



Euphresco

Final Report

Project title (Acronym)
An International Plant Sentinel Network as an early-warning system; research on future pest threats (IPSN II)

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2. Short project report

2.1. Executive Summary

The overall goal of the project 'An International Plant Sentinel Network as an early-warning system; research on future pest threats (IPSN II)' was to develop early warning systems for regulated and emerging plant pests and to provide information that can help prevent their introduction and mitigate their impact.

The project focused on three main objectives:

- Enhancing early detection of regulated and emerging pests
- Supporting of Pest Risk Analysis
- Establishing a self-sustainable network of botanic gardens and arboreta to implement the above objectives after the end of IPSN II.

Botanic Gardens Conservation International (BGCI) coordinated the IPSN II project with funding from Department for Environment, Food and Rural Affairs (Defra) and scientific expertise from Fera Science Ltd. The Euphresco partners included experts from 16 institutions in Europe, Australasia and America representing botanic gardens and arboreta, universities, research institutes and National Plant Protection Organisations (NPPO's).

The IPSN was promoted by partners at national, regional and global events to botanic gardens and plant health professionals. The network was utilised to address knowledge gaps for a variety of regulated and emerging pests and diseases through a variety of surveys by NPPOs, Regional Plant Protection Organisations (RPPO's) and Euphresco members. Two national sentinel networks were created during the project in Australia and Belgium and the potential for developing additional national networks was scoped during the project.

Capacity building in botanic gardens and arboreta to support surveillance was a major activity of the project with partners carrying out workshops and training courses related to sentinel research and plant health to encourage monitoring for unknown threats, as well as known.

The IPSN will continue to be co-ordinated by BGCI and funded by Defra.

2.2. Project aims

The project's overall goal was to develop early warning systems for regulated and emerging plant pests; providing information that can help mitigate the impacts of such organisms or prevent their introductions altogether.

In order to do this, the project utilised its already established network of botanic gardens and arboreta, as well as the tools and resources developed in the first phase of the project (IPSN) and linkages with scientists and National Plant Protection Organisations (NPPOs) were consolidated during the project.

The Euphresco partners form a network of researchers contributing to sentinel research work. By working together, the partners provide access to an expanded pool of expertise, diagnostic services and infrastructures. Supported by BGCI, Euphresco partners worked to establish participation from and strong links to botanic gardens and arboreta within their own (and potentially neighbouring) countries. This has helped to build plant health capacity and capability within these institutes to support country-wide plant health surveillance.

The project focused on three main objectives:

1. **Enhancing early detection of regulated and emerging pests.** The IPSN II network aimed to raise awareness of plant health issues amongst botanic gardens and arboreta

(for first detection) through promotional activities at key events. The network aimed to aid early detection by botanic gardens and arboreta by providing communication tools, protocols and survey material. Further, partners aimed to build capability and capacity in botanic gardens and arboreta by providing training and implementing project activities to support surveillance; encouraging monitoring for unknown threats, as well as known.

2. **Supporting Pest Risk Analysis (PRAs)** through research coordination and evidence gathering to address knowledge gaps to support PRA activities. Facilitated by BGCI, partners had access to data from BGCI's unique databases showing the location of host species in gardens and a key IPSN resource, the Plant Health Checker (a survey form created during the project IPSN I). Euphresco partners aimed to utilise these resources to carry out multi-country surveys for priority organisms and host species using botanic gardens and arboreta (in specific countries/regions with particular host species) identified using BGCI's databases.
3. **Establishing a self-sustainable network.** Throughout Phase 1 of the IPSN a high level of support and coordination was required in order to establish the initial network and to develop the tools to allow the network to function efficiently. During IPSN II the coordination function, responsibilities and operations were reallocated to the members in order to share the workload. Pest surveillance and reporting were integrated into the normal working of botanic garden staff including through national sentinel networks.

2.3. Description of the main activities

The project had 6 main areas of activity:

- Project management and co-ordination
- Awareness raising and enhanced early detection
- Coordination and evidence gathering to address knowledge gaps
- Coordination and evidence gathering for forecasting emerging pests
- Building capacity and capability
- Creating a self-sustaining network

All project partners contributed to sentinel research in key areas of interest to their country/institute (Table 1). BGCI provided coordination to support their efforts and provided links between different partners where appropriate. All partners were responsible for the dissemination of key results from their specific research product, supported and coordinated by IPSN.

Table 1. A list of Euphresco project partners and their key activities

Institute	Activity
BGCI	<ul style="list-style-type: none"> ▪ Coordination, capacity building, dissemination
UNIVIE	<ul style="list-style-type: none"> ▪ Determine the best methodology for detection and identification of potential pests and invasive organisms ▪ Bringing the Austrian network of botanic gardens into the project
APM	<ul style="list-style-type: none"> ▪ Surveys and identification of emerging pests and selected pest organisms in Belgian Botanic Gardens and Arboreta, including laboratory testing by using molecular methods ▪ Face-to-face workshops for training garden staff and providing key networking opportunities



	<ul style="list-style-type: none"> ▪ Elaboration of a Belgian Plant Sentinel Network, integrated into the IPSN
UKZUZ	<ul style="list-style-type: none"> ▪ Raising awareness of new phytosanitary risks ▪ Developing a link between botanic gardens and diagnostic laboratories for diagnosis of new pests, including a simple communication tool ▪ Surveys and monitoring of regulated and emerging pests in arboreta and botanic gardens in the Czech territory
JKI	<ul style="list-style-type: none"> ▪ Further elaborate the 'trap plant approach' by refining protocols for choosing plant species, for planting and for assessing damage
CREA	<ul style="list-style-type: none"> ▪ Provide Italian botanic gardens and arboreta with information about new and emerging threats or susceptible host species ▪ Contribution to the development of training material related to arthropods and nematodes
RBGE	<ul style="list-style-type: none"> ▪ Risk assessment and sentinel research via systematic and responsive monitoring ▪ Public engagement and practitioner trainings focussed on biosecurity
APHI	<ul style="list-style-type: none"> ▪ Provide expertise in risk analysis, pest data information management, and official pest reporting requirements
UNITUS	<ul style="list-style-type: none"> ▪ Provide Italian botanic gardens and arboreta with information about new and emerging threats or susceptible host species ▪ Analysis of the structure of the fungal community of <i>Pinus</i> seeds from botanic gardens and/or arboreta in Europe and abroad
UdL	<ul style="list-style-type: none"> ▪ Surveys in the Lleida's Botanical Garden ▪ Develop training material related to arthropods, and arthropod pest surveys in botanical gardens in its geographical area ▪ Develop a Spanish Plant Sentinel Network
PHA	<ul style="list-style-type: none"> ▪ Access to the Virtual co-ordination Centre to the IPSN for collation and management of data
UCPH	<ul style="list-style-type: none"> ▪ Provide an overview of knowledge on the fate of plants introduced in national botanic gardens and arboreta and identify specific information regarding establishment ▪ Provide a list of native tree species for monitoring in third countries
B3	<ul style="list-style-type: none"> ▪ Identify third country gardens and arboreta with New Zealand native plants ▪ NZ sentinel plants located in "hotspots" where severe plant pest outbreaks are occurring ▪ Data on pest incidence and impact from sentinel plant locations collected, collated and analysed ▪ Coordinate and facilitate links with Chinese researchers and botanic gardens ▪ Work with Chinese collaborators to access information published in Chinese of value to NZ biosecurity and conservation authorities ▪ Develop a project for one or more Chinese –speaking students who could work in a reciprocal way to survey and identify plant pests and conduct research projects

SLU	<ul style="list-style-type: none"> Provide expertise in monitoring tree pests by the use of molecular methods
CABI	<ul style="list-style-type: none"> Database of pests on selected tree species in botanic gardens, across Europe and continents Identify number of trees and locations (i.e. botanic gardens) that should be included in surveys to obtain a representative overview of pests on a tree species

2.4. Main results

The main results of the project for each of the areas of activity are summarised below.

▪ Project management and co-ordination

Over the three years of the project, BGCI has coordinated the IPSN Euphresco network with funding from Defra. After the initial kick off meeting in Berlin, given the dispersed locations of the partners and the lack of funds for physical meetings, it was decided to focus on teleconferences as a means of staying in touch.

In 2018 the Euphresco network also had the opportunity to have an in-person meeting at the COST Action Global Warning [FP1401](#) project final conference. At the conference 'Sentinel Plantings for Detecting Alien, Potentially Damaging Tree Pests' more than 20 participants met to discuss their current and future work.

▪ Awareness raising and enhanced early detection

The IPSN was presented at various national, regional and global botanic garden conferences workshops and training courses. For example, the Central Institute for Supervising and Testing in Agriculture (CZ) organised a seminar on the IPSN in the Czech Republic that was attended by representatives from 21 botanic gardens and arboreta. The IPSN was also presented to plant health scientists and policy makers at the national and global level in the United Kingdom, Australia and during the side session of the Commission on Phytosanitary Measures-13 'Collaboration with research organizations' ([CPM-13](#)).

IPSN was involved in raising the awareness of the general public through botanic garden visitors. Both Auckland Botanic Garden (NZ) and the Royal Botanic Garden Edinburgh (GB) have created biosecurity related public awareness materials. In Auckland a 'biosecurity trail' highlights the risks associated with pests and educates visitors about not introducing them to New Zealand. In Edinburgh, the botanic garden has created an exhibition on biosecurity issues.

A volume of BGCI's in house publication BGjournal was created to coincide with the International Year of Plant Health 2020. Entitled 'Celebrating International Year of Plant Health: Botanic gardens and biosecurity', the publication included case studies from the IPSN network. The journal has been shared with BGCI's Member Gardens (over 500 institutions) and Euphresco partners, and is available for download from the [BGCI website](#).

At the 6th Global Botanic Garden Congress in 2017, several Euphresco partners (PHA, RBGE and CABI) were part of a symposium entitled 'Prevention is better than cure' providing an early warning system for new and emerging plant pests and diseases.

Through various meetings between Euphresco partners, several additional areas for future collaboration were identified. These included the development of training materials, including

e-learning modules, sharing of public outreach materials and potential topics for survey and research by botanic gardens. These topics were beyond the scope of the project, however they provide an opportunity for future collaboration of the network if funding can be secured.

- Coordination and evidence gathering to address knowledge gaps

Through IPSN, botanic gardens and arboreta in Belgium have surveyed tree species to address knowledge gaps on four known regulated plant pests. As a result of this surveillance, two of the targeted organisms were recorded for the first time in Belgium (Schmitz & Chandelier, 2018).

The IPSN carried out a spittlebug hunt, as this is a potential vector for *Xylella fastidiosa*, to provide information on spittlebug host plants. Following on from this, the Royal Botanic Garden of Edinburgh (GB) were involved in a vector monitoring programme in collaboration with the Science and Advice for Scottish Agriculture (SASA) the following year.

- Coordination and evidence gathering for forecasting future pests

The IPSN facilitated links between the COST Action FP1401 project and botanic gardens and arboreta. Collaboration involved identifying Chinese botanic gardens that have the following tree genera: *Quercus*, *Fagus*, *Nothofagus*, *Acer*, *Fraxinus*, *Pinus*, *Podocarpus*, *Picea*, *Abies* and *Eucalyptus* and organising access and permission for samples to be taken from species of these genera. Several Euphresco partners were involved in the COST action project.

Pest monitoring has been ongoing at Lleida Botanical Garden (ES), with good information found on the pest/host relationships of aphids, which are a particular problem.

The IPSN was utilised to identify and organise for the NZ Euphresco partner to visit botanic gardens and arboreta in Europe. The aim of these visits was to survey for pests and diseases including *Xylella fastidiosa*.

Work carried out at the Julius Kühn Institut (DE) involved utilising trap plants in botanic garden collections. These trap plants can act as attractors to new pests, thus providing important information on potential future pests.

Work by the University of Copenhagen (DK) focussed on the fate of exotic tree species in Danish botanic gardens and arboreta that have not survived and to determine if pests are the cause. This study was of interest to Euphresco partners in Germany and Belgium and work has initiated into implementing a similar study in Germany.

Work at Royal Botanic Garden Edinburgh (GB) monitored pathogens in soil to provide information on factors that lead to higher risks of disease and monitored diseases in exotic conifers of conservation interest. The study resulted in the first finding of a new species for the country (Hayden, 2020), and has uncovered and determined the cause of a fatal disease of an International Union for Conservation of Nature (IUCN) red-listed endangered conifer.

- Building capacity and capability

The IPSN II network ran 6 workshops in the United Kingdom and abroad. The workshops provided participants with a wealth of new knowledge, increasing their awareness of the threat from alien invasive species and the importance of biosecurity. The delegates shared experiences and best practices, developed networks, and discussed ways to disseminate the information more widely.

Several Euphresco partners ran training courses related to sentinel research. The national sentinel plant networks in Australia and Belgium ran training courses to botanic gardens and arboreta staff as part of their monitoring and surveillance activities. Partner RBGE was involved in training students and practitioners in plant diagnostics and botanic garden educators on plant health issues through the UK's Botanic Garden Educator's Network.

A variety of electronic materials that were made available to the Euphresco network were developed by BGCI (Table 1). Resources on the IPSN were utilised by the project partners to provide information on the IPSN II at various events. Resources created by Euphresco partners were also made available including a poster on the Biosecurity Role of Auckland Botanic Gardens and a French and Dutch version of the Plant Health Checker. These resources are freely available through the members area of the IPSN website. An example of the English version of the Plant Health Checker can be seen in Annex 1.

Table 1. A list of electronic materials that are available on the IPSN website

Pest and disease identification guidance	IPSN Guide to Bleeding Trees IPSN Guide to Damage by Leaf Eaters IPSN Guide to Submitting Physical Samples
Biosecurity guidance	IPSN Guide to Biosecurity in BG&A IPSN Guide to Plant Health Governance
Monitoring and surveying guidance	Plant Health Checker for Broadleaf Trees Plant Health Checker for Coniferous Trees IPSN Guide to Taking Photographs for Diagnostic Purposes Individual fact sheets and survey forms for various pests and pathogens
Presentations	An Introduction to the IPSN
Posters	IPSN Overview Poster Poster Template for Emerging Pests and Pathogens New and Emerging Pests of Trees (individual posters for multiple tree species) <i>Xylella fastidiosa</i> : a New and Emerging Disease of Concern Rose Rosette Virus: a New and Emerging Disease of Concern <i>Sirococcus</i> Blight of Cedars: a New and Emerging Disease of Concern Spittlebug Poster
Other	IPSN Overview Handout IPSN Overview Leaflet

- Creating a self-sustaining network

Through the Euphresco partnership, two countries - Australia and Belgium set up their own national sentinel networks for monitoring and surveillance of plant pests. The IPSN was used as a model for these national networks and provided guidance on how to make them successful. The Belgian national network surveillance already resulted in 2 of the targeted organisms being recorded for the first time in the country.

In Spain and the Czech Republic initial steps to implementing a national network were taken including outreach to botanic gardens and arboreta regarding the IPSN.

Over 50 botanic gardens are currently members of the IPSN and the network continues to grow with new members joining the IPSN.



2.5. Conclusions and recommendations to policy makers

The IPSN represents an important research resource for sentinel research that NPPOs and RPPOs should utilise going forward. It represents a successful example of a centrifugal (and reciprocal) approach where information gained in one country could contribute to prevent introduction in other countries (and vice-versa) and on which future research should lever (Euphresco Strategic Research Agenda).

The databases hosted by BGCI (GardenSearch and PlantSearch) contains information on over 3,000 institutions with plant collections information for over 1,000 of them, representing 30% of known plant diversity. The databases are updated periodically by botanic garden record managers. These open access databases can be utilised by NPPOs and RPPOs with support from BGCI to identify host species of interest growing outside of their natural regions on a global scale. Botanic garden staff, if provided with the right training, can support the work of NPPOs by monitoring and surveillance of plants in botanic garden and arboreta collections.

The plant collections of botanic garden and arboreta are an important resource to plant health issues. Monitoring plants growing outside their native regions provides a valuable opportunity to increase knowledge of new pest-host relationships and provide an opportunity to identify 'unknowns' and future threats.

It is recommended that NPPOs:

- Familiarise themselves with the range of species cultivated in the botanic gardens and arboreta of their countries
- Take steps to work with and build capacity of botanic garden staff to carry out pest surveillance on plants in their collections
- Take note of new pest-host relationships identified in botanic garden collections and share this information internationally as part of an early warning system
- Participate in the IPSN by identifying and communicating requests for surveys on pests of interest in third-party countries.

2.6. Benefits from trans-national cooperation

The IPSN enabled the strengthening of links between researchers involved in sentinel research. The IPSN was utilised for a variety of surveys including from NPPOs and RPPOs. These included surveys from New Zealand on *Xylella fastidiosa*, from EPPO on *Massicus raddei* and *Agilus fleischeri*, from Australia on *Melaleuca sp.*, from Slovakia on *Erysiphales* and from the United Kingdom on 3 priority groups of interest including *Rose Rosette Virus*. In addition to this, the IPSN was involved in providing network contacts to researchers as part of the COST action on sentinel plantings.

Through the IPSN II project, partners have been able to share information on current research activities on pests such as *Xylella fastidiosa*, *Halyomorpha halys*, Myrtle Rust and *Sirococcus tsugae*.

The Australian Plant Sentinel Network included an R&D priority research pest (RRV) as part of their surveillance activities.

The IPSN has received funding from Defra to continue its coordination of the network and to carry out research activities related to the UK risk register. BGCI will continue to work with Euphresco partners in Australia and New Zealand on these activities.

At the final Euphresco partners meeting, the partners requested that the teleconference meetings continue to take place on a voluntary basis past the end date of the Euphresco

project. The interest in these future meeting highlights the importance and benefits of international cooperation.

IPSN resources, such as the Plant Health Checker (Annex 1), were shared with Euphresco partners and were modified by partners for use, including being translated into French and Dutch as well as being made available in Chinese. The sharing of resources was reciprocal, with resources created by the Euphresco partners being shared within the network and being made available on the [IPSN website](#).

The IPSN allowed links to be created between plant health professionals and botanic gardens and arboreta in order to federate communities that classically do not work together with the goal to support surveillance and aid research activities.

3. Publications

3.1. Article(s) for publication in the EPPO Bulletin

None.

3.2. Article for publication in the EPPO Reporting Service

None.

3.3. Article(s) for publication in other journals

- Eschen R, O'Hanlon R, Santini A *et al.* (2019). Safeguarding global plant health: the rise of sentinels. *J Pest Sci* 92, 29–36. DOI <https://doi.org/10.1007/s10340-018-1041-6>
- Hayden K (2020). Botanic gardens and plant pathogens: A risk-based approach at the Royal Botanic Garden Edinburgh. *Sibbaldia*, 18 (Special Issue: Plant Health), 127–139.
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4. Open Euphresco data

Database of living plant, seed and tissue collections (hosted and maintained by BGCI)

https://tools.bgci.org/plant_search.php

Database on botanic gardens (hosted and maintained by BGCI)

https://tools.bgci.org/garden_search.php



Annex 1. Plant Health Checker



International Plant Sentinel Network

Plant Health Checker - Step 1

Name of Botanic Garden / Arboretum:	
Country:	
Address:	
Name of IPSN contact:	
Survey carried out by:	
Date of survey:	
Best description of season:	
Main reason for surveying this particular individual:	
Plant details	
Species (Cultivar):	
Accession number:	
GPS	
Country/region species is native to:	
Age/amount of time plant has been present in gardens:	
General Comments:	
General description (please tick)	
Generally healthy	Some damage
Dying	Dead
Any recent changes in health or overall look:	

General description of environment

Any management issues (e.g. irrigation, soil pH, sun bleaching) or any recent use of pesticides/fungicides/herbicides:

Description of environment (focusing on recent changes and individuals in close proximity):

For each section of the plant give it a rating dependent on how healthy it appears:

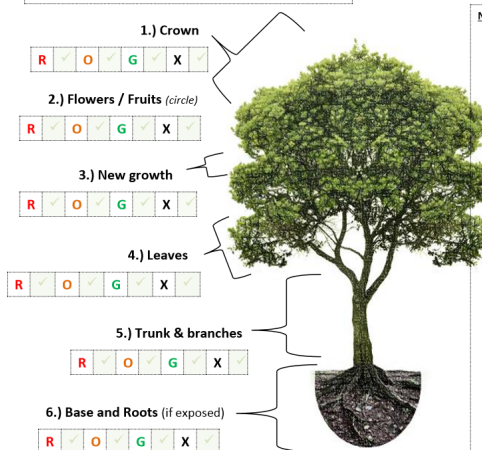
Red (R) = In very poor health and of imminent concern due to significant damage potentially resulting in death of individual

Orange (O) = Not currently a concern but could develop; should be checked frequently to monitor progress

Green (G) = As would be expected on a 'healthy plant'

Black (X) = Absent/not applicable

Where an **orange** or **red** rating is given, ensure you give a description of why you've given it this rating in notes.



1.) Crown	R	O	G	X
2.) Flowers / Fruits (circle)	R	O	G	X
3.) New growth	R	O	G	X
4.) Leaves	R	O	G	X
5.) Trunk & branches	R	O	G	X
6.) Base and Roots (if exposed)	R	O	G	X

Notes:

What do you think is wrong with this plant? (give an indication of how sure you are of this diagnosis)		Reference/file name of any photographs taken:	
1.) Is a re-survey required?	2.) If yes, in what timeframe (include a suggested date)	3.) Should this be escalated to an appropriate staff member to carry out STEP 2?	4.) Name of person escalated to (if applicable):
		5.) Date:	

Broadleaf trees

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Accession number:

Plant Health Checker - Step 2

Please read: This section should be completed if escalation is specified by STEP 1. It should be carried out by an appropriately trained staff member who has the relevant knowledge concerning the plant's history and/or pest and pathogen identification skills.

Tick all signs/symptoms that are at abnormal levels or are unexpected for the individual, and are thus cause for concern (e.g. are out of the ordinary/new to the plant). Give a description and an indication of severity/abundance in the **notes**, plus note anything else of importance or interest.

1. Crown	
Thin / sparse	Notes:
Yellow leaves	
Dead wood	
2. Blossom/Flowers	
Dead	Notes:
Malformed	
Swollen	
3. New Growth (Shoots and Buds)	
Dead	Dieback
Wilted	Malformed
Notes:	
4. Leaves	
Dead	Malformed
Smaller than expected (stunted)	Mosaics / mottled / variation in colour
Sticky	Galls
Rust	Mildew

4. Leaves continued (leaf spots)

Single	Numerous
Present only at the edge	All over leaf
Only on old growth	Only on new growth
Yellowing (chlorotic leaves)	Brown/blackening (necrotic leaves)

Notes:

5. Trunk & Branches

Canker or lesion	Approx. number
Dry	Gummy/sticky
Approx. height of canker from ground (m)	
Galls	Approx. size (m)
Trunk bleeding ('weeping patches')	
Approx. height of bleed from ground (m)	
Approx. number of bleeds over trunk	
Vertical bleeds (in a line up the trunk)	Horizontal bleeds (around the trunk)
Loose Bark / bark flaking / comes off easily	

Notes:

6. Base and Roots (if exposed)

Bootlaces/black strands (1-2mm wide)	
Fungal mycelium/white strands	
Mushrooms/toadstools on plant	
Damage by mammals	Notes:
Decay / Rotting	
Wet	Dry

Survey completed by: Date:

7. General pest damage		Location (e.g. leaf)	
Insect galleries under loose bark			
Insect eggs			
Chewing damage			
Insect webbing			
Insect mines			
Frass			
Bore holes (circle below)			
<5mm	5-10mm	>15mm	

Notes:

8. Pest sightings (give an indication of how sure you are of this identification)		Location (e.g. leaf)	Photo (file name)

9. General Observations and Additional Notes

Reference/file name of any photographs taken:

What do you think is wrong with this plant? (give an indication of how sure you are of this diagnosis)		1.) Is a re-survey required?	2.) If yes, in what timeframe (include a suggested date)
3.) Should this be reported to the local diagnostic laboratory - a physical sample may be required (this is only if symptoms are severe or if a pest of concern)	3.) Date reported:	4.) Should this be escalated to local National Plant Protection Organisation (NPPO)? (as advised by local diagnostic laboratory)	5.) Date reported:

Broadleaf trees

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