees in birch woodlands. Other native woody species in Iceland are: aspen (*Populus tremula* L.), arctic willow (*S. arctica* Pall.), juniper (*Juniperus communis* L.), burnet rose (*Rosa pimpinellifolia* L.) and glaucous dog rose (*Rosa dumalis* Bechst.) (Kristinsson, 2010). In total 52 native arthropod species feed on native woody plants in Iceland (Halldórsson, *et al.* 2013).

Successful planting of exotic tree and shrub species in Iceland started by the end of the 19th Century, although the first attempts can be traced back to the 16th Century, and since then around 150 new tree and shrub species have been tried by the Icelandic Forestry Service alone (Blöndal & Gunnarsson 1999). However, this was on a small scale until after WWII when extensive planting of exotic tree species started. This plant material was earlier often imported as seedlings and Bjarnason (1951) reports that in the year 1950 around 300 thousand Scots pine (*Pinus sylvestris* L.) seedlings were imported from northern Norway and planted in Iceland. Soon after Icelandic plant nurseries overtook the majority of tree plant production, although some import continued. New regulation on import and export of plant material was issued by the Ministry of Agriculture in 1990. This regulation prohibited the import of seedlings of all species of: elm (*Ulmus* spp.), birch (*Betula* spp.), pine (*Pinus* spp.), spruce (*Picea* spp.), larch (*Larix* spp.), willows (*Salix* spp.) and poplars (*Populus* spp.) as well as import of seedlings of all conifer species outside Europe. Furthermore, the regulation specified a quarantine list of harmful organisms which may not be found on imported plant material. This regulation has been updated since then and the regulation now in force is from 2017 (Ministry of Agriculture n.d.).

Introduction and establishment of new arthropod species feeding on trees and shrubs in Iceland was summarised by Halldórsson *et al.* (2013) and updated by Halldórsson *et al.* (2018). Presently, 32 species of forest insect pests have become established Iceland since year 1900, however, three of these species were successfully eradicated so only 29 species have become permanently established (Fig. 1). All of these species are insects, except for one mite species (Halldórsson et al. 2013). The rate of introduction was low until the middle of the 20th Century, when the rate of introduction increased significantly until the beginning of the 1960s. A new period of high introduction rate started in the 1990s and since then around one new arthropod forest pest has been recored every second year on average (Fig. 1.). These fluctuations in the introduction rate of new arthropod forest pests seems to be linked to fluctuation in climate (Halldórsson *et al.* 2013). The

climate in Iceland has been getting warmer and by the middle of the 21th Century it is expected that the average temperature in Iceland will be 1.3-2.3°C higher that during 1986-2005 (Björnsson *et al.*, 2018). The rate of introduction of new forest insect pests can, therefore, be expected to increase further in the coming decades due to climate warming. Other factors, such as increased import and increased tourism, can also enhance the likelyhood of introduction of new forest pest species.

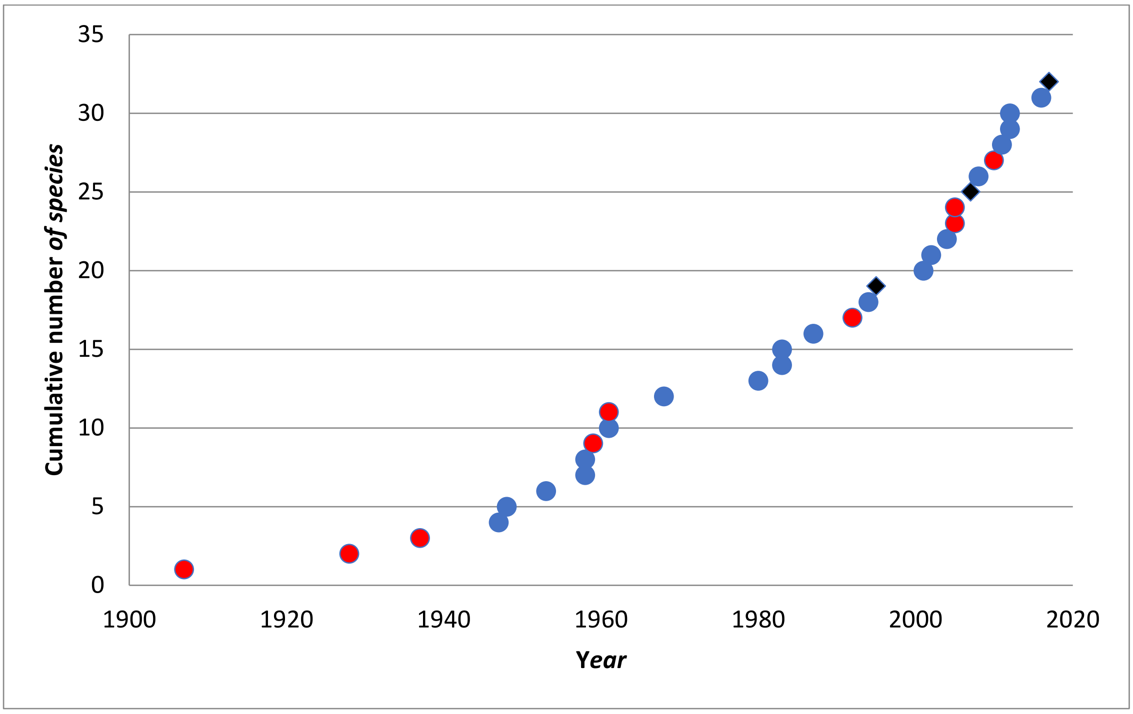

Fig. 1. *New arthropod herbivores on trees and shrubs in Iceland since 1900.* ● *= species which cause moderate or severe damage,* ● *= species which cause minor damage,* ◆ *= species which were successfully eradicated after establishment.*

The first new forest insect pest recorded in Iceland was *Epinotia solandriana* L., which was first recoreded here in 1907. It was followed by the winter moth *Operophtera brumata* L. in 1928 and the pine woolly aphid *Pineus pini sensu lato* in 1937. All these species can cause severe damage and tree death, as well as the green spruce aphid *Elatobium abietinum* Walker, which was first recorded in 1959 (Halldórsson *et al.* 2013). Seven introduced species are considered to cause moderate damage: *Oligonychus ununguis* Jacobi, *Schizoneura ulmi* L., *Zeiraphera grisana* Hübner, *Heringocrania unimaculella* Zett., *Phratora vitellinae* L., *Nematus ribesii* Scop. and *Scolioneura betuleti* Klug. Other species have so far caused minor or no damage. However, as many of these species have recently been introduced it is likely that their damage potential is presently not fully known.

The effect of new forest pests can be very serious. Extensive epidemics of the pine woolly aphid in Iceland, during the 1950s and 1960s, have been considered to be the major cause of extensive death of Scots pine in the country (Ottósson, 1988). Import of Scots pine seedlings from Norway around 1950 and subsequent distribution of these seedlings in Iceland (Bjarnason 1951) is likely to have facilitated the fast spread of the aphid. Historycally, outbreaks of lepidoptera larvae in birch woodlands causing tree death in large areas are well known and documented in old annals and reports (Hallgrímsson *et al*. 2006). However, during recent repeated outbreaks in birch woodlands the introduced *E. solandriana* has played a key roll and caused considerable tree death (Hallgrímsson *et al*. 2006). New forest pests on birch in Iceland, such as *H. unimaculella*, which was first recorded in 2005, and *Scolioneura betuleti*, which was first recorded in 2017, is of concern. Recent surveys have shown that both species are presently spreading fast, and considerable damage on birch has been recorded.

Rapid introduction of new forest pests in Iceland during the last three decades is of serious concern, especially as some of the introduced species are known to be able to cause significant damage in forests and woodlands. Introduced forest pest species have already had a considerable effect on forests and woodlands in Iceland, although the positive effect of warmer climate on forests have so far more than balanced the negative effect of introduced pest species (Björnsson *et al,*. 2018). However, more introductions of new forest insect pest can have serious consequences for forestry and forests in Iceland, bearing in mind that some of the most harmful forest insect pests in Iceland are introduced. Furthermore, the effect of the most recently introduced species may not be fully developed, as they may not have fully become adapted to the environmental conditions in the country. It is important to realise this and to take actions to reduce and mitigate this threat.

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Breeding for disease resistance

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Abstract

The first individuals of *Populus balsamifera* ssp. *trichocarpa* arrived in Iceland in the winter 1943-1944. A young student in forestry, Vigfús Jakobsson, sent some poplar cuttings to the Icelandic State Forestry. He collected them in the autumn 1943 in Cooper Landing, near Lake Kenai on the Kenai peninsula in Alaska. In the next years the poplar got the name alaskaösp (alaskan poplar). Jakobsson went to Alaska for the second time in 1947 to collect more cutting material. Poplar material has been collected in Alaska in five more expeditions, 1950, 1952, 1963, 1985 and 1994. The 1963 expedition was made after a very bad frost damage on poplars in the southern part of Iceland in the spring 1963 in order to get material from the south coast of Alaska where the climate is more oceanic than in the inland of the Kenai peninsula.

In 1979 the first trees of black cottonwood trees began to flower in Akureyri in North Iceland. Seeds were collected and sown. In 1983 seeds were collected in the south of the country and from the progeny collection some clones were selected for trials. In the period 1992-1995 several clonal trials were established in different parts of the country. They included 40 clones. Most of them were nature clones collected in the Kenai peninsula in Alaska and on the south coast of the country, but also a few were seed plants from Iceland. Some large plantations were also established on farm land. Both the research and the poplar forest planting was connected to plans for production of wood biomass for the silicon alloy fabrics in Iceland. The project was financed by the Icelandic government.

The first controlled crossings were done in 1988 and then again in 1995. In 1999 poplar leaf rust (*Melampsora larici-populina*) was found for first time in Iceland. New breeding program was started in order to find clones with good resistance against the rust. The progeny of several crosses were planted in progeny trials in different regions of the country in the years 2002 to 2008. Promising plus trees have been selected and planted in a collection of 350 clones in south Iceland in the period 2009 to 2012. These clones have been tested for rust resistance, susceptibility for frost damage, growth rate and other qualities.

The main goal of the program was to obtain a variety of fast growing clones with good rust resistance and well adapted to the local climate in different parts of the country. Now 24 clones of the progeny from the breeding program have been selected and are being propagated in the greenhouses of the Forest Service.

New invasive species, which may arrive in the European Union: Horizon scan and risk analysis

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Abstract

In the European Union, activities have been carried out and are still ongoing, about new invasive animal and plant species, which may arrive. The work included a horizon scan analysis, where a large team of scientists analyzed and ranked species after characters: chance of arrival; chance of establishment; chance of further spread; severity of damage to ecosystems. The horizon scan was carried out in two steps. First, smaller groups analyzed their own group of organisms, for example I was in the terrestrial invertebrate team. We did a ranking of invertebrate species, and likewise, other teams ranked plant species, vertebrate animals and marine species. Next step was to combine all organisms into one list of ranked species. This work is followed up by detailed risk analysis of selected species. My talk will outline the work and the challenges included.

Susceptibility of different provenances of birch in Iceland to *Heringocrania unimaculella*

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Abstract

There are 80 arthropod herbivore species found on trees and shrubs in Iceland (Halldorsson *et al,* 2013). Thereof are about 31 that live on the native downy birch (*Betula pubescens*), the only native forest forming species in Iceland (Aradóttir & Eysteinsson, 2005). About one third (10 species) were introduced after 1900 and are therefore listed as non-native species. The effect of those herbivores on birch can be very variable. Some have caused total defoliation of large areas of woodland and even tree death (Halldorsson *et al,* 2013). Other only inflict minor damage but act constantly on the plant and may reduce growth and increase plants susceptibility to other stresses.

Heringocrania unimaculella is a small moth, that was introduced to Iceland in 2005 (Halldorsson *et al* 2013). Since then its distribution area has been expanding and number of outbreaks are increasing (Hrafnkelsdóttir & Oddsdóttir, 2018). Adults fly early in spring and lay eggs on birch at or right before bud bust. After hatching, the larvae mines inside birch leaves until late June, when pupation occurs.

Infected leaves become brown over time and changes the appearance of the tree. However, it is not know how much this herbivory affects the plant growth and vigor, but as the damage reduced its ability to photosensitize, the effects are likely to be negative. In addition, a new leafmining wasp species, *Scolioneura betuleti*, was found on birch in Iceland in 2016. Damage and distribution is similar to *H. unimaculella* but *S. betuleti* is active in the autumn so the birch opportunity to photosynthesize normally is even weaker.

A research project focusing on the susceptibility of different provenances of birch in Iceland to *H. unimaculella*, started in 2017. Birch measurements were conducted in South Iceland were 3150 birch plants of 42 different provenances of birch were planted in 1998. *H. unimaculella* was first introduced to Varmidalur in 2017, so the trees had not experienced *H. unimaculella* herbivory before that time. Height and damage of all living trees was measured. Damage of (I) *H. unimaculella* and (II) other herbivory was rated from 0-5, depending of how many leaves were infected.

First results show difference in *H. unimaculella* damage between provenances of birch in Varmidalur. However, no difference in other herbivory damage between provenances was detected. There was also positive relationship between the provenances mean tree height and *H. unimaculella* damage. A small pilot study in Mógilsá, Iceland indicated that trees that have early bud burst are more

susceptible to *H. unimaculella* leaf damage than those that have later bud burst. All this information may be useful for future birch provenances selection in Icelandic forestry.

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AshAdapt – Evolutionary potential of Fraxinus excelsior populations challenged by invasive pests and pathogens

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Poster Abstract

Ash dieback fungus (*Hymenoscyphus fraxineus*) is an invasive pathogen affecting native European ash (*Fraxinus excelsior*). The first European identification was in Poland in 1992, *H. fraxineus* has since devastated European ash in an ongoing outbreak, which has spread west through Denmark, identified in 2002, to the United Kingdom, where it was detected in 2012. Originating in south-east Asia, *H. fraxineus* is an ascomycete fungus, and is considered as a relatively benign forest endophyte/saprophyte in its native environment, where it has continuously co-evolved with Manchurian ash (*Fraxinus mandschurica*). In Europe, the incoming pathogen has spread rapidly with increased virulence on a naïve host and has been forecast to damage 95% of European ash over the course of the epidemic. Ash trees are visibly affected and the level of disease damage can be differentiated through field observations and ranked on a scale. In this study, we have undertaken a sampling campaign of European ash trees (*n*=500 trees) in clonal trials at fourteen sites across seven countries within Europe. We hypothesise that the signature of host resistance to ash dieback fungus is detectable at multiple loci throughout the genome. Using genome wide association studies (GWAS) we aim to correlate field observations of health scores with ash whole genome sequencing to reveal loci which confer resistance to ash dieback fungus. Subsequently, we aim to validate this data from natural ash populations (*n*=300 trees) in forests across Europe, again using a combination of phenotypic and genotypic analysis. Overall, we aim to identify the genomic basis of resistance to ash dieback fungus and provide key evidence to support the re-emergence of ash in European forests.

Host preference of *Phratora vitellinae* among *Populus trichocarpa* clones

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Poster Abstract

Since it´s colonisation in Iceland in 2005, *Phratora vitellinae* L. (Coleoptera: Chrysomelidae) has been dispersing rapidly and reportedly damaging trees and bushes from the family Salicaceae. Both *Salix* and *Populus* species play important role in Icelandic ecosystems and cultivation. *Populus trichocarpa*, Torr. & A.Gray ex. Hook, is one of the most used species in Icelandic forestry. Presently, an ambitious program is running with the aim to breed and select *P. trichocarpa* clones for future use in Icelandic forestry. In Iceland, *P. trichocarpa* is frequently attacked by *P. vitellinae*, causing severe leaf damage on trees that is likely to affect growth and may also make the trees more susceptible to frost damage.

We conducted two studies: (a) A field study where foliage damage caused by *P. vitellinae* was assessed in a clonal trial, where the total damage on each tree was classified as follows: 1 (up to 25%), 2 (25-50%), 3 (>50%). (b) A laboratory feeding trial where host plant selection of *P. vitellinae* beetles were tested with all possible leaf combination from ten *P. trichocarpa* clones.

In the field survey there was a clear difference in preference amongst clones; e.g. the clone Keisari got an average score of 3 while the clone Salka only got an average score of 1. The feeding trial included: (a) clones present in clonal trial, (b) commonly used clones and (c) clones from the breeding program. Seedlings from these clones were cultivated and the host selection of *P. vitellinae* beetles tested in the laboratory with all possible leaf combination from ten *P. trichocarpa* clones. The feeding area on each leaf was measured as well as the selection frequency. Our results showed a clear difference between clones. The clone Keisari had the highest average score for feeding area (17.1%) and selection frequency (61.1%). Clones S19 and Hve16 had very low scores for feeding area (3.0% and 3.1%) and selection frequency (20.8% and 19.4%). The product of our research will hopefully help growers to choose and breed clones of *P. trichocarpa* that are less susceptible to damages caused by *P. vitellinae*.

Predicting the health status of conifer trees using fourier-transform infrared (FT-IR) spectroscopy

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Poster Abstract

The status of forest health affects the growth and development of trees. The most problems faced by conifer trees are pest and disease (biotic stressor). *Heterobasidion annosum s.l.* influencing timber quality and cause economic losses is the main factor determining the forest health status of both Norway spruce and Scot pine in Finland. Fourier-Transform Infrared (FT-IR) spectroscopy is useful to identify between infected and healthy trees. This method involves non-destructive tree samples and is cheaper and more practical. The present study revealed that FT-IR distinguished between asymptomatic and symptomatic trees infected by *Heterobasidion* spp.

Keywords: Forest health, Norway spruce, *Heterobasidion annosum s.l.*, FT-IR spectroscopy

The occurrence of alleles of a resistance gene encoding leucoanthocyanidin reductase (PaLAR3) from Norway Spruce

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Poster Abstract

The pathogenic fungal species complex of *Heterobasidion annosum* s.l. is considered one of the most destructive pathogens in the boreal conifer forests of northern hemisphere. These fungal pathogens cause disease known as root and butt rot infection in conifers and known to cause huge annual economic losses exceeding €50 and €800 million in Finland and Europe, respectively. Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*) are mainly infected by *Heterobasidion annosum* s.s. and *Heterobasidion parviporum*, respectively. Despite of several efforts of implementing various control strategies to restrict the disease in practical forestry, including silviculture and biocontrol methods, the economic losses remain highly significant. Therefore, it is vital to introduce alternate environment friendly and sustainable biological control measures to protect forest trees against *Heterobasidion* infection.

Resistance or tolerance of spruce trees (*P. abies*) against *H. annosum* is known to be a quantitative trait that includes several quantitative trait loci (QTL). This disease resistance has been found to be linked to a resistance gene named as *PaLAR3* encoding leucoanthocyanidin reductase which is a QTL including different alleles that show variation in fungal growth in sapwood (FGS). Previously, research studies showed that there are two allelic lineages of PaLAR3 (A and B alleles) in Norway spruce (*P. abies*) of which B allele significantly restricts FGS. In this particular research study, the screening results of PaLAR3 gene in breeding population of *P. abies* seedlings indicated the presence of both allelic lineages (A and B alleles). In this study of 53 (~1600 seedlings) families of breeding lines (*P. abies*), 927 seedlings were found to be positive for A allele and 518 for both alleles A and B. The B allele was present only in 147 seedlings. Thus, the occurrence of B allele was found with a

low frequency of 23%. Moreover, the resistance appears not to be genetically related with any of the traits selected for in breeding (mainly growth rate in spruce). For future perspective, the results also suggest that breeders would be able to simultaneously improve disease resistance against *Heterobasidion* infection and other traits.

Key words: Heterobasidion, resistance gene PaLAR3, gene alleles, fungal growth

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