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Surveillance guide

A guide to understand the principal requirements of surveillance programmes for national plant protection organizations

Second edition

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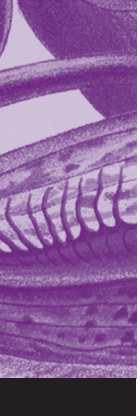
Foreword

Surveillance is an essential component in national phytosanitary systems . Article IV of the IPPC prescribes general provisions for the organizational arrangements for national plant protection and specifically states that the responsibilities of an official national plant protection organization shall include "the surveillance of growing plants, including both areas under cultivation and wild flora, and of plants and plant products in storage or in transportation, with the object of reporting the occurrence, outbreak and spread of pests, and of controlling those pests (ISPM 6, 2018).

ISPM 6 (*Surveillance*) is the International Standard for Phytosanitary Measures relating to plant health surveillance, and describes the requirements for surveillance and the specific requirements and components of a national surveillance system. ISPM 6 (*Surveillance*) was adopted by the Thirteenth Session of the Commission on Phytosanitary Measures in April 2018 after three years of consultation and revision, and replaced the original ISPM 6 (*Guidelines for surveillance*) that was adopted by the 29th Session of the FAO Conference in 1997.

While this guide was developed and published in 2016 (during the review and drafting of the ISPM 6 revision), a review by the expert group in 2020 concluded that the guide was still technically valid and aligned with ISPM 6 (*Surveillance*) adopted in 2018. This guide therefore provides current and appropriate guidance to contracting parties in the requirements for surveillance and the components of national surveillance systems.



Definitions used

Area of low pest prevalence
An area, whether all of a country, part of a country, or all or parts of several countries, as identified by the competent authorities, in which a specific pest is present at low levels and which is subject to effective surveillance or control measures [IPPC, 1997; revised CPM, 2015]

Detection survey
Survey conducted in an area to determine if pests are present [FAO, 1990; revised FAO, 1995]

General surveillance
A process whereby information on pests of concern in an area is gathered from various sources. Sources may include national or local government bodies, research institutions, universities, museums, scientific societies (including those of independent specialists), producers, consultants, the general public, scientific and trade journals, unpublished data, and the websites of other NPPOs or international organizations (e.g. the IPPC, regional plant protection organizations, the Convention on Biological Diversity). [ISPM 6, 2018]

Monitoring survey
Ongoing survey to verify the characteristics of a pest population [FAO, 1995]

National plant protection organization
Official service established by a government to discharge the functions specified by the IPPC [FAO, 1990; formerly "plant protection organization (national)"]

Pest
Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products [FAO, 1990; revised FAO, 1995; IPPC, 1997; revised CPM, 2012]

Pest free area
An area in which a specific pest is absent as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained [FAO, 1995: revised CPM; 2015]

Pest free place of production
Place of production in which a specific pest is absent as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period [ISPM 10, 1999; revised CPM, 2015]

Pest free production site
A production site in which a specific pest is absent, as demonstrated by scientific evidence, and in which, where appropriate, this condition is being officially maintained for a defined period [ISPM 10, 1999; revised CPM, 2015]

Pest risk analysis (agreed interpretation)
The process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it [FAO, 1995; revised IPPC, 1997; ISPM 2, 2007]

Phytosanitary legislation
Basic laws granting legal authority to a national plant protection organization from which phytosanitary regulations may be drafted [FAO, 1990; revised FAO, 1995]

Point of entry
Airport, seaport, land border point or any other location officially designated for the importation of consignments, or the entrance of persons [FAO, 1995; revised CPM, 2015]

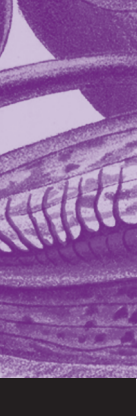
Quarantine pest
A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled [FAO, 1990; revised FAO, 1995; IPPC, 1997]

Regulated pest
A quarantine pest or a regulated non-quarantine pest [IPPC, 1997]

Specific surveillance
a process whereby information on pests of concern in an area is obtained by the NPPO over a defined period. NPPOs actively gather specific pest-related data. Specific surveillance includes surveys that are conducted to determine the characteristics of a pest population or to determine which species are present or absent in an area. [ISPM 6, 2018]

Surveillance
An official process which collects and records data on pest presence or absence by survey, monitoring or other procedures [CEPM, 1996; revised CPM, 2015]

Note: IPPC definitions are sourced from the IPPC *Glossary of phytosanitary terms* (ISPM 5). The glossary is updated annually based on decisions taken by the IPPC Commission on Phytosanitary Measures. The complete and updated glossary is maintained at: http://www.ippc.int/publications/glossary-phytosanitary-terms. The definitions are accurate as of April 2021.



Abbreviations and acronyms

ALPP	Area of low pest prevalence
CDC	Capacity Development Committee (of the IPPC)
CEPM	Committee of Experts on Phytosanitary Measures
CPM	Commission on Phytosanitary Measures
EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization of the United Nations
GIS	Geographic information system
GPS	Global positioning system
HLB	Huanglongbing disease
IC	Implementation and Capacity Development Committee (of IPPC)
IPPC	International Plant Protection Convention
ISPM	International Standards for Phytosanitary Measures
LoA	Letter of agreement
M&E	Monitoring and evaluation
MoA	Memorandum of agreement
MoU	Memorandum of understanding
NPPO	National plant protection organization
PCN	Potato cyst nematodes
PFA	Pest free area
PFPP	Pest free place of production
PFPS	Pest free production site
PRA	Pest risk analysis
RPPO	Regional plant protection organization
SOP	Standard operating procedure
SPS	Agreement on the Application of Sanitary and Phytosanitary Measures of the WTO
STDF	Standards and Trade Development Facility
WTO	World Trade Organization

Section 1: Introduction

International Standards for Phytosanitary Measures (ISPM) No. 6 (*Surveillance*) refers to "the requirements for surveillance, including the components of a national surveillance system. Surveillance is an obligation of a national plant protection organization (NPPO) and provides a technical basis for many phytosanitary measures such as phytosanitary import requirements, pest free areas, pest reporting and eradication, and pest status in an area. It is a critical part of the national phytosanitary system. Plant pest surveillance thus plays a key role in the overall mandate of the NPPO and is required by Article IV.2(b) of the International Plant Protection Convention (IPPC).

A national plant pest surveillance programme should be conducted in such a way that its results are accurate, credible and contribute to national goals and priorities. Management support is critical to a strong, sustainable programme. This guide addresses aspects of policy and management, which together should outline the rationale for the establishment of a national plant pest surveillance programme. In order to be successful, a programme needs to be underpinned by legislation, effective coordination, management, communication and training. In some cases, capacity development may be needed to ensure these requirements can be met.

Surveillance activities can be expensive. However, as activities that support national phytosanitary policy, the benefits will invariably outweigh the costs.

Article IV.2 of the IPPC makes the following provisions in relation to organizational arrangements for national plant protection:

The responsibilities of an official national plant protection organization shall include the following:

[...]

(b) the surveillance of growing plants, including both areas under cultivation (*inter alia* fields, plantations, nurseries, gardens, greenhouses and laboratories) and wild flora, and of plants and plant products in storage or in transportation, particularly with the object of reporting the occurrence, outbreak and spread of pests, and of controlling those pests, including the reporting referred to under Article VIII paragraph 1(a);

[...]

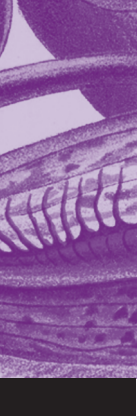
(e) the protection of endangered areas and the designation, maintenance and surveillance of pest free areas and areas of low pest prevalence

Article VII.2 of the IPPC makes the following provisions in relation to imports:

In order to minimize interference with international trade, each contracting party, in exercising its authority under paragraph 1 of this Article, undertakes to act in conformity with the following:

[...]

(j) Contracting parties shall, to the best of their ability, conduct surveillance for pests and develop and maintain adequate information on pest status in order to support categorization of pests, and for the development of appropriate phytosanitary measures. This information shall be made available to contracting parties, on request.



1. National organizational arrangements

National organizational arrangements for a functional NPPO differ between contracting parties and discharging their functions may therefore require different systems of management. Plant pest surveillance is one of those functions that may be organized on the basis of the structure and capacity of the NPPO. Here are three examples of different organizational arrangements that would affect how surveillance is managed.

1.1 NPPO as a quarantine section within a plant protection department

In countries with limited resources, in particular, there may be a shortage of trained personnel and resources within the NPPO. National legislation or administrative instruments may require that other sections of the ministry, or institutions of the country (e.g. research or phytosanitary diagnostic laboratories), carry out surveillance. Some national industry boards and research institutions may also be engaged in surveillance activities. The management challenge for the NPPO becomes one of coordination among the various units involved to ensure accountability, timely implementation, reporting, information sharing and ensuring that protocols are consistent with the IPPC, ISPMs and guidelines.

The NPPO may have limited flexibility to respond to emergencies, to negotiate with partners such as universities or research institutions in the country, and to seek external funding from trading partners. In this case, the NPPO should clearly identify the importance of such partnerships and solicit the government's full support to put measures in place to engage these institutions and allocate funding for phytosanitary emergencies.

It is essential to prioritize activities to match the level of predictability and availability of funding provided by the government for plant pest surveillance activities. The NPPO and any surveillance committee needs to carefully consider cost–benefit implications for all aspects of the programme in order to optimize the allocation of resources.

1.2 Semi-autonomous and autonomous NPPOs

Semi-autonomous and autonomous NPPOs are usually well-defined institutions with competencies and capabilities for fulfilling the functions of the NPPO and are able to manage their surveillance programmes. They are characterized by:

- independence and flexibility to establish necessary systems and policies to effectively implement their functions;
- power to choose to contract surveillance to a third party while maintaining responsibility;
- budgetary independence and flexibility in allocation of resources; and
- ability to attract their own funding from stakeholders.

These types of NPPO can therefore establish a national programme based on their government's priorities, with access to the necessary resources to fund these priorities.

1.3 Integrated institutions

Integrated institutions cover a regulatory sanitary and phytosanitary framework (animal health, plant health and food safety); they are sometimes referred to as biosecurity agencies. They are normally characterized by:

- providing technical and managerial support for each programme;
- acting as an umbrella agency responsible for procuring funding and other resources;
- relationships and collaboration with external agencies; and
- having a framework for management of emergencies and crises, and management of pest incursions or outbreaks.

2. Surveillance approaches and application

ISPM 6 (*Surveillance*) recognizes two kinds of surveillance: general surveillance and specific surveillance.

2.1 General surveillance

General surveillance is defined in ISPM 6 as "a process whereby information on particular pests which are of concern for an area is gathered from many sources, wherever it is available and provided for use by the NPPO".

General surveillance should:

- support NPPO declarations of pest status;
- provide information on the early detection of exotic pests;
- report to other organizations, such as other NPPOs, regional plant protection organizations (RPPOs) and the Food and Agriculture Organization of the United Nations (FAO); and
- compile host and commodity pest lists and distribution records.
- Outcomes of general surveillance may include:
- the imposition or lifting of quarantines based on the knowledge gained; and
- the design of a specific surveillance activity if more information about a pest is needed within a geographic region.

2.2 General surveillance approach and application

According to ISPM 6, a general surveillance approach should include the following.

2.2.1 Sources of information

These may include: NPPOs, other national and local government agencies, research institutions, universities, scientific societies (including amateur specialists), producers, consultants, museums, the general public, scientific and trade journals, unpublished data and contemporary observations. In addition, the NPPO may obtain information from international sources, such as FAO, the IPPC, RPPOs, etc.

2.2.2 Collection, storage and retrieval of information

To use data from these sources, it is recommended that NPPOs develop a system for collecting, verifying and compiling pest information.

Components of such a system should include:

- the NPPO or another institution designated by the NPPO acting as the national repository for plant pest records;
- a record-keeping and retrieval system;
- data verification procedures; and
- communication channels to transfer information from the sources to the NPPO.

Components of such a system may also include incentives to report, such as:

- legislative obligations (for the general public or specific agencies);
- cooperative agreements (between the NPPO and specific agencies);
- use of contact personnel to enhance communication channels to and from NPPOs; and
- public education and awareness programmes.

2.2.3 Use of information

Information gathered through such general surveillance will most often be used to:

- support NPPO declarations of pest freedom;
- aid in the early detection of new pests;
- report to other organizations such as RPPOs and the IPPC Secretariat; and
- compile host and commodity pest lists and distribution records.

An NPPO should establish a general surveillance activity as part of its regular work programme. This would involve:

- designating staff to compile, screen and analyse comprehensive pest information from diverse sources, as appropriate; keeping pest status information updated; establishing and maintaining a system to store, analyse and retrieve data;
- ensuring that third parties involved in surveillance are aware of the need to cooperate with the NPPO, particularly for pest reporting – designated staff

would ensure that agreements made with such third parties are updated, amended, monitored, issued, reviewed and revoked, as necessary;
- establishing a reporting system internal to the NPPO as well as a reporting system for external inputs from third parties; and
- establishing a system to analyse and validate information compiled through this activity before official reports are made to other contracting parties – this could be done through sector-specific groups, scientific panels, etc.

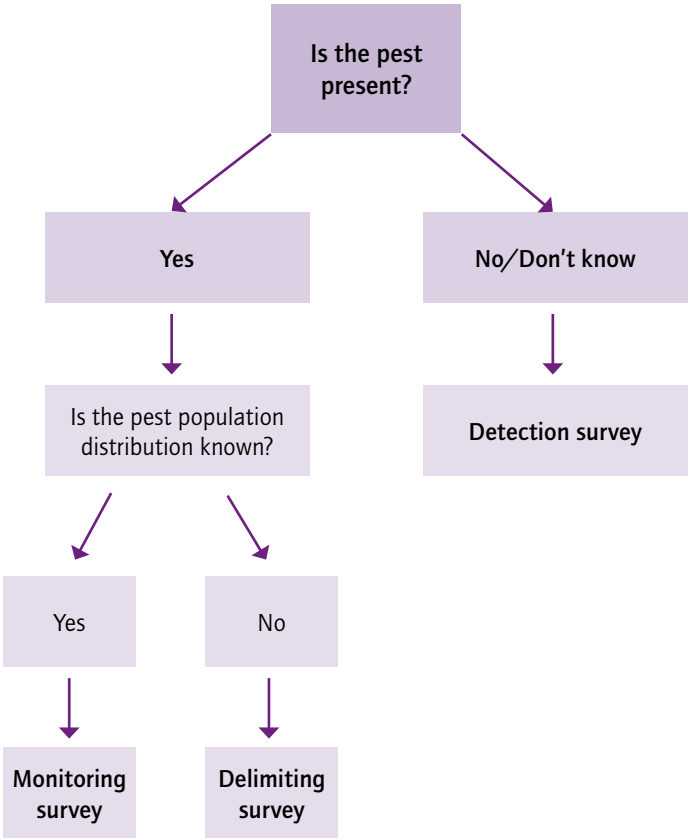
2.3 Specific surveillance

ISPM 6 defines specific surveillance as "a process whereby information on pests of concern in an area is obtained by the NPPO over a defined period. NPPOs actively gather specific pest-related data. Specific surveillance includes surveys that are conducted to determine the characteristics of a pest population or to determine which species are present or absent in an area".

Specific surveillance may be focused on a pest or on a host or commodity. Types of specific surveillance include:
- detection
- delimiting
- monitoring.

Specific surveillance outcomes should:
- support NPPO declarations of pest freedom;
- aid in the early detection of exotic pests; and
- assist in reporting to organizations, such as other NPPOs, RPPOs and FAO.

Figure 1. Decision support process for planning pest surveillance



Section 2: Organizational arrangements

The building blocks for a national plant pest surveillance system

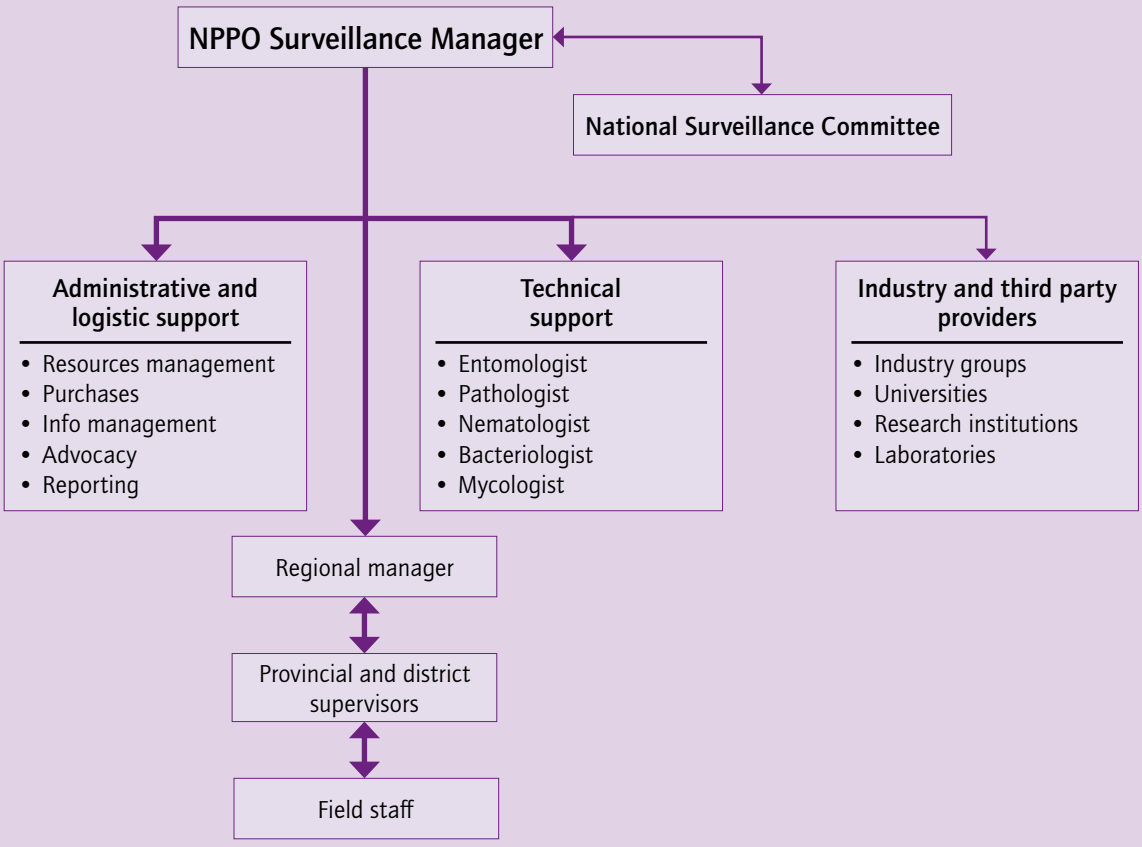
Organizational arrangements for a functional NPPO differ between contracting parties, and discharging these functions may therefore require different systems of management. Surveillance is one of those functions that may be organized on the basis of the structure and capacity of the NPPO. Examples of organizational arrangements are given in the IPPC manual Establishing a National Plant Protection Organization (IPPC, 2015) and may impact on how surveillance is managed.

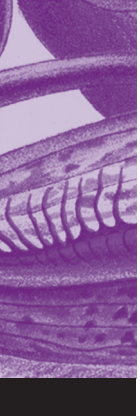
Regardless of the national institutional structure, an NPPO can establish a national surveillance programme on the basis of its government's priorities, with access to the required resources.

An appropriate management structure needs to be established for a surveillance programme.

Figure 2 is a conceptual plan that may be adapted to suit national institutional structures. It suggests the need for a national pest surveillance manager with an appropriate line of command through regional, state, provincial and field staff. It shows the relationship between manager and administrative and logistic support unit, and the technical support unit. Where appropriate, there may be a relationship established between the NPPO and third-party providers and industry where they are required to provide services on behalf of the NPPO. Appointment of a national surveillance committee may also be appropriate in some countries.

Figure 2. Conceptual organization of a management structure for a national surveillance programme





3. National legislation

Appropriate national phytosanitary legislation and policies or official procedures are basic requirements for supporting activities of a surveillance programme. National legislation should have clear provisions related to assignment of authority, financial resources and responsibilities to appropriate administrative levels.

Legislation, policies or official procedures should ensure the following:

- It provides legal authority and responsibility to the NPPO and authorized entities for all surveillance activities (e.g. the right to enter premises, inspect, take samples) in support of the IPPC Article IV.2(b), which requires NPPOs to be responsible for the surveillance of plants.
- Establish and maintain diagnostic facilities or provide appropriate access to up to-date diagnostic services.
- Ensure mandatory domestic reporting to the NPPO on detection or suspected presence of targeted pests as well as pests new to an area, host or pathway to report the occurrence, outbreak and spread of pests. Authority and responsibility should be supported by formal pest exclusion mechanisms to prevent the introduction of pests of phytosanitary concern entering the country, as well as to prevent pest movement into endangered areas such as pest free areas (PFAs), areas of low pest prevalence (ALPPs) and areas that are under official control. Surveillance policies should also cover responsibilities related to administration, finance and governance within the NPPO, including funding for surveillance activities, procedures for surveillance deliverables as well as training and qualification of personnel. Provincial or state legislation, where appropriate, is consistent with and supports national legislation to avoid impediments to implementation of surveillance activities.
- Provisions are made for third party institutions and personnel acting on behalf of the NPPO, for example:
  - mechanisms of engagement (e.g. letter of agreement (LoA), memorandum of understanding (MoU), contracts);
  - mechanisms for recognizing and dealing with conflicts of interest;
  - level of accountability to the NPPO; and
  - redress in cases of breach of trust or contract.
- Staff involved in surveillance programmes are legally protected in performing their duties (e.g. against accidents, trespass charges, physical attacks).
- Confidentiality in use of data is maintained.

4. Funding and sustainability

The cost of running an effective national plant pest surveillance programme can be very high and funding from government budgets alone may not be sufficient. Collaboration between the government and stakeholders may be needed to ensure that adequate funding is available. Stakeholders such as industry and producers often contribute to surveillance efforts where the benefits to them can be clearly demonstrated.

Sustainability should also be considered, including, for example:

- adequate resources and a predictable source and level of funding are essential;
- adequately trained and sufficient staff;
- supporting diagnostic institutions are adequately equipped and diagnostic procedures are consistent to ensure accurate identification, verification and storage of specimens; and
- appropriate information management systems are current and adequate to allow for data analysis, accessibility and sharing of information
  - the information management system should be supported by a structure that facilitates data collection and collation.

4.1 Potential sources of funding

4.1.1 Government-funded national plant pest surveillance programme

A government may absorb the total cost of a national plant pest surveillance programme, particularly when it is seen as a public good. Measures or actions are usually trade-driven and directed at a specific commodity. Or they may impact a wider range of plants and their products, so that economic impact is broadly shared. These measures or actions are often implemented as very structured programmes under the responsibility of the NPPO.

4.1.2 Industry funding

Strong and well-established industries (e.g. coffee, tea, banana, rice) may fund plant pest surveillance operations completely if they stand to benefit from such investments through market access or improved food quality. Where market access is the desired outcome, a strong collaboration may be established with the NPPO so that their procedures conform to international standards.

4.1.3 Joint funding between government and industry

- Appropriate arrangements are made between government and industry to address priorities through a cost-sharing platform.
- Partial investment cost is provided as a start-up incentive for specific programmes. This may hold true for cases where the establishment of a PFA or ALPP are the most appropriate pathways for market access.
- Cost-sharing between the government and the stakeholder (e.g. private-sector producer): contributions may be financial or in-kind (e.g. related to oversight, supervision or the production and dissemination of guidance materials to industry).

4.1.4 Technical cooperation to facilitate trade

An importing country or potential importing country that has a strong interest in importing a commodity from a country where it is evident that risks cannot be adequately managed without additional measures may choose to fund the cost of specific surveillance in order to help mitigate risks associated with the imported commodity.

4.1.5 Loans or grants

A government or autonomous NPPO may obtain a loan or grant from a donor country, or from national or international lending institutions in cases where very clear surveillance targets can be met and can be seen to result in significant benefits to the country.

4.1.6 Technical assistance programmes

Institutions involved in capacity building in developing countries generally have technical assistance programmes to respond to specific and urgent requests that meet certain criteria, including opportunities for trade or food security. FAO, the IPPC and the Standards and Trade Development Facility of the World Trade Organization (WTO), for example, have mechanisms to provide technical assistance in support of the enhancement of phytosanitary capacity that may include national plant pest surveillance. These may require counterpart contributions in kind.

4.1.7 Contingency and other emergency funds

The capability of the NPPO to access extra-budgetary financial resources in order to respond to phytosanitary emergencies (e.g. an introduced quarantine pest to be contained or eradicated, pest outbreaks, and compensating growers whose farms may be quarantined or where crops are subject to destruction or other actions that impact the livelihoods of producers) or emerging issues is very important. It is prudent to establish a contingency fund with substantial resources from extramural sources and from government, industry and other stakeholders to deal with emergencies.

5. Management

5.1 Strategy

The rationale for the establishment of a national plant pest surveillance strategy should relate directly to national priorities regarding trade and protection of plant resources and the environment. The creation of a clear vision provides an NPPO with a tool for encouraging broad support by setting out what is going to happen and what will be achieved. The strategy should ensure the highest level of cooperation, national response and participation. In this regard, pest surveillance is a critical part of a national phytosanitary system that, for example, allows an NPPO to:

- detect and monitor pest threats in order to prevent their introduction and to manage them if they become present in the country – this can be achieved by using:
  - pest alerts
  - unofficial and official information regarding the occurrence or changing status of a pest for which a pathway has been identified
  - reports in the press
  - scientific but unofficial reports
  - published data;
- maintain and enhance market access and international trade by collecting and providing current surveillance data on the status of pests associated with commodities that are being or will be traded;
- gain the confidence of trading partners by ensuring the availability of current and reliable data on pest status in the country;
- support the preparation and updating of regulated pest lists and technically justifiable import requirements;
- put in place phytosanitary improvement measures in the context of national programmes, including those that relate to the establishment and maintenance of PFAs, pest free places of production (PFPPs), pest free production sites (PFPSs) and ALPPs where specific conditions must be met in order to support exports; and
- Enhance food security and protect the environment through effective monitoring of threats to national plant resources.

5.2 Authority

The NPPO assumes all responsibilities for the plant pest surveillance programme. Clearly defined lines of command and delegation of different levels of authority must be addressed for a successful programme. In a decentralized system, levels of authority may be delegated to national, state, province, county and district levels so that there is a well-coordinated programme throughout the target areas.

The NPPO may authorize relevant institutions and personnel to work under its authority, but the NPPO in all cases maintains responsibility for all actions taken on its behalf.

5.3 Responsibilities

Responsibilities include:

- defining the programme
- selecting and approving partners
- public awareness
- training
- preparation of training materials and protocols
- implementation
- information management and communication.

The NPPO should take overall responsibility for management and coordination and, *inter alia*, may:

- appoint a national surveillance manager and regional or provincial managers where decentralized management and supervision are necessary; and
- establish a national plant pest surveillance committee that includes key stakeholders but is managed by the NPPO.

5.4 Planning

Specific activities to be considered may include procurement and distribution of tools and equipment, trapping, sampling and transport.

- Consistency, credibility and sustainability in approaches should be maintained across all regions and among all actors:
  - all supervisors, regional and sub-regional managers and field staff use the same operating procedures
  - supervision and auditing are at the same level
  - access to the same support services
  - vehicles for timely transporting and sampling.
- Procedures and methodologies should be determined and standardized in their use, for example:
  - sampling and collection procedures
  - trapping densities
  - trap servicing
  - transporting samples
  - preparing samples for identification. The NPPO should:
- establish documented procedures to ensure consistency at all levels of the operations;
- ensure that adequate management systems are in place for the efficient and effective storage, retrieval and distribution of information; and
- ensure that adequate supporting systems, institutions and personnel are identified and engaged for:
  - diagnostics
  - reference collections
  - quality control (standard operating procedures, audits, tracking, etc.).

5.5 Resources and budget allocation

Resources need to be prudently sourced and applied across plant pest surveillance priorities and activities (see chapter 13). The NPPO should have a clear understanding of:

- the priorities and required activities;
- the resource requirements for each priority to effectively launch and sustain the required activities;
- the resources that are available;
- the resources that are needed;
- providers of these resources; and
- whether the sustainability of these resources is guaranteed.

5.6 Engagement mechanisms

The NPPO may:

- establish mechanisms of engagement between the NPPO and stakeholders so that responsibilities can be assigned, honoured and levels of accountability determined (see IPPC, 2015, section 8) – common examples of mechanisms of engagement include LoAs, memoranda of agreement (MoAs), contracts and government–industry agreements; and
- ensure that all stakeholders are properly informed and cued into the surveillance strategy, and that their roles are clearly defined.

5.7 Performance review

Plant pest surveillance and the use of surveillance data in international trade and phytosanitary improvement are critical – the consequences of ineffective surveillance and monitoring to ensure accurate results can be devastating. The programme of plant pest surveillance should be technically sound, and include effective supervision of personnel and methods to ensure that all activities are undertaken correctly.

A surveillance programme should be regularly reviewed against its targets, goals and objectives. A formal review process may be established to ensure that:

- the programme is reliable and credible to stakeholders;
- quality is assured and maintained throughout the programme;
- all aspects of the programme are supported by current technology and procedures, and are appropriate to achieve the stated objectives; and
- efficiency is gauged against performance standards (auditing where applicable).

The occurrence of incidents that threaten the surveillance programme should be corrected transparently, urgently and effectively.

Internal reviews by a competent review panel may be undertaken periodically on all aspects of the surveillance programme to ensure that quality is being maintained.

External reviews may also be appropriate in cases where a trading partner or potential trading partner needs verification of the quality and effectiveness of a surveillance programme such as PFA, ALPP or eradication.

5.8 Monitoring and evaluation

Monitoring and evaluation (M&E) together provide the knowledge required for effective surveillance programme management and reporting, and accountability. Countries that opt to establish an M&E system generally tend to do so at the level of a department, the ministry or, in other cases, at a higher, possibly national, level. Whatever the case may be, an M&E system developed for plant pest surveillance would need to be adapted to the existing system.

An M&E system is a tool in a project manager's repertoire that uses methodologies designed to strengthen the ability of people and teams to make management decisions for the successful achievement of stated objectives. An M&E system should help the NPPO to:

- determine whether the surveillance programme is on track, on time and on target;
- ensure that funds were used as intended;
- determine whether the surveillance programme was implemented as planned; and
- learn whether the surveillance programme made a difference.

6. Human resources

6.1 Training

Plant pest surveillance requires different skills and competencies from different groups of people. The NPPO responsible for any given plant pest surveillance programme should strive to maintain the technical integrity of all activities and be responsive to emerging and new pest situations. Specific, task-related training for those involved, as shown in Table 1, will address these issues.

6.2 Staff retention

Staff training is a costly but necessary investment, so efforts should be made to support retention of trained staff for the effectiveness and sustainability of the surveillance programme. This may be encouraged by providing, for example:

- salaries commensurate with tasks assigned;
- attractive incentives and benefits;
- conducive working conditions, such as appropriate tools and transport; and
- awareness of the importance of their tasks to national development.

The NPPO may ensure succession planning to provide for smooth transitions when required.

6.3 Safety at work

Safety at work is an important consideration to which management should be committed. Where applicable, management should lead by example. Management should also ensure adequate funding for:

- protective equipment
- personal security gear
- adequate health care and medical coverage
- first aid equipment
- clearly marked or identifiable means of conveyance or transport, where appropriate
- proper identification.

Table 1. The kinds of training that different groups of people involved in a surveillance programme might require

Managers and supervisors	Plant protection and production personnel involved in surveillance activities	Farmers, producers and industry personnel	Subject specialists from universities and other research institutions
Management and supervision related to specific tasks	Data collection	Protocols for surveillance of specific pests	Relevant ISPMs
Personnel management	Information on pest biology and ecology	Pest and pest damage recognition	Procedures consistent with the IPPC in surveillance and pest diagnostics
Procedures for enforcement and integrity	Surveillance methods	Data collection and recording	
Resources management			

7. Information management

Information systems are required to ensure effective management of information as it moves from the field to record keeping to reporting.

The NPPO should select hardware and software in terms of short- and long-term programme goals. For example, in order to collect location data more efficiently, the geographic information system (GIS) software package in the office should be able to interact with the global positioning system (GPS) units of field workers. The NPPO should consult with a database administrator and hardware and software solution providers.

7.1 Data flow: structure and presentation

7.1.1 Workflow structure

- It is the responsibility of the surveillance manager to plan a complete data flow cycle in the very early stages of implementation.
- On the basis of strategic decisions regarding programme goals, a flow chart should be prepared to clarify the appropriate order for the transfer of data.
- A form, whether paper or computer based, needs to be designed for collecting raw pest data from the field; consistent layout is important.
- Surveyors need to understand the form, how often the form is transferred to data collectors, and by what means (paper forms will be faxed, computer files sent by email, etc.).
- A computer-based collection scheme requires choosing a standardized file format.
- Data collectors must enter the new data, merging these into the growing database. As data are entered, they should be validated.
- Data should be entered in a timely manner depending upon the requirements of the programme.
- The tools used to query the database to extract the required reports must be understood by data analysts (or field personnel if they serve dually as data analysts); data analysis should be relevant to the goals of the surveillance programme.

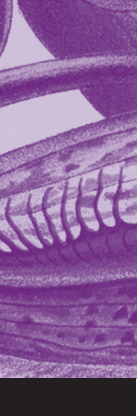
7.1.2 Record keeping

ISPM 6 (*Surveillance*) details a set of minimum records that need to be kept. These are:

- scientific name of the pest and European and Mediterranean Plant Protection Organization (EPPO) code, if available;
- family/order;
- plant part affected or means of collection (e.g. attractant trap, soil sample, sweep net);
- locality, e.g. location codes, addresses, coordinates;
- date of collection and name of collector;
- date of identification and name of identifier;
- date of verification and name of verifier
- references, if any; and
- additional information, e.g. nature of host relationship, infestation status, growth stage of plant affected, or found only in greenhouses.

7.1.3 General guidelines for information management

- Data standards should be considered: they need to be consistent and allow for sharing of data (e.g. between surveillance programmes or between countries) as required.
- The NPPO is responsible for secure data storage and is the final authority for approval of a security protocol. Data should be stored in safe and secure locations and standard operating procedures (SOPs) should be developed for security protocols, data storage and backup.
- The database should be validated and updated as needed.



8. Communication

Communication helps to ensure that stakeholders and staff understand and support phytosanitary surveillance activities, requirements and systems, and have sufficient information to manage their own related activities. A communication strategy for plant pest surveillance will ensure that communications are handled as effectively as possible.

8.1 Communication strategy

A communication strategy should take into consideration:

- information needs of staff, stakeholders and affected parties;
- urgency with which decisions need to be made;
- extent to which engagement and communication will improve plant pest surveillance and the use of information provided by surveillance; and
- costs of communication and engagement, both to the NPPO and to those engaged.

Coordination of surveillance programmes requires timely and effective means of communication. The NPPO should ensure that communication provisions cover all parties involved, as shown in Table 2.

8.1.1 NPPO internal communication

Internal communications are important to ensure that the surveillance programme is efficient and effective. Topics may include:

- line communication, reporting and feedback;
- communication among field officers, for sharing experiences and relevant information, problem-solving, etc.; and
- communication among NPPO technical managers and supporting administrative staff, regarding budget, procurement and resource distribution, staffing issues, etc.

8.1.2 NPPO external communication

External communications are also necessary to ensure that all parties directly engaged in the programme are kept informed. NPPOs should be prepared to communicate with:

Table 2. Audiences for communications and official reporting

Communication	Reporting to
NPPO internal communication	Concerned trading partners
NPPO and industry groups	RPPOs
NPPO and third-party providers	IPPC, FAO
NPPO and surveillance committee	
NPPO and general public	
NPPO and media	

- industry groups, especially those directly involved in surveillance activities and those directly affected by outcomes, timely and effective communication regarding ongoing issues that may arise from strategies, and procedures and implications of findings;
- third-party providers acting on behalf of the NPPO regarding progress, implementation issues, ongoing monitoring and review activities;
- surveillance committees on strategic issues and outcomes for decision-making; and
- the general public regarding outreach programmes for effective cooperation, restrictions on movement of plant material, where appropriate, and reporting relevant observations.

8.2 Stakeholder engagement

Meaningful engagement of stakeholders requires effective bidirectional communication between the NPPO and all stakeholders regarding their possible and assigned roles in the detection of plant pests.

Stakeholders and their roles may include:

- universities, research institutions and subject specialists to undertake specific surveillance with related activities, such as:
  - provide training in surveillance methodology for specific plant pests or pest groups
  - prepare protocols and data sheets
  - make arrangements for diagnostics
  - provide aerial photos to aid delimiting surveys where appropriate (e.g. lethal yellowing disease in areas that are otherwise impossible to reach);
- industry groups (banana, tea, coffee, citrus, etc.):
  - provide information on occurrence or incidence on farms
  - provide data gathered over time on pest occurrence and status
  - provide staff for training and deployment on farm to collect information, set and service traps, sampling and other services, where possible and according to protocols provided by the NPPO;
- farmers and producers, plant nurseries:
  - provide alerts on current and past occurrences, service traps;
- forestry, parks commissions and similar groups:
  - report incidence of plant pests or pest damage, outbreaks of pests on ornamentals and forestry crops;
- consumers, markets and vendors:
  - report unusual or new cases to the NPPO;
- press and media:
  - disseminate information
  - educate and raise awareness
  - encourage support for the programme and related activities.

8.3 Reporting

The NPPO has a responsibility to report the results of surveillance activities, specifically the occurrence, outbreak and spread of plant pests, and efforts to control them. Information gathered through general surveillance will be used most often for reporting to concerned trading partners, RPPOs and the IPPC (Article IV).

Plant pest surveillance results should be reported in a timely manner to concerned trading partners in a spirit of international cooperation to prevent the spread of pests. Industry groups affected by the results of surveillance should be properly informed.

8.4 Awareness-raising and advocacy

It is valuable for key groups and individuals to understand the surveillance programme's goals, its main operations and what support is needed in order for the programme to function well. The surveillance programme will benefit from having a plan in place to generate awareness and build support among key stakeholders.

An awareness-raising plan should identify the interests of different stakeholders and refine messages and styles of communications to match the interests of the stakeholders, helping them to understand why the surveillance programme is important.

The stakeholders may include:

- private sector, who may be concerned about losses both from pests and from control programmes;
- high-level government officials, who may not be familiar with the technical issues of phytosanitary measures but may be very concerned about access to export markets, protection of domestic natural resources and jobs, and who may be influential in the policy-setting and budget-planning processes;
- the general public, who may be concerned about plant pest surveillance and control programmes as a result of concerns about damage to natural resources and loss of jobs in addition to concerns about consequences to the environment and human health of chemical control of pests; and
- academia.

An advocacy plan would target these stakeholders differently to address each group's concerns and help them to understand why a surveillance programme is important and how it will benefit them. The plan can encourage them to ensure that the surveillance programme receives the sustained financial, political and public support needed in order to function effectively and achieve its goals.

Section 3: Planning and prioritization

Planning, coordination and implementation of a surveillance programme should be based on national priorities such biosecurity, trade and market access, incursion response or pest monitoring. Planning also ensures the design of a statistically valid surveillance programme that complies with NPPO, trading partners and other stakeholders' expectations. Priorities for surveillance may vary from country to country depending on the needs for surveillance information. Once priorities for surveillance have been established, NPPOs should develop plans for the implementation of surveillance programmes, taking into account phytosanitary legislation and policies.

9. Planning a surveillance programme

An NPPO generally plans a surveillance programme on the basis of a need to facilitate trade and protect national plant resources. Such a plan has several components.

9.1 Cost–benefit analysis

A cost–benefit analysis must be carefully considered prior to the expenditure of significant resources. For examples of surveillance planning and cost consideration, refer to Pheloung (2005).

Some considerations for a surveillance programme cost–benefit analysis include:

- level of stakeholder interest in a surveillance programme;
- importance of the agricultural commodity at risk to the local economy;
- potential export economic importance of an agricultural commodity;
- economic importance of an agricultural commodity to an importing country;
- risk of pest introduction, early warning and emergency response;
- estimated economic damage and impact of a pest to an agricultural commodity;
- available field, diagnostic and administrative human resources to implement a surveillance programme;
- available target-specific traps, lures and other tools for pest detection; and
- feasibility of the surveillance programme with available monitoring tools.

If the estimated economic cost for conducting a surveillance programme does not outweigh the value of the benefit to a country's agricultural and natural areas, then an adequate return on investment may be anticipated. Although several possible surveillance programme efforts could result in a significant return on investment, the NPPO must prioritize the most important needs for the country. Refer to chapter 10 for more guidance on pest prioritization.

9.2 Key issues

The NPPO will need to consider several key issues in formulating the surveillance plan.

9.2.1 Strategic rationale:

- threat detection and contingency or mitigation
- early warning
- rapid and appropriate response
- preparedness for negative impact to certain productive sectors or to avert environmental damage.

9.2.2 Feasibility:

- technical capacity to undertake the survey work
- Resource availability, i.e. human (personnel), financial (for logistics and travel) and physical (field and laboratory equipment).

9.2.3 Stakeholder relations and support:

- An established record of trust and the protection of the country's agricultural and natural resources is necessary.
- The surveillance programme needs to clearly identify its purpose (current or future benefit) and its beneficiaries.
- Key personnel within the NPPO should be assigned to establish, manage and maintain stakeholder relations.

Stakeholders interested in a surveillance programme should first consult with their own NPPO and consider the following:

- identity and availability of subject matter specialists – if expert contacts are not available within a given NPPO, consider whether regional or international expertise could provide cooperative project support; other regional governments may also be at risk from newly introduced pest-detection or trade barriers, and would mutually benefit from the partnership;
- availability of pest reference collection repositories; and
- budgetary supply and human resources for monitoring, sample screening, management and general surveillance.

9.2.4 Other considerations

The difficulty of plant pest detection and diagnostics can negatively impact a surveillance programme in terms of rationale, design, operation and cost.

Pest-specific surveys with clear protocols and commercially available traps will be easier to deploy uniformly and monitor regularly.

A surveillance programme needs a communications plan (see chapter 8). Even if stakeholder support is obtained, mismanagement of public communications may end a surveillance programme. A good message for the general public should be simple and appropriate for a broad audience. Producers and other stakeholders who are more directly affected by the surveillance programme will need additional information.

9.3 Surveillance implementation

An NPPO should review the procedures and results of other surveillance programmes with similar goals and consider the following questions related to survey programme implementation.

- If surveillance programmes on this pest have been conducted in other regions, what was the outcome?
- How can an improved surveillance programme be implemented, based on lessons learned from other surveillance programmes focused on this pest?
- If surveillance programmes have been conducted on similar pests in your country or other regions, how can you apply the lessons learned to your surveillance programme?
- Has the pest of focus in your surveillance programme been reported on new hosts or within a new ecological niche?
- Has the pest you are surveying been detected outside previously known environmental limits?

A pest's ability to respond to a new habitat is often unknown; however, some inferences can be deduced from a pest's invasion history in similar habitats to those in the country of concern. The surveillance results of another NPPO can also assist to guide the development of a pest-specific survey.

A surveillance programme is generally designed either to generate a commodity pest list to facilitate export of a new agricultural commodity or to assist with a regulated pest list. A regulated pest list may include pests of quarantine significance and may affect imports or assist with defining pest risk analysis (PRA) needs. A regulated non-quarantine pest may economically affect plants for planting (see Table 3).

The gathering of information should focus on the needs of general and specific surveillance programmes and generally relates to both. Methods may include the following:

- Horizon scanning: identifying current issues or strategies that may have a significant medium- to long-term future impact on the successful outcome of the survey. An NPPO may also use results from PRA for this purpose.
- Article/data mining: discovering interesting and useful patterns and relationships in large volumes of data.
- In-country sources: information from producers, immigration information, customs data, traders, etc.
- Formal requests to NPPOs of other countries.

Table 3. Definitions associated with categories of pests and lists

Specific terminology	IPPC definition
Commodity pest list	A list of pests present in an area which may be associated with a specific commodity [CEPM, 1996; revised CPM, 2015]
Regulated pest	A quarantine pest or regulated non-quarantine pest [IPPC, 1997]
Regulated non-quarantine pest	A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party [IPPC, 1997; revised CPM, 2013]

10. Prioritization

Failure to properly assign NPPO resources to the highest risk plant pests may result in:

- delays in new market access;
- unnecessary or unjustifiable import requirements; and
- significant and devastating agricultural crop loss.

PRA can be an important component of the decision process for target pest or commodity-focused surveillance programmes.

Pest risk analisys

The process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it [FAO, 1995; revised IPPC, 1997; ISPM 2, 2007]

Additional information about PRA can be found in ISPM 11 (*Pest risk analysis for quarantine pests*) and ISPM 21 (*Pest risk analysis for regulated non-quarantine pests*).

The NPPO may give high priority to:

- conducting surveillance to develop a commodity pest list that potential trading partners need in order to enable them to conduct a PRA – some degree of urgency may be necessary as denial of market access for a commodity planned for import may result from failure to produce such information;
- an urgent need to determine which pests currently occur in a country, to facilitate the establishment of justifiable import regulations; and
- a demand for updated pest information from an importing country to an exporting country
  - the importing country may have credible information on the status of a new or existing pest that could result in trade restrictions; trade may be stopped if information is not provided.

10.1 Early detection

Early detection and rapid pest eradication are often the goals of a regulatory surveillance programme. Available field tools, such as species-specific pheromone-baited traps, can significantly improve field detection efficiency. However, visual scouting remains a relatively low-cost and frequently used method in many cases. Budget plans for trained field scouting personnel need to be considered. The visual scouting process often seeks to detect "hotspots" or concentrated small patches of pest activity.

The NPPO should consider the difficulty of pest detection and overall cost during the development of the surveillance programme. If a pest is difficult to detect and unlikely to be reported early in the invasion phase, the NPPO may choose not to designate resources to the pest even if it is high risk. A pest that is of medium to high priority and easy to detect may receive a higher priority in a surveillance programme because there are more opportunities to detect a successful pest invasion.

10.2 Stakeholder interests

Stakeholder input must be considered in prioritization. A lack of stakeholder support will hinder success of the programme. External stakeholders may need pest status information in order to complete a PRA for a commodity. Producers and other individuals employed in agriculture may be the first to detect a pest or symptom of concern. Producers and exporters may also be required to provide information related to market access. Finally, producers will be primarily interested in local and export pest management recommendations.

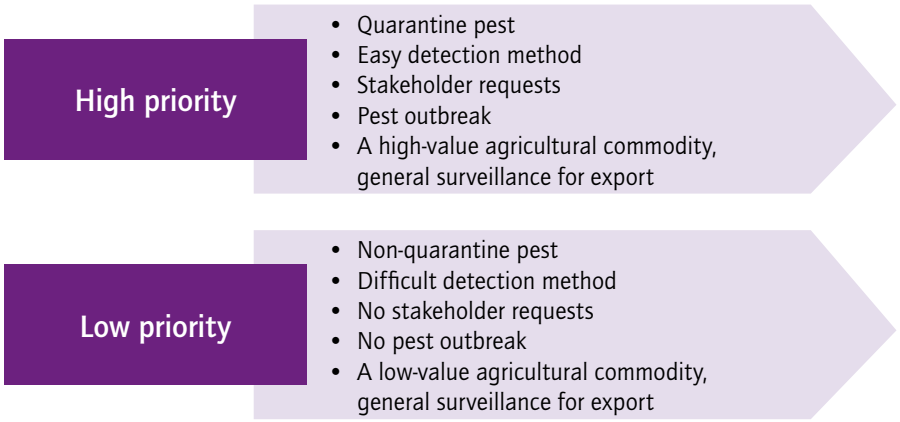
10.3 Responses to outbreaks or incursions

A response to a plant health emergency involves detection, identification, confirmation, assessment, containment, control and management of the plant pest. A strong network of trained individuals who are prepared to respond is an essential component of an emergency response programme. Although not every pest outbreak will trigger a formal emergency response programme, pest outbreaks often influence prioritization.

Following a new pest outbreak, resource allocations and personnel must be shifted to the new, high-target pest. Response activities from national agencies may include the following:

- rapid detection and delimiting surveys
- technical working groups
- identification and diagnostics
- emergency funding
- emergency response coordination
- mobilization
- unified command
- data management
- regulatory framework
- environmental compliance
- situation reports.

Figure 3. Prioritization factors of surveillance programmes.



11. Designing a specific plant pest surveillance programme

11.1 Survey design

Survey design will depend on the purpose of the surveillance programme, whether to look for a pest of unknown status in an area, to gather data about an existing pest population in an area or to determine the boundaries of an infestation.

ISPM 5 (*Glossary of phytosanitary terms)* defines the following survey designs.

- Detection survey: "Survey conducted in an area to determine if pests are present". Detection surveys are appropriate if a pest's presence in an area is not known.
- Monitoring survey: "Ongoing survey to verify the characteristics of a pest population". Monitoring surveys are appropriate to document changes in prevalence of a particular pest population over time and to assist with pest management.
- Delimiting survey: "Survey conducted to establish the boundaries of an area considered to be infested by or free from a pest". Delimiting surveys are usually used to define the boundaries of spread for a new, invasive pest. A delimiting survey often precedes the implementation of an eradication programme. Delimiting surveys may also be useful for shipping commodities outside of the pest range for a pest of limited distribution.

11.2 Pest-specific surveillance

According to ISPM 6 (*Surveillance*), a pest-specific surveillance approach should include the following:

- identification of the target pest(s);
- identification of scope (e.g. geographic area, production system, season);
- identification of timing (dates, frequency, duration);
- in the case of commodity pest lists, the target commodity;
- indication of the statistical basis (e.g. level of confidence, number of samples, selection and number of sites, frequency of sampling, assumptions); and
- description of survey methodology and quality management based on an understanding of the biology of the pest, purpose of the survey and including an explanation of:
  - sampling procedures (e.g. attractant trapping, whole plant sampling, visual inspection, sample collection and laboratory analysis)
  - diagnostic procedures
  - reporting procedures.

11.3 Commodity-specific surveillance

Specific pest lists of commodities can be useful in the context of cultural practices or to provide general data in the absence of general surveillance. Commodity-specific surveillance may also be useful to provide information to requesting countries to facilitate their PRAs.

Commodity-specific survey sites should be selected by the following parameters:

- geographic distribution of production areas and their size;
- pest management programmes (commercial and non-commercial sites);
- cultivars present; and
- points of consolidation of the harvested commodity.

Survey methodology will depend on the harvesting time, target commodity pests and associated sampling techniques, and type of commodity.

11.4 Examples of survey design

11.4.1 Target pest: pink bollworm

The pink bollworm moth, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae), is a globally important pest of cotton. Prevention, management and yield loss associated with pink bollworm costs cotton producers in the United States of America an estimated USD 32 million annually. Pink bollworm is capable of long-range migration, so cotton producing regions

are at constant risk of infestation and reinfestation. Effective long-term surveillance is necessary to detect incursions and reduce the risk of establishment.

11.4.1.1 Sampling and collection methods for adults

- At planting, hang delta traps containing rubber septa impregnated with 4 mg of gossyplure pheromone attractant around the perimeter of cotton fields at a rate of one trap per 4 ha.
- Inspect delta traps weekly for adult pink bollworm moths, until harvest or killing freeze. Record presence (and quantity) or absence.

11.4.1.2 Sampling for larvae

- Select ten non-Bt (non-transgenic) cotton fields per 4 856–6 070 ha at random and visually inspect the blooms for signs of pink bollworm larvae. If larvae are detected, collect specimens and preserve in 70 percent ethanol to send out for expert identification.
- Start at the bloom stage and continue weekly inspection through cut-out. Record presence (and quantity) or absence.

11.4.1.3 Information management

- Sampling data may be recorded on paper or by electronic means in the field, but should be permanently stored in a secure electronic database. The NPPO should establish procedures for generating reports from field survey data and disseminating reports to relevant parties.

11.4.1.4 Occupational safety

Field survey workers will need the following to safely perform their survey activities:

- basic first aid items, such as antiseptic wash, sterile bandages, pain reliever tablets and antihistamines;

a field communications plan to keep workers connected to base operations. This may include mobile telephones or radio communications; and

- safe transportation to and from field sites.

11.4.1.5 Stakeholder engagement

Pink bollworm survey plans are best enacted with the cooperation of producer communities and government regulatory entities. Develop survey plans with cotton growers and create stakeholder buy-in through effective communication with the target audience.

11.4.2 Target pest: Asian citrus psyllid and Huanglongbing disease

The Asian citrus psyllid, *Diaphorina citri* Kuwayama (Insecta: Hemiptera: Psyllidae), is an important pest of citrus in several countries due to its ability to vector citrus greening or Huanglongbing disease (HLB). HLB is caused by the bacterium *Candidatus Liberibacter asiaticus* and originates from Asia. HLB can kill a citrus tree in as little as five years, and there is no known cure. The only method for protecting citrus trees is to prevent spread of the HLB pathogen through the control of psyllid populations and by the removal and destruction of infected trees.

11.4.2.1 Sampling and collection methods for adults

- Tap sample: Use a laminated sheet of paper or a smooth white surface such as a clipboard and a 0.3 m piece of half-inch or three-quarter-inch (or equivalent size) PVC (plastic) pipe. Place the sheet or board about 0.3 m below a leafy branch. Hit the branch three times with the pipe. Count and record the number of psyllids that fall onto the sheet. The slippery sheet surface prevents the psyllids from taking flight, but some may fly away before they can be counted if numbers are high.
- Sweep nets: Swing a 15-inch (or equivalent size) diameter sweep net in a 180° arc so that the net rim strikes well into the canopy. After a few sweeps, count and record the number of psyllids captured inside the net.
- Trees with apparent psyllids or psyllid feeding damage should be preferentially sampled. If trees do not have visible psyllids or psyllid damage, no more than 20 trees should be sampled at a given location. The number of trees sampled may be varied depending upon the needs of the surveillance programme.

11.4.2.2 Sampling for larvae

- Nymphs and eggs are found only on young flush and must be sampled by direct observation.
  - Field personnel should practise recognizing the difference between psyllid and aphid feeding on flush; the presence of the insect is always the best indicator of the actual cause of damage. In general, psyllid feeding results in twisted flush and aphid feeding causes leaf curl.

- The number of psyllids per shoot should be correlated with the percentage of infested shoots.
- Determine for each shoot examined whether psyllid eggs or nymphs are present.
- Ten shoots should be checked at each stop at the same ten locations per block used for the tap sample.
- Determine the amount of flush present and measure shoot density. Keep records of the number of trees needed to locate ten new shoots at each stop and the number of trees examined. No more than 20 trees should be examined at a given location even if ten new shoots are not found.

11.4.2.3 Sampling and collecting methods for HLB

- Samples should consist of short sections (10–15 cm or greater) of symptomatic branches with the attached leaves.
- If fruit is present on the branches, the fruit can either be left on or can be trimmed off the tree. If the fruit is removed, leave the fruit stem on the sample (i.e. trim the fruit off as close to the button as possible leaving the stem on the branch).
- If a variety of symptoms are present, the preferred samples (in order of preference) would be:
  - branches with mottled leaves;
  - branches that contain shoots that are almost entirely yellow;
  - branches that have leaves with yellow veins;
  - branches with leaves that have either green islands on a yellow background or yellow islands on a green background;
  - branches with nutrient deficiencies that have a "rabbit ear" appearance (small, upright leaves);
  - branches with leaves that show chlorosis and "vein corking";
  - branches with zinc or iron deficiencies that are not related to blight or other known causes.
- Place the leaves and twigs into a sealable (e.g. Ziploc) plastic bag and keep the sample cool and out of sunlight.
- Label the bags "HLB" to expedite their movement in the laboratory.
- Flag the tree or a branch in commercial sites in order to be able to rapidly recognize and revisit the place where a sample was collected. In residential sites, flagging could be performed at the discretion of the surveyor.

11.4.3 Target pest: potato cyst nematodes

Potato cyst nematodes (PCN) (Nematoda: Tylenchida: Heteroderidae) comprise two closely related species

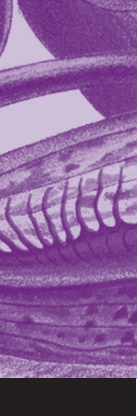
- the pale cyst nematode, *Globodera pallida* (Stone) and the golden nematode, *Globodera rostochiensis* (Wollenweber). These microscopic worm-like organisms are quarantine pests and present a serious threat to domestic and international commerce in potatoes and nursery stock. They feed on the roots of the plant and can cause significant loss of yield, and the cysts can survive in the soil for many years, multiplying rapidly when a new crop of host plants is planted. PCN spread primarily by the transport of cysts in soil. Once a field is infested, management includes sanitation, crop rotation, use of resistant varieties and chemicals.

11.4.3.1 Sampling procedures

Field freedom from PCN, based on sampling and testing of soil prior to planting, is a general requirement for seed potatoes and may also be suitable to confirm lot freedom of ware potatoes.

Fields are sampled at a standard rate of 1 500 ml/ha or, if certain conditions are met which reduce the risk of PCN infestation, at a lower rate of 400 ml/ha. These conditions relate to history of the land, in relation to previous potato crops and the size of the sampled unit. A field is eligible for the lower rate if:

- no potatoes have been grown there for six years prior to the test; or
- no PCN have been found in the previous two official tests; or
- no PCN or dead cysts have been found in the most recent official test.



12. Response, delimiting and trace-back surveillance

12.1 Early warning detection surveys

12.1.1 Pest identification and information

Correct plant pest identification is critical to response, delimiting and trace-back surveillance. Information that needs to be prepared about the pest includes:

- field screening information for further pest surveys
- pest biology and origin
- distribution and establishment potential
- pest significance
- population dynamics and epidemiology
- pest vector status
- potential pathways
- potential establishment and range
- eradication, containment and control measures
- detection methods
- damage symptoms.

12.1.2 Public education to disseminate information for early warning

Public awareness programmes aimed at reminding the general public and target groups of the potential threats and where to report. Different modern IT tools, e.g. mobile applications, may be used for this purpose.

12.1.3 Training of principals (field personnel of NPPO and other technical stakeholders) in detection of the target pest

Training of personnel from the NPPO and other concerned stakeholders according to the target pest is essential. This may require time, resources and a certain level of commitment. The NPPO should plan accordingly. This is emphasized in sections 6.1, 6.2, 8.2 and 13.1.

12.1.4 Monitoring system

Where possible and as resources allow, establish a monitoring system using traps or other detection methods along likely pathways or most vulnerable areas.

12.1.5 Review

Adjust the survey strategy based on updated information.

12.2 Investigation plan

12.2.1 Pathway analysis

If a new, exotic invasive species is detected, the likely source of the pest should be analysed and determined. The following steps should be taken in order to determine the spread and origin of the pest:

- Conduct a delimiting survey around the site of initial detection. This will provide information about the spread of the pest. The NPPO may have to conduct interviews with the owners of plants where the pest was detected.
- Assess the degree of damage (insignificant to severe), level of infestation (low to high) and, if possible, duration (old to recent) of the infestation from the time of detection. During the delimitation survey, this information should be collected and mapped along with GIS information. This information could assist determination of the likely origin or location (foci) of the infestation.
- Consider the native region and current distribution of the pest. What commodities are currently imported that could be a source of the pest? How were these commodities moved and transported?
- Once the origin has been identified (trace-back), a follow-up of areas that could have also received a pest introduction (trace-forward) also needs to occur.
- An effort to quarantine and eradicate the pest or maintain the pest within a quarantine zone may follow the delimiting survey.
- Host plant and product movement in and out of the area of new pest detection should initially be controlled within the known distribution area and a buffer zone.
- The pest biology will need to be understood in order to officially control the new pest.

12.2.2 Budget and human resources

Budget and human resource considerations for surveillance and sample processing need to be evaluated before implementing an extensive response. All response activities and resource allocations should be priority-based.

12.2.3 Data analysis and recommendation

Data entry needs to be streamlined for rapid electronic response. If data cannot be evaluated at least weekly, unnecessary resources may be expended. Data analysis also needs to be included in the budget.

12.3 Delimiting surveillance

These surveys are usually carried out to determine the boundaries of an infestation or area infected rather than to define an area that is "free from a pest".

A delimiting survey generally:

- determines the extent and distribution of a pest incursion
- determines whether the pest can be eradicated.

12.3.1 Site selection

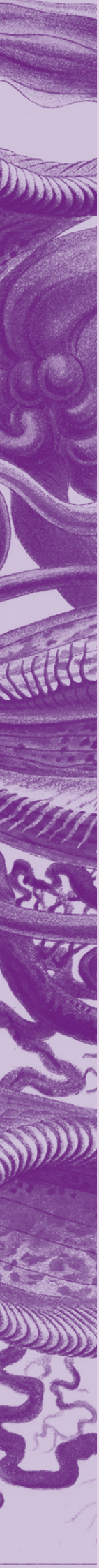
For delimiting survey sites:

- initial detection site or target zone – this is usually the starting point for the survey
- extent of survey is determined by the spread of the pest
- target plant hosts (number of and species) should be known
- alternative plant hosts should be known
- sampling and collecting methods specific to the target pest need to be identified and deployed – some target pests may have species-specific traps or detection methods that may improve collection and hence knowledge of distribution.

12.3.2 Survey preparations

The following information must be prepared for a delimiting survey:

- Define the survey period that can be funded, based on the value of the crop or other relevant prioritization criteria.
- Identify equipment needed and purchase if necessary.
- Designate responsible personnel and agree overall logistical coordination.
- Establish budget availability and parameters.
- Prepare field survey methodology and guides.
- In some instances, an NPPO may choose to designate work to a non-regulatory entity through a cooperative agreement. The non-regulatory entity must understand the regulatory nature of the delimiting survey.
- Data collection and mitigation methods are established by the NPPO. Methods must be clearly described in an SOP and their application monitored by the NPPO.
- Awareness campaigns:
  - educational materials need to be prepared for field survey specialists and farmers
  - IT applications and printed materials for the general public also need to be available
  - a chain of communication needs to be established for general inquiries and questions – a designated public information officer can assist with awareness questions or concerns. This may be done via special phone number or mobile application.
- Data analysis and recommendations.
- Pest status reporting (see ISPM 17).



Section 4: Operations

13. Resource requirements

Surveillance should be adequately resourced with appropriate human, financial and physical resources. Resources should be planned in advance in order to ensure that field activities are delivered in a timely and efficient manner. It is the responsibility of NPPO that the staffing, financial and physical resources (equipment, traps and consumables) are in place before starting field activities. Diagnostic services are an essential part of a surveillance programme and should be taken into account. The resources may be planned for each pest, for groups of pests or for the whole surveillance programme.

13.1 Human resources

Human resources should include the relevant technical skills and training to effectively deliver the surveillance activity. This may also include resourcing additional surveillance officers to provide assistance. The human resources may be calculated, for example, how many inspectors are necessary to carry out the inspections in particular places, how many hours they have to spend carrying out inspections, how many people need to be involved in identification of pests, hours of work in the laboratory and time for training about methodology. Time for preparation of pest reports and reporting to an international organization should be included into calculation of surveillance costs.

13.2 Financial resources

Financial resources should cover all expenses relating to the delivery of the surveillance activities (travel, accommodation, per diems, equipment and supplies, etc.).

13.3 Physical resources

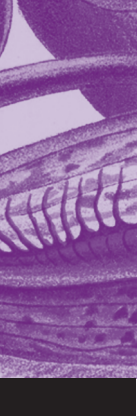
Infrastructure resources may include laboratory buildings, offices for staff, storerooms and warehouses, processing areas, communications infrastructure and waste facilities.

Equipment and supply resources may include vehicles, pest traps, lures, personal protective equipment and consumables (see Appendix A). The most significant costs are vehicles and fuel. Vehicles are used to get to the field, plantation or site where inspection is planned. Costs associated with fuel depend on the price of fuel in the country, the amount of fuel needed to reach a site, the distances involved, including from the office to a site and from one site to another, and how often a site must be visited in a season. Extra funds need to be allotted for incidental and ancillary costs, for example if traps are broken, stolen or missing. Equipment and diagnostic reagents may also have significant costs.

Data collection resources may include cameras, GPS units, smartphones, tablets, notebooks, computer equipment and stationery (see Appendix A).

Public awareness resource materials refer only to the physical materials used to enhance or gain support for surveillance activities, and may include items such as brochures, posters, postcards and calendars.

Note: These physical resource needs will be dependent on the methodology and equipment needs of the survey plan developed.



14. Methodologies

Surveillance protocols and methodologies provide consistent instruction on the delivery of a surveillance activity. Surveillance managers and surveillance officers need to be aware of current methods associated with pests of interest and must ensure that the methods meet survey objectives. Methods of plant pest surveillance are further described in *Guidelines for surveillance of plant pests in Asia and the Pacific* (McMaugh, 2005); chapter 8 focuses on specific case studies.

Surveillance methods may be based on recognized guidelines and international protocols or negotiated equivalents.

In some cases, NPPOs may need to derive new methodologies when faced with new and emerging pests.

14.1 General surveillance

General surveillance activities provide a useful means for NPPOs to gather pest information beyond specific surveillance. The importance of general surveillance and the central collection of data for national plant biosecurity is discussed in the *National Plant Biosecurity Surveillance Strategy 2013–2020* (PHA, 2013). General surveillance also serves the purpose of potentially proving the absence of a pest for trade purposes. Participatory engagement of industry, citizens, growers and academia is a critical component of general surveillance.

General surveillance activities can be delivered in the following ways:

- undertake desktop reviews of scientific journals, publications and databases;
- deliver outreach and awareness campaigns to inform the audience about the target pests and ways in which they can assist; and
- ensure mandatory reporting for agencies and institutions involved in scientific research and publication – in some cases this may involve legislative obligations or cooperative agreements to report.

General surveillance must comply with the ISPM 8 (*Determination of pest status in an area*) validation process, and therefore requires adequate screening, validation, data management and analysis to manage data before they are included in information management systems.

Before implementing these general surveillance initiatives, it is important to ensure that adequate human and physical resources (computer systems, databases, communication systems, etc.) are available.

14.2 Specific surveillance

Specific surveillance provides the means for NPPOs to actively gather pest distribution information through structured programmes.

A wide variety of technical methods are available, based on the three fundamental types of surveillance:

- sampling survey: host material, target pests or soil are collected for identification and analysis;
- trapping survey: chemical or physical traps used to capture target pests in a given area; and
- visual examination: host or habitat examined for life stages, signs or symptoms associated with target pests.

These methods may not always be delivered independently, and some surveys may include a combination of sampling, trapping and visual inspection.

The three types of surveys on the objectives of the specific surveillance programme recognized by ISPM 6 (*Surveillance*) are:

- detection surveys: conducted in an area to determine if pests are present;
- delimiting surveys: conducted to establish the boundaries of an area considered to be infested by or free from a pest; and
- monitoring surveys: ongoing survey to verify the characteristics of a pest population.

Table 4 indicates different circumstances under which certain types of survey are deployed.

Table 4. Use of three types of surveys for different pest situations

Specific surveillance	Pest situation				
	Pest present without control	Pest present under suppression	Pest present under eradication	Pest absent under exclusion	Pest transient, eradication of an incursion
Monitoring	Uncontrolled pest subject to monitoring surveys	Pest under suppression subject to monitoring surveys	Pest under eradication subject to monitoring and verification surveys		
Detection				No pest; detection surveys including intensive trapping for exclusion in a PFA	
Delimiting					Incursion detected through ongoing detection surveys, therefore additional implementation of delimiting surveys

Source: derived from IAEA (2003).

14.3 Methods

14.3.1 Standard operating procedures

According to the guidelines for quality management in soil and plant laboratories, produced by the Natural Resource Management and Environment Department (Bashour and Sayegh, 2007), "a Standard Operating Procedure (SOP) is a document which describes the regularly recurring operations relevant to the quality of the investigation. The purpose of a SOP is to carry out the operations correctly and always in the same manner. A SOP should be available at the place where the work is done".

SOPs should include at least the information identified as a minimum requirement (refer to ISMP 6):

- purpose and scope
- timing and duration
- target pest
- target host
- target areas and site selection
- survey duration
- site selection
- statistical basis
- sample collection
- detailed survey methodology (procedures)
- biosecurity and sanitation considerations
- sample handling and laboratory submission
- equipment and supplies
- reporting.

SOPs may also include:

- legislative authority
- roles, responsibilities and accountabilities
- record-keeping
- reference material (keys, publications, protocols, etc.)
- occupational health and safety.

Note: SOPs must be available and accessible to all staff..

14.3.2 Sampling

Sampling may be:

- random:
  - simple random sampling – unbiased; each unit has equal chance of being selected
  - stratified sampling – a form of random sampling that is based on knowledge of pest distribution and assures collection of pest;
- systematic:
  - follows a predetermined pattern, such as X-, W- or Z-shaped transects
  - may involve collection of symptomatic or asymptomatic plants – visible field symptoms are often not immediately expressed at early-stage plant disease or nematode infections; the collection of asymptomatic plant samples provides valuable positive and negative data beyond the known infection range of a given pest.

ISPM 6 (*Surveillance*) also refers to cluster sampling and targeted sampling.

Methods of sampling for pests are further described in McMaugh (2005); chapter 2 is devoted to designing a specific survey, and section 2.16 focuses on methods of collecting pest specimens.

14.3.3 Trapping

Traps can be used for many purposes, including:

- area pest control of a specific pest or type of pest, such as stink bug traps baited with a species-specific aggregation pheromone;
- as part of a specific pest eradication effort;
- surveillance (monitoring, delimiting and detection); and
- sentinel traps for early detection of a new pest incursion in an area.

14.3.3.1 Trap types

Semiochemical-based traps use a message-bearing substance from a plant or animal (or a synthetic analogue) to solicit a behavioural response. See Table 5 for advantages and disadvantages.

Examples of semiochemicals include:

- allomones: a signal that benefits the sender, but not the receiving species;
- kairomones: a signal that benefits a receiving species, but not the sender;
- pheromones: a chemical released by a species for species-specific communication;

Table 5. Advantages and disadvantages of semiochemical traps

Advantages	Disadvantages
More selectively attract certain pests depending on the lure	Lure may be too specific or not specific enough to trap target pest
Easy to deploy in the field	Lure may not be available for target pest
Relatively inexpensive	Trap may need a particular field set-up to be effective
Can yield good population data with a minimum effort	Lure may not attract the primary pestiferous life stage of the pest or may not indicate pest distribution

- synomones: a chemical that benefits both the sender and receiver species.

Semiochemical-based trap lures are generally available through a speciality supplier and are relatively inexpensive.

Attractant-based traps often use food or insect-attracting visual clues to selectively trap a particular type of pest. See Table 6 for advantages and disadvantages.

Examples of visual-based attractant traps include

- light traps
- yellow or blue sticky cards.

Attractant-based and semiochemical trap lures are generally easy to set up in the field, but field placement and the time frame for a new attractant or semiochemical lure must be known. The NPPO should establish protocols for monitoring and replenishing traps on the basis of the known life cycle of the target pest.

Physical traps generally take the form of a mechanical or physical barrier that prevents pest movement. For example, a band of folded burlap can be placed around tree trunks that may be potentially infested with the Asian gypsy moth, *Lymantria dispar asiatica*. Caterpillars will use the burlap as a resting site and can then be destroyed. See Table 7 for advantages and disadvantages.

Table 6. Advantages and disadvantages of attractant traps

Advantages	Disadvantages
Low cost and easy to deploy	Not as specific as semiochemical-based traps
Some selectivity may occur depending upon the available research for the pest	Light traps and sticky cards attract several non-target pests; sorting less target-specific samples may be challenging
May be constructed and designed from local materials	Food-baited attractant traps will require more maintenance and generally degrade more rapidly than semiochemical-based trapping methods
May be used to enhance and improve semiochemical-based trapping methods	May be less specific in terms of trap placement
Species- or genera-specific attraction may occur for some species (e.g. fruit flies within the genus Anastrepha are more attracted to protein-based food lures)	

Table 7. Advantages and disadvantages of physical traps

Advantages	Disadvantages
Not generally harmful to the environment	Often difficult to implement on a larger scale
Effective on small-scale areas of concern	Not as effective as chemical control methods
Relatively easy to deploy	Potentially time intensive for data collection

14.3.3.2 Application method

Trap site selection, mounting and placement will depend upon the target pest and host density. Once a trap has been deployed, GIS coordinates should be recorded. Urban trap locations should also include the full street address. Placement in a natural or rural area should include the nearest address and landmarks, in addition to the GIS coordinates.

The following factors need to be considered with trap set-up:

- Concentration of attractants or semiochemicals:
  - release rate should be understood for a given geographical area (e.g. fruit fly pheromones have faster release in hot and dry conditions); release rate may also differ with trap type.
- Trap density (monitoring and control):
  - should be determined for each geographical region and species or species complex of concern
  - plan for appropriate personnel resources for trap services.
- Trapping period should be defined prior to initiating a trapping programme.
- Servicing and replacement:
  - instructions on servicing and replacement of commercially available lures should be followed
  - spilling liquid lures during trap servicing will reduce overall trap effectiveness.

14.3.4 Sample screening

Traps should be positioned so that specimens can be easily retrieved.

Protocols for handling samples need to be clearly provided to field survey specialists.

- Field sample screening should include observations on the presence or absence of the suspect target, symptoms of plant damage and other relevant information.
- Field symptoms that should trigger an urgent sample submission should be clearly identified in the protocol.
- Transportation of the sample needs to be defined as:
  - hand carry
  - standard mail or express delivery.
- Appropriate equipment for labelling and submitting samples should be provided.
- Digital images may be used to further support sample collection information;
  - Digital images are not considered confirmatory for new pest detections or finds.

14.3.5 Data collection and reporting

Detailed overall trap information should be collected and related to a unique trap code.

Examples of important trap data include:

- date of servicing
- date of trap replacement.

Information specific to the sample of specimen collected may include:

- host plant
- stage of host plant
- collection date
- collector
- GPS coordinates.

Standards for initially reporting data in either paper-based or electronic form need to be clearly articulated in the protocol.

Additional general information, such as weather patterns during sample collection or changes in crop management practices, should be noted.

14.3.6 Quality assurance

The NPPO should routinely conduct staff performance reviews in order to ensure that records are properly maintained and field staff time is managed appropriately.

Routine procedures for auditing equipment, supplies and data quality are recommended. Field personnel can also be periodically evaluated for competence by the assessment of marked specimens.

14.4 Inspection

Inspection methods for plants will depend on the target pest and commodity. Examples of target pest survey protocols are included in section 11.4.

Additional details regarding inspection methods are described in McMaugh (2005); chapter 3 includes inspection information.

14.5 Sample coding

Each sample should be given a unique identifier (label, number, etc.) to enable tracking and monitoring from the point of collection in the field through to other stages of processing and identification.

Potential coding types:

- permanent marker label (do not use whiteboard marker)
- paper-based labels
- automated barcode labels.

Regardless of the method used, the surveillance officer must ensure that the label integrity is not compromised and that the label remains intact throughout processing.

14.6 Sample collection

Specimens must be collected in accordance with the relevant SOP and surveillance protocols to ensure specimen integrity for diagnostic processing.

The field data collection sheet may be electronic or in paper form, and will differ according to the purpose of the survey. Uniform sample collection information should be included on all data sheets used by all users within a given survey. Longitude and latitude coordinates should be recorded, preferably with GPS software. If field surveyors are conducting multiple surveys simultaneously, the data sheet should provide a clear indication of the survey of focus for the data collected. Examples of data that should be associated with a sample from a sample collection perspective (derived from ISPM 6) include:

- scientific name of host and Bayer (EPPO) code, if available and known
- plant part affected by symptoms
- means of collection:
  - attractant trap
  - soil sample
  - sweep net
- locality data:
  - location codes
  - addresses
  - coordinates
- date of collection and name of collector
- additional information relevant to the sample collection may be:
  - nature of host relationship
  - infestation status
  - growth stage of plant affected
- specific details related to the infestation locality, such as:
  - found in an agricultural field
  - found in greenhouses.

14.7 Submission to diagnostic laboratory

Specimens must be handled, packaged and submitted to the diagnostic laboratory in accordance with the relevant SOP and surveillance protocols to ensure specimen integrity, preservation and timeliness for diagnostic processing. Additional details regarding the handling, packaging and submission of samples can be found in McMaugh (2005, section 2.16, Step 14).

Local diagnostic laboratories should be consulted for specific sample submission techniques and to confirm sampling handling capacity prior to submission. Sample submission will depend on the type of organism or type of sample collected. If pests are collected from multiple non-agronomic crop hosts, submission of plant samples to appropriate botanical staff is also recommended.

14.7.1 Packaging

Field personnel should receive training in the proper packaging and submission of samples for the focus pests within a surveillance programme. The NPPO should develop a general protocol for sample submission relevant to its country, and a survey-specific SOP for sample submission may also be needed.

General guidelines within a sample submission protocol may include these instructions on the preferred method of sample delivery:

- hand-delivered;
- mail:
  - if a sample is suspected as high-risk, express or expedited mail services should be requested, if available
  - designated diagnostic labs should be aware of the anticipated sample volume and delivery prior to arrival;
- include the sample submission form and data sheet with the sample;
- use a crush-proof box or container for sample transport;
- do not add water to the sample;
- soil samples should be separated from leaf samples – soil on leaves may result in the development of additional plant pathogens on the surface of the leaves during the shipping process;
- plant samples with a suspected plant disease should be submitted with multiple plant samples that show a range of symptoms;
- a potential plant disease or micro-arthropod can be submitted by placing the plant segment within a dry paper towel and shipping the sample to an approved laboratory.

Sample submission also depends on the sampling technique used during collection. See Table 8 for details.

14.7.2 Sample preparation

Procedures for the specific sampling programme should be followed.

Basic techniques:

- prepare according to relevant SOP
- call laboratory if there are questions about shipping or preserving samples
- most specimens need to be kept cool to prevent degradation.

14.7.2.1 Insects

Larvae

Place into near-boiling water. Heat about 125 ml (½ cup) water (using a gas burner, microwave oven or kettle) until the first signs of boiling. Add the larvae to this water and let sit for at least 30 s (up to 3 min for large larvae). Remove from water and place into vials with a 70 percent non-denatured ethanol solution. Put a paper label into the vial. The label must include the sample code, survey name and collector (written in pencil, rather than ink, which will dissolve in ethanol). Close the vial firmly and mail it in a well-padded tube or box.

Adult Lepidoptera and other fragile insects

Kill by freezing (two cycles). Submit between layers of cotton in a labelled container. Place just enough pressure on the specimen to prevent it from moving and damaging scales in transit.

Arachnids, adult insects, molluscs, mites and most nymphs

Place live insects in a vial with 70 percent ethanol solution and a pencil-written label. For true bugs, note colour of live insect in comments section.

Mites smaller than 0.5 mm should be shipped live on host material in a tightly sealed, labelled plastic bag.

Plant tissue:

- samples should show signs of various stages of disease
- wrap samples in dry paper towels or newspaper and enclose in plastic bag
- place in polystyrene shipping container with a few frozen cold packs (wrapped in paper towel) at the bottom.

Nematodes:

- precautions must be taken to prevent drying, freezing and overheating of samples
- whole plants or roots with soil should be placed in plastic bags.

Table 8. Sample packaging

Dry	Liquid	Sticky trap
Shipped in vials or glassine envelope	Mites, insect larvae, soft-bodied and hard-bodied adult insects can be transferred to vials of 75–90 percent ethanol or an equivalent, such as isopropyl alcohol	Specimens (Lepidoptera, Diptera, etc.) are fragile and require special handling and shipping techniques
May break during shipment and only recommended for larger insects	Funnel trap samples may have rainwater in them; drain off all the liquid and replace with alcohol to prevent decay of insects	Specimens in traps should not be manipulated or removed for preliminary screening unless expertise is available
If a soft envelope is used, wrap it in shipping bubble sheets; if a rigid cardboard box is used, pack it in such a way that the samples are restricted from moving in the container	Vials used to ship samples should contain samples from a single trap and a printed or hand-written label with the associated collection number using a micron pen or a pencil	Traps can be folded, with Stick Em glue on the inside, but only without the sticky surfaces touching, and secured loosely with a rubber band for shipping
Always include sample collection data		Inserting a few polystyrene (styrofoam) beads on trap surfaces without insects will cushion and prevent the two sticky surfaces from sticking during shipment to taxonomists
		Do not fold traps flat or cover traps with transparent wrap (or other material), because this will damage the specimen making identification difficult or impossible

15. Data collection and submission

It is critical that survey data are collected in a consistent and uniform manner to ensure data integrity through to submission.

NPPOs should develop and implement minimum data standards (refer to ISPM 6) for use across all surveillance programmes.

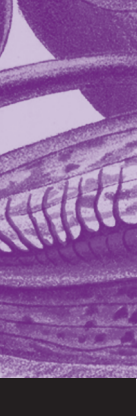
Survey records should include (but not be limited to) the following data fields:

- scientific name of pest (and Bayer/EPPO code);
- family and order details of pest;
- scientific name of host (and Bayer/EPPO code);
- plant part affected;
- means of collection;
- location details (GPS coordinates, addresses);
- date of collection and name of collector;
- date of identification and name of identifier;
- date of verification and name of verification;
- references; and
- additional information relating to the data record.

Consistent application of minimum data standards will ensure that surveillance records may be utilized for official phytosanitary purposes.

Negative data

NPPOs should also recognize the importance of capturing and recording negative data in their data collection systems. Negative data are used by NPPOs to support a country's pest status, PFAs and to support trade and market access.



16. Field communication and feedback

Effective field communications are essential to ensure that field surveillance findings are communicated back to the surveillance manager in a timely and regular manner throughout the delivery of the surveillance activity.

It is recommended that surveillance managers and surveillance officers conduct the following field communication and feedback as part of surveillance activities.

16.1 Pre-survey briefing

Surveillance managers and surveillance officers should conduct a pre-survey briefing to ensure that survey preparation, equipment methodologies, communication, data requirements and stakeholder engagement considerations are discussed and agreed prior to undertaking the survey activity. This could be summarized in a checklist review.

16.2 Survey (in-field) communications

Surveillance managers and officers should communicate regularly throughout the survey to ensure:

- communication of surveillance outcomes (significant findings, trapping results); and
- communication of survey delivery issues (health and safety, equipment issues, emergency response, stakeholder concerns).

16.2.1 Post-survey briefing

Surveillance managers and surveillance officers should conduct a post-survey briefing to discuss the findings of the survey, delivery issues, methodology issues, stakeholder feedback and diagnostic considerations.

16.3 Methods of communication:

- face to face
- mobile phone
- UHF/HF radios
- email communication (phone or tablet computer).

17. Interaction with stakeholders

Stakeholder interaction and engagement is critical to the successful delivery of surveillance activities.

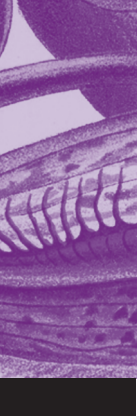
Stakeholder types (for access considerations) may include:

- commercial (farmers, processing facilities, cooperatives),
- community (homeowners, traditional owners, reservations, interest groups, farmers markets); and
- government (military, border, airports, seaports, rail, national parks, protected areas, etc.).

Stakeholder interaction and engagement considerations include:

- be prepared to show government identification and explain purpose of visit;
- maintain a proper personal appearance and keep your vehicle clean and tidy;
- provide business card or appropriate contact information;
- provide pest information and relevant publications, where available;
- always ask permission to enter property;
- never assume permission will cover repeat visits – request permission for each visit;
- do not try to anticipate consequences of survey results or discuss them with the property owner;
- allow property owner or employee to accompany you if they express interest;
- avoid damage to crops;
- after the survey is completed, inform the property owner whether any samples have been taken and that the results will be forthcoming;
- leave all gates, doors, etc., as you find them; and
- be aware of and comply with any biosecurity and sanitation measures in the location and protocols.

Provide survey result feedback as appropriate (considering programme and notification sensitivities and operational feasibility).



18. Supervision of activities

Effective supervision is essential to ensure that field officers deliver survey activities in accordance with relevant SOPs. ISPM 26 (*Establishment of pest free areas for fruit flies* (*Tephritidae*)) provides the following specific language in relation to supervision of the establishment of PFAs for fruit flies (Tephritidae).

"The [fruit fly] PFA programme, including regulatory control, surveillance procedures (for example trapping, fruit sampling) and corrective action planning should comply with officially approved procedures.

Such procedures should include official delegation of responsibility assigned to key personnel, for example:

- a person with defined authority and responsibility to ensure that the systems/procedures are implemented and maintained appropriately
- entomologist(s) with responsibility for the authoritative identification of fruit flies to species level.

The effectiveness of the programme should be monitored periodically by the NPPO of the exporting country, through review of documentation and procedures." (ISPM 26, section 1.3)

Further explanation and information regarding effective supervision for a fruit fly area-wide programme can be found in the International Atomic Energy Agency guidelines (IAEA, 2003).

Key elements involved in a supervision plan include the following:

- Official independent evaluations should occur periodically to assess the effectiveness of surveillance activities. The timing of evaluations will differ across surveillance programmes, but it is recommended that they be conducted at least twice a year in programmes that run for six months or longer.
- The evaluation should address all aspects related to the ability to detect targeted pests within the time frame required to meet the survey outcomes.
- Aspects of an evaluation should ensure adherence to SOP (see section 14.3.1 for more detail). Aspects that are found to be deficient should be identified and specific recommendations should be made to correct these deficiencies.
- Proper record-keeping is crucial to the successful delivery of a survey. The records for each survey should be inspected to ensure that they are complete and up to date. Field confirmation can then be used to validate the accuracy of the records.

Feedback surveys may be used as an external evaluation tool by relevant stakeholders to assess the effectiveness of a surveillance programme.

Section 5: Bibliography and additional resources

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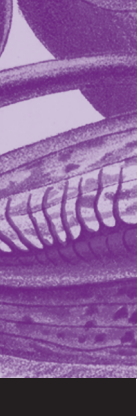

ISPMs Directly related to surveillance

The international standards that are directly concerned with matters relating to surveillance are listed below:

ISPM 1. *Phytosanitary principles for the protection of plants and the application of phytosanitary measures in international trade*. Rome, IPPC, FAO.

ISPM 2. 2007. *Framework for pest risk analysis*. Rome, IPPC, FAO.

ISPM 3. 2005. *Guidelines for the export, shipment, import and release of biological control agents and other beneficial organisms.* Rome, IPPC, FAO.

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ISPM 31. 2008. *Methodologies for sampling of consignments.* Rome, IPPC, FAO.

ISPM 32. 2009. *Categorization of commodities according to their pest risk.* Rome, IPPC, FAO.

Internet resources

International Plant Protection Convention (IPPC)

https://www.ippc.int/en/
The IPPC website contains ISPMs and links to other multinational plant protection organizations.

Surveillance

https://www.ippc.int/en/core-activities/capacity-development/phytosanitary-system/surveillance/
Each component page under a Phytosanitary System (https://www.ippc.int/en/core-activities/capacity-development/phytosanitary-system/) brings together all of the relevant technical resources to help NPPO staff understand and access information related to a subject. Relevant technical resources include: ISPMs, CPM Recommendations, IPPC Guides and training materials as well as Contributed resources.

Contributed resources

https://www.ippc.int/en/core-activities/capacity-development/guides-and-training-materials/contributed-resource-list/
Contributed resources are phytosanitary technical resources that were developed by National NPPOs, RPPOs and other organizations for their own use and kindly provided to the IPPC Secretariat as they are considered useful for other organizations too.

International Symposium for Pest Free Area and Surveillance (2019)

https://www.ippc.int/en/core-activities/capacity-development/symposia/symposium-on-pfas-and-surveillance/
The main objectives of the symposium were to raise awareness of the international phytosanitary framework for Pest Free Areas (PFAs) and Pest Surveillance and the IPPC implementation resources with the emphasis on the PFAs and Pest Surveillance related materials. Presentation slides are available on the website.

Plant Surveillance Network (Australasia and Pacific)

https://plantsurveillancenetwork.net.au/portal/
The Plant Surveillance Network Australasia–Pacific (PSNAP) enables members to communicate about plant pest surveillance and acts as a coordination point for surveillance professionals and practitioners to strengthen surveillance capacity and capability. The network was formed in 2017 as an initiative of the Subcommittee for National Plant Health Surveillance (SNPHS).

European and Mediterranean Plant Protection Organization (EPPO)

http://www.eppo.int/
This organization is an RPPO and coordinates numerous aspects of plant protection across most European countries. EPPO has produced a number of standards on phytosanitary measures and plant protection products.
North American Plant Protection Organization (NAPPO)
http://www.nappo.org/
This organization is an RPPO and coordinates numerous aspects of plant protection across North American countries. NAPPO has produced a number of standards on phytosanitary measures.

The Plant Protection Committee (COSAVE)

http://www.cosave.org/
This organization is an RPPO and coordinates numerous aspects of plant protection across South American countries. COSAVE has produced a number of standards on phytosanitary measures.

CAB International (CABI)

http://www.cabi.org/

CABI is an international not-for-profit organization that improves people's lives by providing information and applying scientific expertise to solve problems in agriculture and the environment.

CABI Crop Protection Compendium

http://www.cabi.org/cpc

The compendium contains fact sheets on a wide diversity of pests.

Plantwise

http://www.plantwise.org/

Plantwise is a global programme led by CABI, which works to help farmers lose less of what they grow to plant health problems.

Animal and Plant Health Inspection Service (APHIS) of United States Department of Agriculture

http://www.aphis.usda.gov/wps/portal/aphis/ourfocus/planthealth

The website has manuals on a number of invertebrate pest species, with useful information on identification, survey methods and pest control. Pest risk assessments of commodities being considered for import into the United States of America are available for numerous pests, and these can provide readily accessible information about host ranges and surveillance methods, among other useful sections. APHIS also provides useful links to a wide range of pest information databases.

American Phytopathological Society (APS)

http://www.apsnet.org

APSNet contains discussions of plant pathogens through newsletters, and an image collection. It also contains a database of pest lists for different crops and commodities.

Guidelines for surveillance for plant pests in Asia and the Pacific

https://aciar.gov.au/node/8941

This manual will assist plant health scientists to devise surveillance programmes and to transmit specimens to the laboratory for identification and preservation.

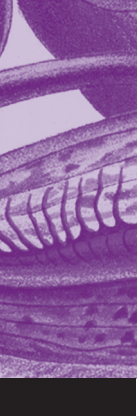
Purdue University

CAPS Resource & Collaboration website: http://caps.ceris.purdue.edu/
2020 National Pest Surveillance Guidelines: http://caps.ceris.purdue.edu/pest-surveillanceguidelines/
2020 Priority Pest List: http://caps.ceris.purdue.edu/pest-surveillance-guidelines/2020
Approved Methods for Pest Surveillance: http://caps.ceris.purdue.edu/approved-methods
Survey Manuals: http://caps.ceris.purdue.edu/survey-manuals
Pest Lens: https://pestlens.info/

European Food Safety Authority (EFSA)

28 Pest survey cards
https://efsa.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)1831-4732.toolkit-plant-pest-surveillance
10 Story maps https://efsa.maps.arcgis.com/apps/MinimalGallery/index.html?appid=f91d6e95376f4a5da206eb1815ad1489
These materials guide the surveyor in the gathering of the relevant data for the survey design.
Statistical tools (RiBESS + and SAMPELATOR) for the sample size calculation freely available online with prior registration at https://shiny-efsa.openanalytics.eu/

Appendices



Appendix A: **Surveillance equipment**

The list below is not exhaustive. Surveillance specialists should ensure they have the right equipment for the type of survey to be undertaken. This includes appropriate and reliable means of transport outfitted for the tasks to be undertaken ranging from domesticated draft animals, bicycles, motorcycles, all-terrain vehicles, motor vehicles, watercraft, aircraft and other necessary vehicles. Safety equipment should always be carried without exception.

Equipment	Reagents	Supplies	Tools for data collection
Ethanol flame lamp	Ethanol (70–90 percent)	Brightly coloured ribbons	GPS unit
Spade	Calcium chloride chips (desiccant)	Spray paint	Maps
Soil sieves for nematodes	Water	Ice packs	Mobile phone, radio or satellite phone
Sweep net	Ethyl acetate	Camel-hair brushes	Diagnostic keys
Pooter or aspirator	Ammonium carbonate	Corrugated cardboard	Random number generator
Collecting vacuum		Plastic tubes with snap on caps (assorted sizes)	Digital camera
Mounting boards		Tape	Watch
Scissors		Clear plastic bags (assorted sizes with zip lock or ties)	Notebook
Plant press		Newspaper	Permanent marker pens
Pruning saw		Pins for insects	Compass
Water spray		Lures	Laptop or personal handheld device
Small combination pick, mattock or trowel		Traps	Aerial drones
Field microscope		Glassine envelopes for delicate specimens (moths, etc.)	
Beating sheets		Specimen pots	
Hammer		Glass vials with screw caps (assorted sizes)	
Chisel		Parafilm	

Equipment	Reagents	Supplies	Tools for data collection
Strong knife		Culture plates	
Secateurs		Razor blades	
Hand lens		Scalpels	
Binoculars		Gloves (gardening type)	
Survey bag (backpack type)		Surgical gloves (disposable)	
Small bucket		Absorbent fibre-free paper tissue	
Icebox		Disinfectant wipes	
Power saw		Hand towels	
Machete		Acid-free collectors tags	
Penknife		Mosquito repellent	
Cigarette lighter		Sunscreen	
Whistle		Disposable coveralls with boot covers	
Tweezers or forceps			
Collecting/killing jars			
Hat			
Rain gear			
Sunglasses			
First aid kit with eyewash			
Spare clothing			

Appendix B: **Case studies**

Case study 1: General surveillance

Surveillance for invasive forest pests: Innovative national trapping and rearing surveys

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Location and timeline of the case study:

Canada, since 1998

Content of the case study:

Solid wood packaging material (SWPM) and loose wood dunnage are high-risk pathways for the introduction of invasive wood boring pests. While ISPM 15 (*Regulation of wood packaging material in international trade*) has decreased the risks associated with this pathway, there are still interceptions of live wood boring insects at Canadian ports of entry.

To detect these insects as quickly as possible, the Canadian Food Inspection Agency (CFIA) delivers a number of pest specific detection surveys in accordance with ISPM 6 principles, as well as two innovative, early detection general pest surveys called the Invasive Alien Species (IAS) Forest Trapping Survey and the IAS Insect Rearing Survey.

The IAS Forest Trapping Survey has been implemented by the CFIA since the late 1990s. This is a semiochemical-based survey that uses pheromone and kairomone lures on funnel traps to detect new pests. Based on research done by the Canadian Forest Service (CFS), the CFIA uses different lures every 3 to 5 years in order to target a wide variety of high-risk wood borers. Survey sites are selected in wooded or treed sites in industrial and commercial zones or landfills as these are high-risk areas for the introduction of pests via international SWPM. Six black, 12 unit funnel traps are set at each site; a rope is suspended about 1.5 m above ground between two trees and the funnel trap is attached at the middle of the rope (Figure 1). Three of the traps are baited with a combination of fuscumol, fuscumol acetate and UHR ethanol (i.e. general longhorn lures) (Figure 2) which attracts longhorned beetles, but also bark/ambrosia beetles and other secondary boring insects (Sweeney *et al.*, 2016). The other three traps are baited with monochamol, alpha-pinene, ipsenol and ethanol (i.e. pine sawyer lures) which targets sawyer beetles but also many other wood-boring taxa (Ryall *et al.*, 2015).

Since 2011, this survey has resulted in 40 new records, 11 Canadian records and 29 provincial records (Thurston *et al.*, forthcoming). Some of these records represent natural distribution of native species, while others appear to be northward extensions of insects native to the United States due to climate change or are the result of introductions of non-actionable species from other countries.

As not all insects respond to the semiochemicals used in the IAS forest trapping survey and as not all high risk industrial sites can be surveyed without trap theft/vandalism or other restrictions, there is a gap in what can be detected with the IAS trapping survey. In order to address this gap, in 2006 the CFIA and the CFS developed the IAS Forest Insect Rearing Survey, where logs are sourced from hazardous municipal street trees that are being removed by the city.

The selected trees, mainly those showing signs or symptoms of insect attack, are cut into short logs. The logs are placed in a mesh cage and are suspended from ceiling racks in 12 m (40 foot), steel transport containers which have been modified into a climate-controlled insect rearing facility (Figures 3 and 4).

The CFIA has five insect rearing facilities, located across Canada. This survey has produced two provincial and two Canadian records. Three of these records are either a range expansion of a native Canadian species or a northward expansion of an insect native to Washington and Oregon states in the United States of America. In 2010, adult *Trichoferus*

campestris was reared from bolts from a declining Norway maple tree in Mississauga, Ontario. Although this non-indigenous longhorned beetle was detected in Quebec in 2002, this was the first detection in Ontario and was the first published North American host record (Bullas-Appleton *et al.*, 2014).

Even though ISPM 15 has been implemented by many countries, non-compliant SWPM still enters Canada and some consignments still include infested SWPM. Therefore, these two general detection surveys are important for the CFIA's ability to quickly detect new incursions of forest IAS and limit their impacts.

References

Bullas-Appleton, E., Kimoto, T. & Turgeon, J.J. 2014. Discovery of *Trichoferus campestris* (Coleoptera: Cerambycidae) in Ontario, Canada and first host record in North America. *The Canadian Entomologist*, 146: 111–116.

Ryall, K., Silk, P., Webster, R.P., Gutowski, J.M., Meng, Q., Li, Y., Gao, W., Fidgen, J., Kimoto, T., Scarr, T., Mastro, V. & Sweeney, J.D. 2015. Further evidence that monochamol is attractive to Monochamus (Coleoptera: Cerambycidae) species, with attraction synergised by host plant volatiles and bark beetle (Coleoptera: Curculionidae) pheromones. *The Canadian Entomologist*, 147: 564–579.

Sweeney, J.D., Silk, P., Grebennikov, V. & Mandelshtam, M. 2016. Efficacy of semiochemical-baited traps for detection of Scolytinae species (Coleoptera: Curculionidae) in the Russian Far East. *European Journal of Entomology*, 113: 84-97.

Thurston, G.S., Kimoto, T., Slater, A., Nei, I. & Roberts, J. (forthcoming). New Canadian and provincial records of Coleoptera resulting from routine CFIA surveillance activities.

Figure 1. Setting an IAS trap in the field.

Figure 2. IAS trap baited with general longhorn lure – UHR ethanol (long sleeve), fuscumol and fuscumol acetate (white pouches).

Figure 3. Steel container, modified into a mobile insect rearing facility.

Figure 4. Logs suspended in an IAS insect rearing facility.

Case study 2: General surveillance

Observatree – an early warning system for tree health using citizen science

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Content of the case study:

Context

Observatree is a project aimed at helping to protect the trees of the United Kingdom of Great Britain and Northern Ireland. Where trees have evolved alongside a pest or pathogen, a natural balance has often resulted whereby the tree has developed some level of defence against affecting organisms. However, with increased global movement of trade and people, pests and diseases from around the world have the potential to arrive on British shores faster than by natural movement. The changing climate is also facilitating the introduction of alien pests and diseases. When these pests or diseases arrive, British trees are often unable to combat them as they have not had time to evolve defence mechanisms. Many pests and diseases can slow the growth of British trees making them unsightly or unproductive. Others have potential to kill the tree completely. While the loss of any tree species would be tragic, several different species are currently under threat from these new pests or diseases.

What activities were undertaken?

Tree health early warning surveys: a British network of up to 200 specialist, trained volunteers (citizen scientists) undertake a range of surveys to assist with spotting new tree pests and diseases. This comprises of three different activities: surveys for the presence of a narrow list (currently 22) of high-priority pests and the distribution of some established pests, general health surveillance of trees and monitoring of sentinel trees plots. They also complete surveys to help track the spread of new, established diseases such as *Hymenoscyphus fraxineus* and assist in research and development projects appropriate to their skills. Volunteers receive annual training to help with identification and surveying techniques.

Triage and verify the most significant reports: the project works with our specialist volunteers to help triage and verify reports of pests and diseases received through an online reporting tool called Tree Alert. This may involve visiting sites to carry out further surveillance work following an initial report, including sampling or sending additional photographs or information or verifying the position of a finding.

Share best practices: Observatree connects with other tree health early warning systems in other countries; Observatree learns from the experience of others and shares what it is doing in the United Kingdom of Great Britain and Northern Ireland.

Who was involved?

The project brings together the best skills, knowledge and experience from across the United Kingdom of Great Britain and Northern Ireland to collaborate and share in this single aim. The partnership includes: Forest Research (project leaders), the Animal and Plant Health Agency, the Department for Environment, Food and Rural Affairs (Defra), the Forestry Commission, Fera Science Ltd, the National Trust, Scottish Forestry, the Woodland Trust and the Welsh Government.

The Observatree project has a network of up to 200 volunteers (citizen scientists) from across the country who can look out for, and report findings of, pests and diseases. The volunteers come from all walks of life with a wide range of experience and

backgrounds, they receive an intensive induction and scientific training programme through online and face-to-face training. Observatree provides pest and disease recognition guides and other extensive online resources, which are also freely available on its website and have become a valuable resource for many stakeholders. The volunteers are requested to attend a face-to face training session every year, access online training resources and carry out regular surveys throughout the year reporting their findings on a regular basis. There are many other additional training and surveying tasks they can access or offer to support dependent on their availability and skills.

How were the activities initiated and undertaken?

The finding of ash dieback in the natural environment in the United Kingdom of Great Britain and Northern Ireland in 2012 led to a review of tree health and biosecurity, and the publication of *Protecting Plant Health: A Plant Biosecurity Strategy for Great Britain.* This recognized the importance of engaging with stakeholders and the opportunity to harnesses citizen science for enhanced surveillance. The project was initiated in 2012 as a short feasibility study funded by National Plant Protection Organization, which in turn led to a four-year European LIFE+ Programme project (January 2013 to September 2017), that provided 50 percent of the costs. The remainder was provided by partner organizations (Forest Research, Forestry Commission, Fera Science Ltd, National Trust and Woodland Trust), supported by APHA, Defra and Natural Resources Wales. Since October 2017, the project is solely funded through the partner organizations listed above.

What ISPMs were successfully implemented?

The project supports the work of the NPPO, which is built upon the core principles of many ISPMs. For example, the priority pests and disease list is drawn from the plant health risk register of the United Kingdom, which is based upon the principles of pest risk analysis described in ISPM 11 (*Pest risk analysis for quarantine pests*). Observatree draws upon the requirements laid out in ISPM 6 (*Surveillance*), which makes specific reference to public education/awareness programmes as well as principles such as data verification procedures and good surveillance practices. The results of the surveys help to inform the status of pests in the country as per ISPM 8 (*Determination of pest status in an area*). In developing its training concerning plant health and biosecurity, Observatree draws upon ISPMs, such as ISPM 39 (*International movement of wood*) and ISPM 41 (*International movement of used vehicles, machinery and equipment)*, to illustrate the risk of different pathways of introduction and spread the various pests and pathogens.

Figure 1. Observatree volunteer-training workshop

Identify any IPPC implementation resources that were used and how they were helpful

In developing the training programmes for volunteers, Observatree has drawn upon the IPPC implementation capacity development guides and training materials, such as IPPC Factsheets.

Outcomes and impacts

Observatree volunteers have submitted over 10 000 tree health reports, of which almost 2 500 were of pests or diseases. These reports have included sightings of all priority pests and diseases known to be present in the United Kingdom of Great Britain and Northern Ireland. For example, Oriental chestnut gall wasp, which creates deformed growth on sweet chestnut foliage, was first recorded in the country in 2015. An Observatree volunteer made only the second reporting of this tree pest in the country; it was found in a different area to the previous outbreak, leading to follow-up inspections and intervention to help manage the situation. More recent significant findings have included reports on chestnut blight and oak processionary moth, which have also led to follow-up activities by inspectors.

While recording positive results is very important for detecting new outbreaks, unlike many other citizen science projects, Observatree encourages volunteers to submit information on locations where no pests or diseases are found. These "negative data" are very important in helping map rates of spread of any tree pests or diseases. It may identify areas where tree pests or diseases are unable to become established. All mapped results are shared with volunteers, to feedback the outcome of their efforts, and with project partners and stakeholders for information. Over time this will help Observatree to build a comprehensive map of where pests or diseases are causing concern and allow much more targeted responses to them.

Observatree is about more than reported observations of tree pests or diseases. The value of some of these other indicators of success can be more difficult to measure. For example, a significant role of the project is about raising awareness of tree health and the threat these pests and diseases pose to British trees. Observatree is keen to promote these issues to a wider audience. In addition to providing information and resources to volunteers, the communications

Figure 2. Examining symptoms of Armillaria decay

Figure 3. Volunteer boot washing.

team have placed printed and digital advertisements in targeted media, given talks to interested groups and participated in shows and events targeting key audiences. It has also provided training for stakeholder groups. Public information boards about the project, featuring local pests and diseases, have been placed in sites where they will be seen by members of the public

Lessons learned and areas for improvement

Collaboration: to raise further awareness of tree health, and to help other citizen science projects by sharing our lessons learned, Observatree has been keen to collaborate with others. The organization is working with other similar plant health citizen science projects both within and outside the country to form a network for knowledge exchange and partnership working. Observatree has hosted international conferences and spoken to others about its project, reaching a much wider international audience.

Investing in volunteer management: it should not be underestimated the level of investment required to maintain an engaged and productive volunteer workforce. Although they give their time freely, they have the same needs as professional staff – they need support to do their job, they must develop and maintain their skills and receive feedback on the value of their work.

Data management: the success of the project has resulted in considerable interest in the resources that Observatree develops and the volume of data that the volunteers produce. This requires robust and resilient infrastructure and investment to ensure the value of the volunteer surveillance work is made available for national surveillance.

Staying focused: inevitably with such a talented volunteer workforce, there will be requests to get them involved in a diversity of activities. Good governance of the project has ensured that the views of the volunteers and partners are well balanced and the project stays focused on its core mission.

Future plans and activities

The work of the volunteers and the data gathered are now becoming an essential part of tree health surveillance in the United Kingdom of Great Britain and Northern Ireland. Observatree continues to remain focused on its core mission for an early warning system for tree health, but it continues review its priority pests and diseases for surveillance (e.g. the addition of the elm zig-zag sawfly, *Aproceros leucopoda*), and seeks to develop the skills of its volunteers and the network to support them. Observatree works closely with the National Plant Protection Organization, plant health services and stakeholders to ensure it is meeting their needs; but equally as important, Observatree works with its volunteers to ensure it is also meeting volunteer needs.

Figure 4. Observatree training materials.

Figure 5. Observatree workshop.

Case study 3: Specific surveillance

Monitoring of the avocado seed moth (*Stenoma catenifer*) using pheromones

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Location and timeline of the case study:

This case study was carried out in avocado production sites located in the provinces of Pichincha, Carchi and Imbabura. The purpose of this study was to identify the presence of the avocado seed moth (*Stenoma catenifer*). The monitoring network began in May 2019 with the installation of traps and their respective pheromones.

The monitoring of this pest is currently carried out jointly with the Corpoaguacate association, whose representatives carry out monitoring every 7 days. Once a month, their work is overseen by technicians from the Agrocalidad agency.

Monitoring is conducted using a web platform and a free mobile application (Epicollect5) to periodically record information about the insect. The data are analysed by officials from the agency's Phytosanitary Surveillance Unit.

At present, the insect has been identified at two production sites, one in the province of Pichincha and one in the province of Carchi. Thanks to this activity and the commitment of the producers, the monitoring network for *S. catenifer* has been strengthened. At present, Ecuador is negotiating with the United States of America to establish the requirements for the export of fresh avocado fruit. As *S. catenifer* is a regulated pest, having a strong monitoring network will be of benefit in these negotiations.

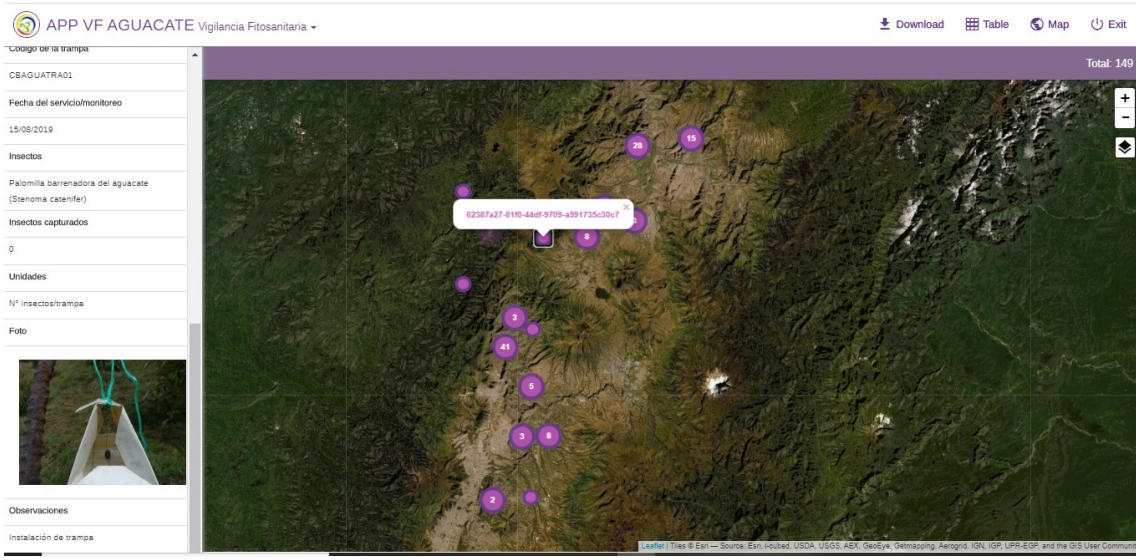

Figure 1. Map of S. catenifer monitoring sites.

Content of the case study:

Context

The Phyto and Zoosanitary Regulation and Control Agency – Agrocalidad has been developing strategies regarding the strengthening of its phytosanitary surveillance network. To do so, the use of pheromones has been recommended for pest monitoring, including for *S. catenifer*, which affects avocado fruit. A joint programme was established with Corpoaguacate producers who were seeking to export their product to the United States of America, where the insect is regulated by the Animal and Plant Health Inspection Service (APHIS) of United States Department of Agriculture.

To meet the requirements set out by the United States of America for the import of Ecuadorian avocados, it was necessary to determine the pest's distribution in Ecuador. This was a major challenges for Ecuador's avocado sector.

Key features of the surveillance project included:

- use of a free mobile application (Epicollect5)
- installation of traps and pheromones
- service-time monitoring
- international and national regulations (objectives)
- preparation of report on findings
- identification of the pest in larva and adult states
- management of pheromones and traps.

In order to strengthen the surveillance network, ongoing monitoring has been carried out by agency officials. This includes on-site monitoring in avocado production areas as well as the verification of monitoring activities carried out by producers at avocado production sites.

It is important to note that the agency's technicians are responsible for taking samples to verify that the insects collected in traps correspond to the target pest.

For Corpoaguacate avocado producers, the main aim of the surveillance programme is to obtain a seal of origin for Ecuadorian avocados, so they can be exported to and be competitive in key international markets. In addition to the surveillance programme, producers will implement a programme of good agricultural practices on their farms and will be supervised by agency officials.

As the phytosanitary authority of Ecuador, Agrocalidad's primary interest is to keep ongoing records of the pest in the country in order to comply with processes required by APHIS and negotiate the phytosanitary requirements for the entry of Ecuadorian avocados into the United States of America.

Avocado seed moth monitoring began with the following activities:

- initial and ongoing training provided by the agency;
- traps and pheromones used by producers;
- mobile application developed to collect monitoring data; and

Figure 2. Training on the trapping of S. catenifer.

Figure 3. Identifying damage caused by S. catenifer.

- agency commitment to take samples and send results to avocado producers.

Successfully implemented ISPMs for this project were ISPM 6 (*Surveillance*) and ISPM 8 (*Determination of pest status in an area*). The surveillance system was strengthened, and the presence of a pest in the country was ascertained based on procedures set out in ISPM 8.

IPPC actions taken into consideration when establishing this monitoring programme included:

- initial and ongoing training provided by the agency;
- use of regulations related to the phytosanitary surveillance;
- determination of the presence or absence of the pest to avoid non-compliance notifications of the phytosanitary requirements; and
- notification of the presence of pests so that the status of the pest in the country is transparent.

Results

Trapping was conducted in a total of 10 production sites with an average area of 53 hectares. Of these sites, the presence of the insect was confirmed in only in two farms, one located in the province of Carchi and the other in the province of Pichincha.

It is important to note that the use of traps and pheromones had a signification impact to the programme. It allowed for the expansion of pest monitoring areas and also allowed for the monitoring of nocturnal insects, in particular adult avocado seed moths.

Agrocalidad plans to promote the use of pheromones for pest monitoring in other crops such as grapes, corn and sugar cane to determine the status of pests and their distribution in Ecuador.

Figure 4. Installing traps and pheromones for S. catenifer

Case study 4: Specific surveillance

Phytosanitary measures and procedures taken to manage the risk of fall armyworm in Egypt

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Location and timeline of the case study:

Upper Egypt (1 year, since 2019)

Content of the case study:

The devastating, rapid spread of the fall armyworm (FAW) pest (*Spodoptera frugiperda*), across Africa has had a dramatically negative impact on crop production, especially for maize farmers who who sought desperately to avoid crop destruction. The crisis has compelled governments across Africa to help farmers manage the pest and control its effect on crops.

The pest was first reported in Africa in 2016 (Goergen *et al.*, 2016; Cock *et al.*, 2017), with subsequent reports across the continent up to 2019, when it was first reported in Egypt. FAW is reported to attack more than 350 plant species (Cock *et al.*, 2017; Day *et al.*, 2017). It has had a significant impact in Africa, on maize production in particular (Abrahams *et al.*, 2017).

In August 2017, the FAO Regional Office for the Near East and North Africa (RNE), notified the Ministry of Agriculture in Egypt about the detection of FAW in most African countries, including in neighbouring Sudan. The insect was discovered in some agricultural areas in southern Egypt by the Central Administration of Plant Quarantine (NPPO of Egypt).

Figure 1. Fall armyworm in caterpillar stage.

To speed up the detection process, notifications were sent to all governorates across Egypt. Existing monitoring systems were reinforced with field inspections and the use of pheromone traps to detect the insect anywhere it occurred and to report its occurrence. Cooperation among various NPPO-related authorities strengthened this action, with the following measures taken:

- phytosanitary specialists received training by relevant research institutes and were assigned duties to perform;
- pheromone traps were deployed across all of Egypt's agricultural regions, under the supervision of the Central Department of Pest Control; and
- delimiting survey was conducted by specialists from the Plant Protection Research Institute (PPRI) and the Central Department of Pest Control using traps and field inspections to determine the presence of the pest and identify hosts across all the governorates of Egypt, with rapid reporting to the Committee to control the pest and take necessary measures.

Awareness and training sessions:

Training seminars were conducted for relevant stakeholders, including pest control agencies and farmers, to raise awareness of the devastating dangers posed by this pest, how to detect it, how to monitor for it and how to identify it by phenotype or symptom of infection.

Action taken in cooperation with the FAO regional office:

- Several workshops and training sessions were conducted in the governorates of Upper Egypt over the course of 2019. These events were attended by 587 pest control specialists and academic staff of the Field Crops Research Institute to raise awareness of fall armyworm (FAW) and the measures needed to manage this pest.
- In cooperation with FAO, 100 pest control specialists were trained in Luxor, Egypt to use modern technology to forecast and detect FAW via a mobile application (FAMEWS), (April–May 2019).
- Publications and flyers were produced to illustrate the procedures for FAW prevention, and addressed the symptoms of infection, pest risk and biological hosts in picture form. These publications were distributed to various agricultural directorates in Egypt (Faiyum, Beni Suef, Minya, Asyut, Qena, Luxor, Aswan).
- FAW adult insects were detected in Aswan governorate (in Kom Ombo and Edfo towns) using pheromone traps to attract the insect. Identification of the collected specimens was confirmed at the Plant Protection Research Institute (PPRI).
- *Trichogramma* parasite was used to control the emergence of fall armyworm and to eradicate the outbreak quickly.

Figure 2. Fall armyworm in adult stage.

Figure 3. Fall armyworm frass.

- A chemical control programme for fall armyworm was sent to the directorates of agriculture in all the provinces of Upper Egypt and to other at-risk areas to combat to combat any possible future outbreaks of fall armyworm. The programme will be applied to maize, cotton, vegetable, sugarcane and clover crops in case of fall armyworm outbreak.

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Figure 4. Injured maize leaves.

Figure 5. Fall armyworm frass.

Case study 5: Specific surveillance

The International Plant Sentinel Network Spittlebug Hunt

As part of their efforts to protect the United Kingdom of Great Britain and Northern Ireland from *Xylella fastidiosa*, the Department for Environment, Food and Rural Affairs (Defra) drew upon the expertise and resources of the International Plant Sentinel Network (IPSN). The aim was to improve understanding of host plants of spittlebugs in the country that are known to vector or are potential vectors of the disease.

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Location and timeline of the case study:

Botanic gardens in the United Kingdom of Great Britain and Northern Ireland, May–June 2017

Content of the case study:

Spittlebugs and *Xylella fastidiosa*

There are a number of spittlebugs (also known as froghoppers) that are native to the United Kingdom of Great Britain and Northern Ireland. Nymphs (spittlebug young) develop in foam nests commonly called "cuckoo spit", so finding cuckoo spit can indicate that a plant species is a preferred place for the spittlebugs to develop.

Spittlebugs do not cause significant damage to plants, and many are native to the country; however they do have the potential to carry *Xylella fastidiosa* (ISPM 27, Annex 25), a disease-causing bacteria, which can kill a wide range of plants including many iconic tree species.

Defra and the plant health service of the United Kingdom of Great Britain and Northern Ireland are gathering information to ensure that the risks relating to *X. fastidiosa* are understood, to reduce the risk of the pest arriving in the country and to be prepared for any outbreaks.

Botanic Gardens Conservation International's (BGCI) International Plant Sentinel Network (IPSN) is a network of botanic gardens and arboreta working together to provide an early warning for, and vital information on, new and emerging pests and pathogens.

Defra drew upon the expertise and resources of the IPSN as part of their efforts to protect the United Kingdom of Great Britain and Northern Ireland from *X. fastidiosa*.

BGCI worked with Fera Science Ltd and Royal Botanic Gardens, Kew to provide scientific expertise.

Aims and activities

Information was gathered via a public engagement activity. Staff and visitors to botanic gardens were encouraged to look out for the conspicuous "cuckoo spit" produced by the spittlebug nymphs (ISPM 6).

The information requested was purposely designed to be simple and easy to gather – a picture of the "cuckoo spit" on the host, host identity and location. An advantage of the IPSN involvement was that most host plants could easily be identified due to the labelling in botanic gardens and arboreta. This activity aimed to provide valuable information for plant health, but also to offer an opportunity to engage the public. This survey also acted as a pilot project for potential future plant health engagement/citizen science activities.

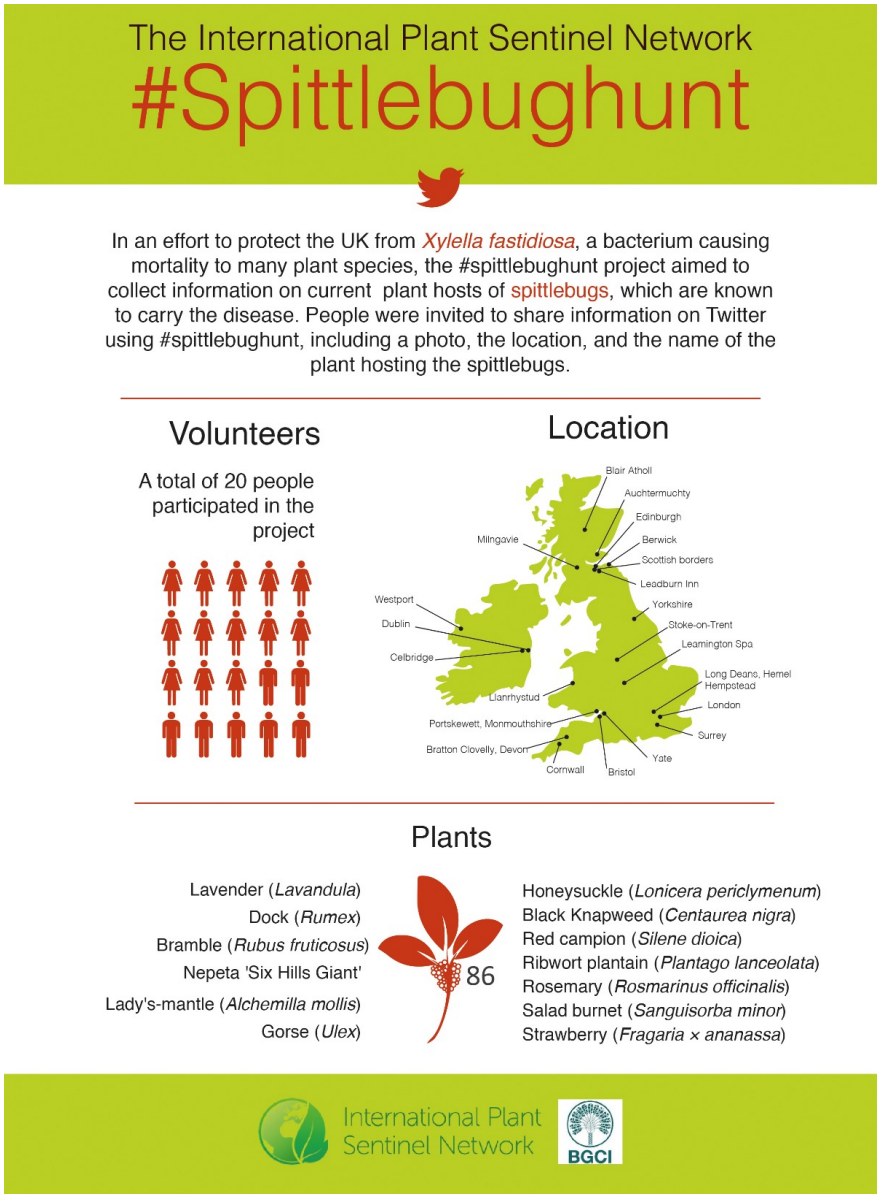

Figure 1. Spittle bug infographic.

Several different methods of outreach were employed in order to increase the scope of the project and engage a wide range of stakeholders:

- A poster was created in collaboration with Fera Science Ltd, Royal Botanic Gardens, Kew, BGCI and Defra with information on the Spittlebug Hunt. The poster included images to aid spittlebug identification and information on both the vectors (spittlebugs) and the pathogen (*X. fastidiosa*). It has links to more information regarding the IPSN and spittlebugs (through the Royal Horticultural Society website). The poster also included information on the Twitter campaign (details below) and an alternative reporting mechanism (other than Twitter).
- The survey was run on Twitter using the hashtag #Spittlebughunt. Participants were invited to include a photo, the location and the plant name (common or Latin) in the tweet.
- A news article was created and published on the IPSN website (http://www.plantsentinel.org/news/1409/).
- Participants could also send information directly to a staff member at Defra plant health policy.
- Participating gardens were invited to get involved in the survey by showcasing the poster in their entrance/visitor centre and to involve garden visitors in the activity.
- Some suggested ways to do this included:

- visitors simply reporting findings to reception;
- a table where visitors could fill in the host name and date;
- a chalkboard or a white board which could be recorded at the end of a week/day.

What ISPMs were successfully implemented?

The project supports the work of the NPPO which is built upon the core principles of many ISPMs. For example, IPSN's research on priority pests and disease is drawn from the plant health risk register of the United Kingdom of Great Britain and Northern Ireland, which is based upon the principles of pest risk analysis described in ISPM 11 (P*est risk analysis of quarantine pests*). IPSN draws upon the requirements laid out in ISPM 6 (*Surveillance*), which makes specific reference to public education/awareness programmes as well as principles such as data verification procedures and good surveillance practice. The results of the surveys help to inform the status of pests in the United Kingdom of Great Britain and Northern Ireland as per ISPM 8 (*Determination of pest status in an area*).

Identify any IPPC implementation resources that were used and how they were helpful.

In developing training programmes for its volunteers, IPSN has drawn upon the IPPC implementation capacity development guides and training materials, for example, IPPC Factsheets.

Outcomes and impact

The news article on the IPSN website was promoted through IPSN's network, PlantNetwork (a network of botanic gardens and arboreta) and *Cultivate* (BGCI's newsletter). The poster was sent to IPSN member gardens in the country. According to Google analytics data, the website news item was viewed close to 200 times since it was published.

Between 26 May and 30 June, 65 tweets were received from 20 participants. Tweets were received from Scotland, England, Ireland and Wales. A total of 86 plants were identified as having cuckoo spit on them. The most commonly observed plant was lavender. The tweets were sent in by a combination of plant health officials, botanic garden staff and volunteers.

Emails with information on spittlebug sightings were sent to the staff member at Defra plant health policy. The emails contained data related to 78 sightings of spittlebug. A total of 44 plants were recorded, 30 of which were identified to species level. Twelve sightings were sent by email and also tweeted.

In addition, 30+ samples of spittlebug nymphs were taken by Defra and Fera Science Ltd staff and were analysed to confirm their identity.

Figure 2. Spittlebug on fireweed (Chameanerion angustifolium).

Conclusions

Research outputs and impact of the campaign

The aim of the campaign was to collect information on current host plants of spittlebugs that are known to vector the disease. The results have expanded the list of potential hosts in the United Kingdom of Great Britain and Northern Ireland, demonstrated the range of managed and unmanaged habitats that spittlebugs can been found in, emphasized the widespread distribution of spittlebugs in the country and provided information on the time of year when spittlebug larvae are active. This information has been used by plant health scientists to improve their understanding of the host range, frequency and geographical distribution to inform the pest risk analysis. The information will also be helpful as part of the contingency planning process supporting the plant health service in its efforts to prevent the introduction or spread of *X. fastidiosa* in the United Kingdom of Great Britain and Northern Ireland.

Figure 3. Spittlebug on Nepeta 'Six Hills Giant'

Outreach

The Twitter and email campaign proved an effective form of outreach in creating information related to spittlebug host plants. It represents a successful campaign where volunteers, botanic gardens and plant health officials worked together to gather important plant health data. One nice example of this collaboration can be seen where Twitter users found spittlebug outside of botanic gardens and were unable to identify the plant species. The botanical experts involved in the campaign used the pictures from the tweets to identify the species that were acting as a host plant to the spittlebug to ensure that the data captured was useful and of high quality.

Future plans and activities

Surveys have been run in subsequent years by SASA in 2018 and the John Innes Centre in 2020. Campaigns through Twitter can be set up in advance, using a function in Twitter in order to collate data. Data contained in tweets with a specific hashtag can be automatically recorded to a spreadsheet to reduce amount of time needed to pull the data from individual tweets. Other social media platforms, such as Instagram, could be used to carry out future surveys.

Additional information of the case study:

Further information on *X. fastidiosa* can be found on the Plant Health Portal factsheet: https://planthealthportal.defra.gov.uk/assets/factsheets/Xf-Plant-Pest-Factsheet-2017v3.pdf.

Case study 6: General surveillance

Management of an expert network in Argentina

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Location and timeline of the case study:

Argentina, 2004–2020

Content of the case study:

Developing a general plant pest surveillance network under the aegis of the NPPO involves both NPPO personnel from all over the country as well as numerous non-NPPO members who participate in different ways according to their role in the national phytosanitary system and their expertise with specific crops.

In 2002, when a plant pest surveillance system was started in Argentina, the NPPO contacted different experts in order to gather information about plant pest status in the country, with the aim of responding to requirements by third parties during negotiations.

As the system evolved, the need to form a more structured network of experts was noted.

To this end, a database was created of experts participating in the network so that their data were readily available when there was a need to access phytosanitary information. The database can be accessed online (www.sinavimo.gob.ar (Spanish only)).

Extensive work was carried out with the experts so they could understand the importance of their contribution and the usefulness of the information provided.

The network operates on a voluntary participation basis and spans national experts in plant production and protection in both the public and private sectors. The network includes not only specialists in science and academia, but also extension agents and producers recognized for their wide range of experience and knowledge.

Members of the network are regularly called on to provide information in Argentina on pests and their associated crops through personal interviews, online consultations, workshops, etc.

Since 2010, local surveillance officials have been added to the network. These officials are agents of the NPPO with strategic functions to support plant pest surveillance in their area of concern. Local surveillance officials have a focus on responsibility, commitment and technical capacity, but work in particular to strengthen interpersonal relationships and communication. They act as a liaison to strengthen the link with the external experts in the network. They keep in contact with these experts and promote understanding of the network, encourage experts to join and participate in the network, and seek to sustain their participation over time. They also provide training to local NPPO agents in general surveillance practices in order to incorporate them into the phytosanitary surveillance system.

The number of experts participating in the surveillance network has increased progressively since the beginning of the plant pest surveillance system. Currently, there are more than 700 members. The active participation of experts allows existing, dispersed information to be gathered together. Their expertise can be incorporated into the country's plant pest surveillance system. Expert opinions are especially important in efforts to reduce uncertainty due to incomplete or contradictory data and determining the validity of pest records. Single or outdated pest records may not represent an established population of a pest in a location; the experts' knowledge and experience of the current situation can be very helpful in determining a pest status.

The following ISPMs were successfully implemented:

- ISPM 6 (*Surveillance*)
- ISPM 8 (*Determination of pest status in an area*)

Additional information on the case study:

https://www.sinavimo.gov.ar

https://repositorio.iica.int/bitstream/11324/2775/2/BVE17048794i.pdf

IPPC

The International Plant Protection Convention (IPPC) is an international plant health agreement that aims to protect cultivated and wild plants by preventing the introduction and spread of pests. International travel and trade are greater than ever before. As people and commodities move around the world, organisms that present risks to plants travel with them.

Organization

- There are over 180 IPPC contracting parties.
- Each contracting party has a national plant protection organization (NPPO) and an official IPPC contact point.
- 10 regional plant protection organizations (RPPOs) have been established to coordinate NPPOs in various regions of the world.
- IPPC liaises with relevant international organizations to help build regional and national capacities.
- The Secretariat is provided by the Food and Agriculture Organization of the United Nations (FAO).

Did you read this guide?

Please send an email to ippc@fao.org and share your feedback.

Your responses will help the IPPC Secretariat and the IPPC Commission on Phytosanitary Measures (CPM) Implementation and Capacity Development Committee (IC) strengthen this and other guides and training resources.

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