International Weed Risk Assessment workshop proceedings

This, the second International Weed Risk Assessment workshop was held in conjunction with the 2007 EMAPi9 Conference in Perth, Western Australia, almost eight years after the first such workshop was held in Adelaide in 1999. Organized by Rod Randall under the auspices of the Weeds Society of Western Australia Inc., this workshop had over 60 participants from North America, New Zealand, Asia, Europe and around Australia.

These papers represent a diverse range of Weed Risk Assessment concerns and contribute to our understanding of the practise. Some detailed refinements and explanations of existing methodologies are a significant outcome of the workshop.

Editors: Kurt Daehler, Paul Pheloung and Peter Williams.

The EPPO decision-support scheme for pest risk analysis and invasive alien plants

Sarah Brunel and **Françoise Petter**, EPPO/OEPP, 1, rue le Nôtre, 75016 Paris, France.

Summary

The European and Mediterranean Plant Protection Organization (EPPO) is an intergovernmental organization responsible for cooperation in plant protection in the European and Mediterranean region. It has 50 member countries. Since 2005, it is in charge of performing Pest Risk Analyses at a regional scale. As invasive alien plants threatening the environment may qualify as quarantine pests, they are assessed through the EPPO decision scheme for pest risk analysis of quarantine pests. This scheme has been developed in accordance with International Standard on Phytosanitary Measures No. 11 '*Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms*'. It is composed of three sections: initiation, pest risk assessment, and pest risk management.

The initiation part aims at identifying whether the organism has the characteristics of a quarantine pest; in this case the organism is then evaluated in greater detail in the pest risk assessment section. This section considers the potential of introduction of the organism (i.e. entry, establishment, spread and invasive behaviour (assessed through impacts)). If this assessment concludes that the organism represents an unacceptable risk, the pest risk management part will identify measures to prevent entry, establishment, or spread of the pest.

The EPPO scheme is described using examples of invasive alien plants.

Keywords: Pest risk analysis (PRA), invasive alien plants, plant health.

EPPO context for pest risk analysis on invasive alien plants

The European and Mediterranean Plant Protection Organization (EPPO) is an intergovernmental organization responsible for cooperation in plant protection in the European and Mediterranean region. As of September 2009, it has 50 member countries. It is in charge of performing Pest Risk Analyses (PRA) on a regional scale. These pest risk analyses are intended to provide advice for administrative and legislative decisions by countries in the EPPO region. While EPPO performs the risk analyses and recommends management measures, it is up to the individual member countries (or the European Union for member countries) to implement the recommendations.

Since PRA is a technical analysis providing a basis for administrative and legislative decisions, it is important that it should be done transparently according to accepted standards. Pest risk analysis in EPPO is based on International Standard on Phytosanitary Measures (ISPM) No. 11 '*Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms*' (IPPC 2007b). EPPO has built on ISPM No. 11 a regional scheme for pest risk analysis called the *EPPO Decision-support scheme for pest risk analysis of quarantine pests* (called EPPO scheme hereafter) (EPPO 1997). The EPPO scheme guides the assessor through a logical sequence of questions covering all elements mentioned in the international standard. Initially, this scheme was developed for pests of agricultural concern (invertebrate pests and pathogens). In 2003, ISPM No. 11 was revised to cover environmental risks and the EPPO scheme for PRA was adapted accordingly.

In 2002, the EPPO Council recognized that species that may be invasive and that directly or indirectly affect plants or plant products should be assessed and monitored according to IPPC provisions and standards (in particular ISPM No. 11). It also encouraged the National Plant Protection Organizations (NPPOs) to be active in the area of invasive alien plants, and to cooperate with the authorities responsible for environmental protection. In order to achieve this, EPPO initiated a work program on invasive alien species, and a Panel on invasive alien species was created to help the EPPO member countries. This Panel now counts experts from 18 countries of the EPPO region. As a part of the work program, elements to cover invasive alien plants were added to the EPPO scheme.

The EPPO scheme provides an example of how a PRA scheme developed in the framework of the IPPC can be used to assess invasive alien plants (Schrader 2004). Unlike Weed Risk Assessments systems, the EPPO approach is to assess the risk posed by invasive alien plants using the same tools as for other organisms. The EPPO scheme allows the assessment of both unintentional (e.g. as a contaminant of a commodity) and intentional introductions (e.g. for ornamental purposes) of the plant species under study. It can be used for species which are not present within the EPPO region or for species which are present in only limited areas within the EPPO region. Additionally, the EPPO scheme proposes management measures if needed.

This article presents the approach developed by EPPO for the evaluation and management of risks posed by invasive alien plants, using examples from the plant species that have been assessed so far.

The EPPO scheme

Pest Risk Analysis is a framework for organizing biological and other scientific and economic information, and using it to assess risk. This leads to the identification of management options to reduce the risk to an acceptable level. Risk analyses can be very short and simple, or very long and complex. There are no fixed criteria for the quantity of information needed. The evaluation does not necessarily have to be quantitative and it can include qualitative considerations, as long as they are scientifically sound (Burgiel *et al.* 2006). Expert judgement may be used in answering the questions.

The EPPO scheme provides detailed instructions for the following stages of pest risk analysis for quarantine pests: initiation, pest categorization, probability of introduction, assessment of potential economic consequences and pest risk

management. These different steps are illustrated with examples of invasive alien plants that have been assessed by EPPO so far.

Initiation

The very first question of the EPPO scheme consists in explaining the reasons for performing the risk analysis.

As a starting point to the EPPO work program on invasive plants, it was decided to assess species that were recent arrivals in Europe and that were still of restricted distribution. This group of species was smaller and easier to prioritize than species that were not known from Europe, and it helped raise member countries' awareness of existing problems.

Whereas the EPPO scheme specifies many reasons for which a PRA may be initiated, most are not relevant for invasive alien plants (e.g. the review of a policy). For the species assessed by EPPO so far, the reason for performing a PRA was the recorded invasiveness of a species in the EPPO region. These species can be divided in two categories:

- Plants which have been (or are proposed to be) intentionally introduced as ornamentals, and which have escaped (or might in future) from plantings, and invade and threaten unmanaged ecosystems (i.e. semi-natural or natural habitats). Such species represent about 80% of invasive alien plants (Hulme 2007). With respect to the PRAs performed so far by EPPO, *Crassula helmsii*, *Hydrocotyle ranunculoides*, *Lysichiton americanus*, *Pueraria lobata*, *Heracleum sosnowskyi*, *H. persicum* and *Eichhornia crassipes* fall into this category.
- Plants which are unintentionally introduced as contaminants associated with international movement of various commodities and articles, including soil and vehicles. With respect to the PRAs performed so far by EPPO, *Heracleum sosnowskyi*, *H. persicum*, *Solanum elaeagnifolium* and *Polygonum perfoliatum* fall into this category.

Initiation mainly consists in identifying clearly the pest to be considered for risk analysis, the area under study (called the PRA area), and whether some previous risk analyses exist. The EPPO scheme is primarily concerned with the assessment of individual pests, since this is the basis on which European countries formulate their phytosanitary regulations.

The information generally needed for PRA is listed in EPPO Standard PM5/1(1) *Check-list of information required for pest-risk analysis (PRA)* (EPPO 1998), although this standard needs revision to cover invasive alien plants. While using the scheme, the user should specify all details which appear relevant to the replies to individual question, indicating the source of the information (Schrader 2005).

Pest Risk Assessment

Pest Risk Assessment (see Figure 1) follows the logical sequence of introduction of an invasive alien species: entry, establishment, spread and invasive behaviour (assessed through impacts). The main questions relevant for plants are presented and commented on below.

Pest categorization

A rapid qualitative assessment is initially made, with minimal information, to determine whether the organism meets the criteria of the definition of a quarantine pest (i.e. 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, according to IPPC 2007c) and therefore can be regulated in international trade. The main aim of this step is to avoid conducting a full PRA in a case which can immediately be seen not to require one.

If the pest has recorded impacts somewhere in the world and is absent or present but not widely distributed in the PRA area, the categorization step leads to a positive answer, and the main Pest Risk Assessment starts. The EPPO scheme is essentially composed of a series of questions with the answers expressed qualitatively (e.g. very unlikely, unlikely, moderately likely, likely, very likely).

Probability of introduction

Introduction is defined as the entry of a pest resulting in its establishment (IPPC, 2007c).

Probability of entry

The pest risk analysis methodology in both ISPM No. 11 and the EPPO scheme can be used for all relevant entry pathways – either intentional or accidental. In this way, the EPPO scheme differs significantly from screening tools such as the Australian Weed Risk Assessment (Pheloung 2005) which have been developed to assess species proposed for intentional import.

When the EPPO Scheme is used for the intentional introduction of plants, entry does not need to be considered as it can be assumed that it will occur. The assessor can go directly to the probability of establishment. Among species assessed by EPPO, *Crassula helmsii*, *Eichhornia crassipes*, *Heracleum sosnowskyi*, *H. persicum*, *Hydrocotyle ranunculoides*, *Lysichiton americanus* and *Pueraria lobata* have been introduced intentionally for ornamental purposes (see EPPO website). Nevertheless, ornamental species may also be introduced as contaminants. For instance, seeds of *Heracleum* species may contaminate soil and growing media, or the plant could be intentionally introduced. In these cases, it is appropriate to assess the full range of entry pathways, both intentional and unintentional.

For species unintentionally introduced, there is often limited specific information on which to base an assessment of likelihood of entry. For instance, *Polygonum perfoliatum* was recorded as introduced as a contaminant of seeds of *Ilex* spp. from Japan and *Meliosma* spp. from China in 1930. For the same outbreak, another reference states that the plant had been introduced as a contaminant of soil associated with rhododendron stock. Which pathway should be considered? Another example is *Solanum elaeagnifolium,* for which nine pathways have been assessed: contaminant of plants for planting, soil/growing media, used machinery, grain and seeds for planting, etc. Selecting relevant pathways is usually done by considering the biology of the species, recorded interceptions, and recorded pathways of introduction.

Assessing a pathway of unintentional introduction implies that the following should be considered.

a) The probability of the pest being associated with a pathway

- The probability of the pest being associated with the pathway at its origin: in the case of seeds of *P. perfoliatum* introduced as a contaminant of plants for planting with growing media coming from countries where the plant occurs, the probability was considered moderate since the plant is only a contaminant of nurseries and Christmas tree plantations,
- The concentration of the pest in this pathway: in the case of seeds of *P. perfoliatum* introduced as a contaminant of plants for planting, this probability was considered moderate as the plant is easily controlled by treatments in nurseries.
- The volume and frequency of the movement along the pathway: although fundamental, such information is difficult to obtain. In the case of *P. perfoliatum,* the information required was the frequency and volume of plants for planting imported from countries where the species occurs. The available information, global figures for the whole ornamental plants trade from Asia and from North America (areas where the species occurs), was not specific enough to answer the question.

b) The probability of survival during transport or storage

This step is important for the assessment of invertebrates, while survival during transport is seldom a barrier to invasion of plants, both those travelling as contaminants in the form of seeds or rhizomes, or as ornamental products.

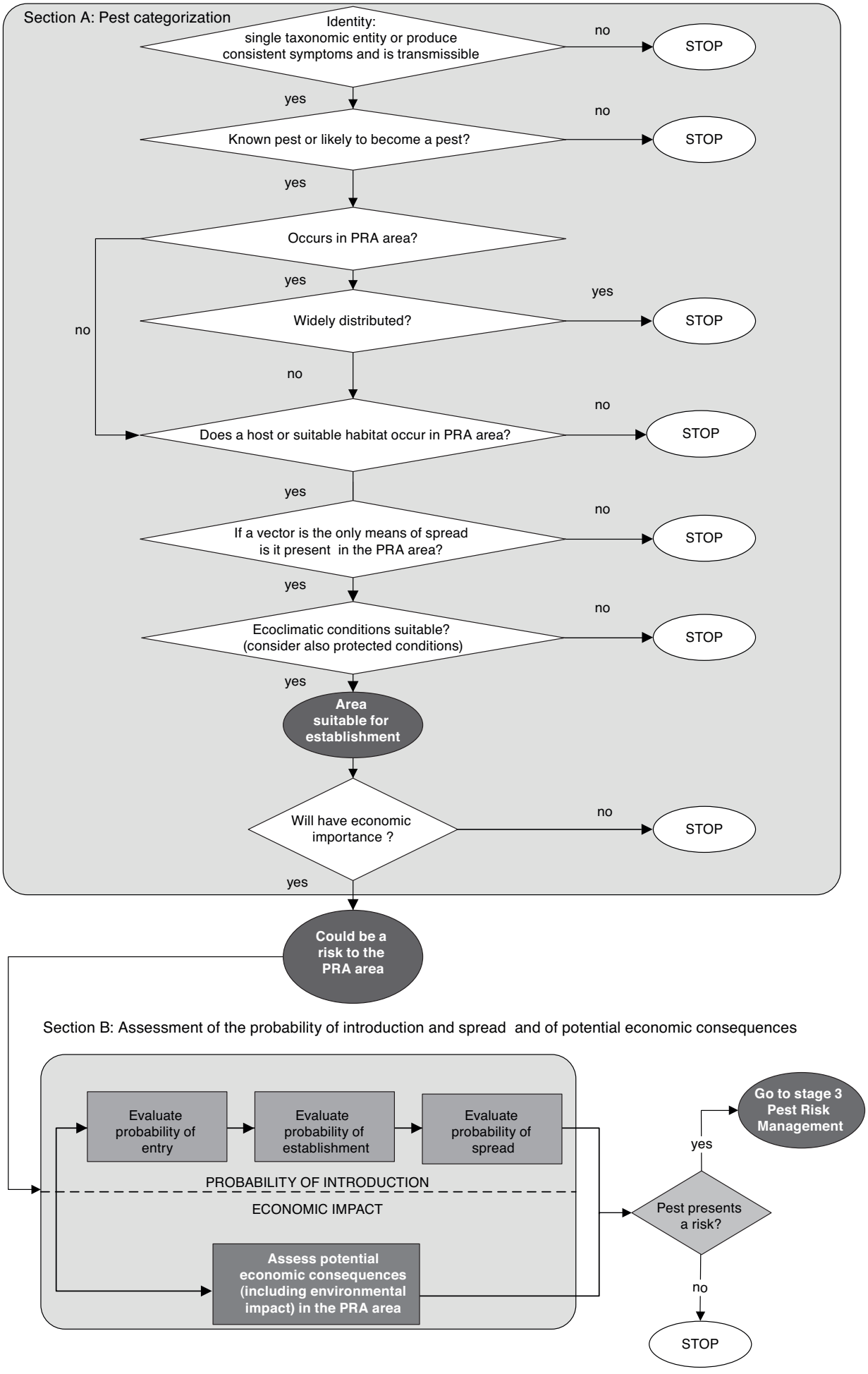

Figure 1. Decision-support scheme for quarantine pests Stage 2 Pest Risk Assessment.

c) *The probability of the pest surviving existing pest management procedures*
This question considers whether existing control measures or measures in the exporting countries (e.g. visual inspection, fumigation, etc.) would have an impact on the pest. In the EPPO region, the pest surviving pest management procedures is often very likely since few specific phytosanitary measures are in place for invasive alien plants, except for soil in Eastern European countries.

d) *The probability of transfer to a suitable host or habitat*
- The distribution of the commodity throughout the PRA area is studied: in the case of *Solanum elaeagnifolium* whose propagules may contaminate plants for plantings in countries where it occurs, these plants for planting (e.g. olive trees, *Nerium oleander*, *Citrus* spp.) could be traded and distributed throughout the EPPO region.
- The suitability of the time of arrival of the commodity for establishment of the pest: in general, it is considered that when propagules (seeds, rhizomes) contaminate commodities, in most cases they are long lasting, and whatever the time of arrival they survive until there are suitable conditions for germinating or vegetative regeneration.
- The ability of the pest to transfer to a suitable habitat: in general, when the plant is introduced as a contaminant of agricultural or ornamental products (seeds for sowing, plants for planting, soil, used machinery), it may easily escape. For instance, if an olive tree with the associated growing medium contaminated by *S. elaeagnifolium* is planted on a roadside or in a garden, the pest may very easily escape.

Natural pathways (e.g. through irrigation waters and sheep manure for *Solanum elaeagnifolium*) are considered in the section on spread to evaluate their contribution to the risk of entry. It is important to consider natural spread as well as spread by human activities, because under ISPM No. 11 'Measures are not justified if the risk is already acceptable or must be accepted because it is not manageable (as may be the case with natural spread)'. As an example, the pest risk analysis for *Senecio inaequidens* identified that international measures are not justified as the main pathway of entry is natural spread by wind.

Probability of establishment
For plants which are intentionally imported, the assessment of the probability of establishment concerns the unintended habitat (i.e. the habitats to which the plant might escape).

An organism which enters does not necessarily establish. Many exotic plants enter a new territory intentionally or unintentionally, but few escape. Of those that do, many are only reported as casual and then disappear since they cannot maintain self-sustaining populations. Only a small fraction establishes in the wild, and it is this probability that is assessed through the following questions:

a) *Availability of suitable habitats, or vectors in the area under study (i.e. the PRA area).*
The first requirement for the establishment of the plant is the presence of suitable habitats. They are listed and their number and distribution are assessed to determine whether the invasive plant will find an adequate environment for establishment. A plant like *Pueraria lobata,* for example, which colonizes disturbed habitats such as roadsides, fallow lands and forests edges, has numerous potential habitats.

b) *Suitability of the environment*
Similarity of climatic conditions in the PRA area and in the current area of distribution of the species is considered. When possible, a climatic prediction analysis is performed with the software CLIMEX (Sutherst *et al*. 2007). Climatic prediction allows the assignment of different levels of risk according to climatic parameters. For instance, for *Solanum elaeagnifolium*, Mediterranean countries are considered more at risk than temperate countries, and northern countries are not at risk.
- Abiotic factors such as soil type are considered, but they have rarely been considered as limiting factors for the invasive alien plants assessed.
- Prevention of establishment by competition and natural enemies are considered.

c) *Cultural practices and control measures*
Two elements are assessed: to what extent is the managed environment in the PRA area favourable for establishment? Could existing control or husbandry measures prevent establishment of the plant? Both questions are relevant for invasive plants of cultivated ecosystems.

The likeliness of survival following specific eradication programs is related to several parameters such as longevity of the seed bank, vegetative reproduction, ability to re-sprout and prominence of the plant.

d) *Other characteristics of the pest affecting the probability of establishment*
Biological characteristics such as the reproductive strategy, genetic diversity and adaptability are carefully taken into account.

Probability of spread
A plant that can rapidly spread after establishment presents a much greater risk. An assessment is made of the risk of natural spread, including wind or water dispersal, transport by vectors such as insects or birds and rhizome growth, combined with the presence of natural barriers and the quantity of pest (seeds or vegetative reproductive parts) to be dispersed. Likelihood of spread by human activities (through movement of soil, irrigation water, footwear, used machinery, etc) is also evaluated. The possibility of containing the plant is also considered, since management options such as for instance herbicide treatments may easily contain a plant even if it has become established.

Assessment of consequences
In the case of introduced plants, establishment and spread do not necessarily imply that there is a negative impact. It is therefore necessary to further evaluate whether there are potential negative economic impacts. Under IPPC definitions, economic impact covers direct effects on plants, as well as environmental and social impacts. Any such effects are documented and evaluated for the current area of distribution of the plant, and estimated for the area under study.

This may be done in monetary terms, especially for control costs. For example, the EPPO PRA for *Crassula helmsii* states that 'one recent estimate puts the cost of control of *C. helmsii* at between 1.45 and 3 million Euros based on the treatment of 500 sites over a period of 2–3 years (Leach and Dawson 1999)'.

The negative effect of the pest on yield and/or quality of crops and cultivated plants or on control costs is considered. In the case of *Solanum elaeagnifolium*, this plant competes for moisture and nutrients with many crops such as *Gossypium hirsutum* (cotton), *Medicago sativa* (lucerne), *Sorghum bicolor* (common sorghum), *Triticum aestivum* (wheat), *Zea mays* (maize), *Lycopersicon esculentum* (tomato), *Olea europaea* subsp. *europaea* (olive), *Solanum tuberosum* (potato), etc. which are cultivated in the EPPO region and could be threatened by this invasive plant.

When evaluating environmental impacts, reduction in the populations of individual species, particularly keystone or endangered species; indirect effects on plant communities (species richness, biodiversity); significant change in ecological processes and the structure, stability of an ecosystem (including further effects on plant species), etc. are evaluated. In the assessment of the environmental impacts of *Pueraria lobata,* part of the information provided is: 'The plant has a fast development and rapidly covers the soil, affecting indigenous plants and completely modifying the structure of the ecosystem (Clabassi *et al*. 2003)'.

Invasive alien plants may also have social impacts to be taken into account. These social impacts could include: damaging the livelihood of a proportion

of the human population, affecting human use (e.g. water quality, recreational uses, tourism, animal grazing, hunting or fishing). Effects on human or animal health, the water table and tourism could also be considered, as appropriate, by other agencies/authorities. In the case of *Solanum elaeagnifolium*, agricultural land infested with this pest loses considerable rental and resale value: in Morocco, the value of infested fields decreased by 25% (Gmira *et al*. 1998); in the USA, farms have been abandoned because of infestation (Parsons 1981).

Degree of uncertainty and conclusion of the Pest Risk Assessment

Whether for entry, establishment or impacts, the areas and degree of uncertainty should be noted. They ensure transparency of the process (according to the SPS Agreement principle of transparency) and may help identify additional research needed to complete the PRA or give it more accuracy.

The overall conclusion of the pest risk assessment is to decide whether the pest represents a risk on the basis of the answers given. If so, pest risk analysis continues with the selection of risk management options, provided the level of risk identified is considered unacceptable.

Pest Risk Management

This part of the analysis identifies measures to prevent entry, establishment, or spread of the pest. It explores options that can be implemented: (i) at origin or in the exporting country, (ii) at the point of entry or (iii) within the importing country or invaded area. The options are structured so that, as far as possible, the least stringent options are considered before the most expensive/disruptive ones, and are consistent with the SPS-Agreement and Plant Health principles (IPPC 2007b) (see Figure 2).

The methods for selecting risk management options differ according to whether the introduction is intentional or unintentional, and whether the organism is absent or already present in the PRA area.

Plants intentionally introduced

Measures recommended for intentional introductions are either the prohibition of imports (e.g. in the case of *Pueraria lobata* and *Eichhornia crassipes*), or actions that can be taken in the importing country and refer to the EPPO Standard PM 3/67 *Guidelines for the management of invasive alien plants or potentially invasive alien plants which are intended for import or have been intentionally imported.* These measures can be used either nationally or within specified endangered areas and include:

- Publicity (existing regulations and lists of invasive or potentially invasive plants, information about threats and pathways should be publicized to raise awareness among all the persons concerned, e.g. horticultural industry, botanical gardens and gardeners),
- Labelling or marking of plants explaining the risks and appropriate actions/uses,
- Surveillance,
- Control plan,
- Restrictions or codes of conduct on sale, holding, movement of the plant,
- Restrictions or codes of conduct for importers (including notification before import, limitation of quantities),
- Import restricted to specified cultivars or clones, and
- Restrictions or code of conduct on planting (including authorization to plant in intended habitats, prohibition of planting in unintended habitats, required growing conditions for plants).

Plants unintentionally introduced as contaminants

These measures are classical plant health measures and include:

1. Measures intended to prevent a pathway from being contaminated. This applies to exporting countries:

- Prevention of infestation of the commodity:
  – specified treatment of the crop or of the consignment (e.g. cleaning of maize grain contaminated by *Solanum elaeagnifolium* seeds originating from places where the invasive plant occurs),
  – specified period of treatment of the crop,
  – specified growing conditions (e.g. plants for planting grown in sterilized growing media free from *Solanum elaeagnifolium* seeds and rhizomes, originating from places where the invasive plant occurs).
- Establishment and maintenance of pest freedom of a crop, pest-free place of production or area, pest-free area.

2. Measures intended to detect an infestation in a consignment such as visual inspection or removal of the pest from the consignment, are also valid for invasive alien plants.

Entry with human travellers and vehicles

The scheme also proposes specific measures for these pathways:

- Entry with human travellers: possible measures are inspection of human travellers and their luggage, publicity to enhance public awareness of pest risks (e. g. public awareness of pest risks due to the accidental introduction of seeds or rhizomes of *Solanum elaeagnifolium* with travellers is recommended by EPPO to its Members), fines or incentives.
- Entry with contaminated machinery or means of transport: possible measures are cleaning or disinfection of machinery/vehicles (e. g. this is recommended to EPPO countries in the cases of *Heracleum sosnowskyi* and *H. persicum*).

Other EPPO activities on invasive alien species

Since plants intentionally introduced for ornamental purposes are the major pathway for plant introduction, EPPO is currently developing codes of conduct for invasive alien plants and horticulture. This approach encourages plant producers and sellers to remove invasive alien plants and to propose alternative non-invasive alien plants. This project is developed in partnership with the Convention on the Conservation of European Wildlife and Natural Habitats (known as the Bern Convention) of the Council of Europe (see Heywood and Brunel 2009 and the EPPO website).

Because several species included in the EPPO List of Invasive Alien Plants are sometimes planted as bioenergy crops, the EPPO Council made a special declaration in 2007 on 'Plants for renewable energy and Invasive Alien Plants' to warn its member countries about this potential risk.

Pathway risk analyses are not normally done in Europe (though the EPPO Standard follows ISPM No. 11 in allowing the possibility). For invasive alien plants, a study of imported aquatic plants has been performed by the EPPO Secretariat, identifying those that may represent a risk in the future (Brunel 2009).

EPPO also seeks to constantly improve its scheme and to make it accessible and user friendly. Therefore a web-based version is under development. EPPO is also a member of a project of the European Union Framework 7 called 'PRATIQUE' (Enhancements of Pest Risk Analysis Techniques) which aims to develop more efficient risk analysis techniques for pests and pathogens of phytosanitary concern.

Conclusion: results and further challenges

As a starting point to the EPPO work program on invasive alien plants, recent arrivals in Europe have been the focus so as to raise countries' awareness on existing problems. As of September 2009, nine species (*Crassula helmsii*, *Eichhornia crassipes*, *Heracleum sosnowskyi*, *H. persicum*, *Hydrocotyle ranunculoides*, *Lysichiton americanus*, *Polygonum perfoliatum*, *Pueraria lobata*, *Solanum elaeagnifolium*) have been subject to PRA and are now recommended for regulation to the 50 EPPO countries. All these species have a limited distribution within the EPPO region and their entry into other countries of the region could be prevented. Future PRAs will be conducted in Expert

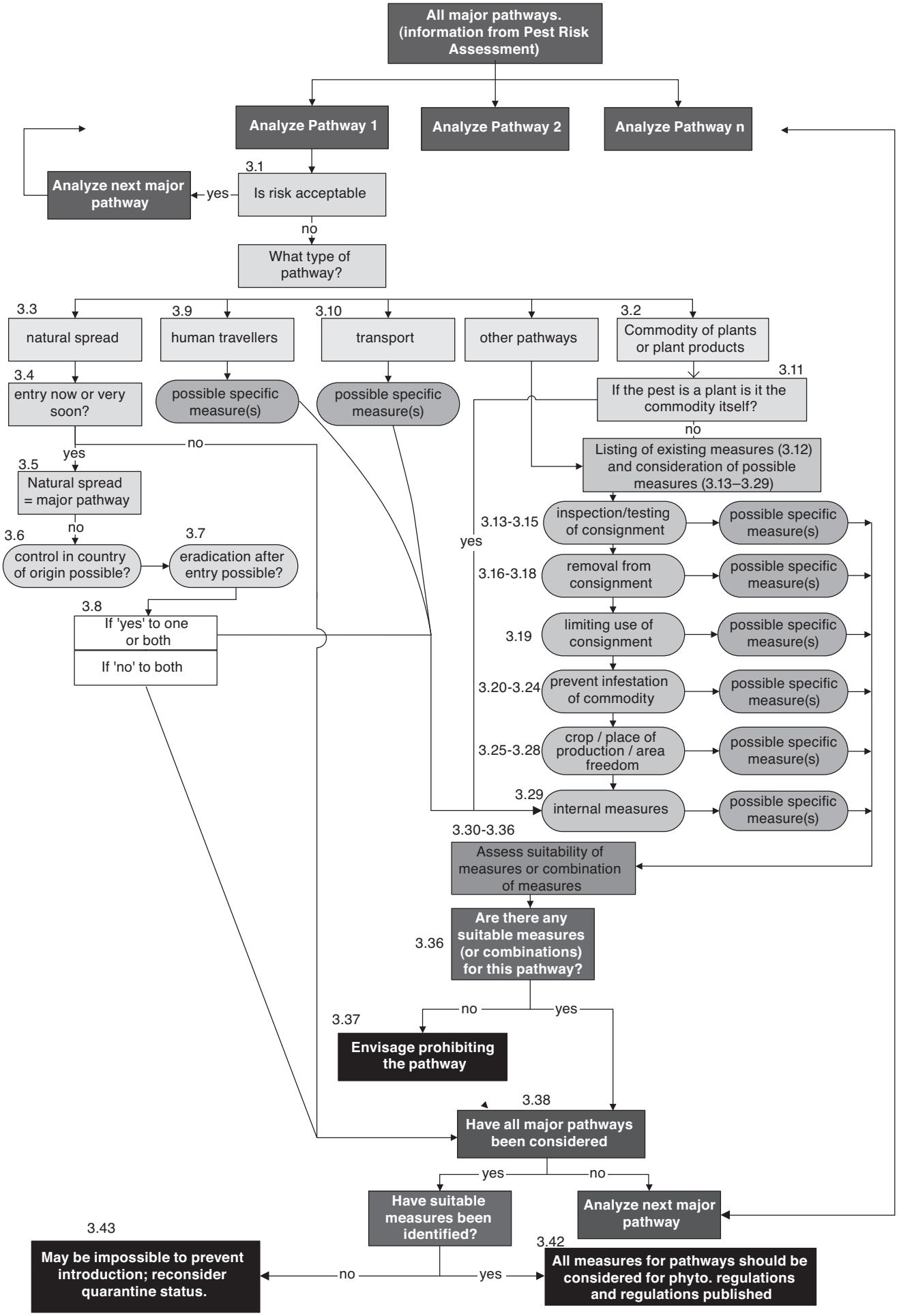

Figure 2. Decision-support scheme for quarantine pests Stage 3 Pest Risk Management.

Working Groups composed of experts selected on the basis of their knowledge on the plants to be studied.

The output of an EPPO PRA takes the form of a general recommendation to countries, with measures proposed for each organism concerned, distinguishing different levels of risk for different parts of the EPPO region as applicable (Smith 2005). This recommendation has then to be adopted by consensus by the EPPO Members, after appropriate consultation. Members decide individually whether the reported risks concern them, and select appropriate measures if they do. The EPPO Convention creates no greater obligation on members than that they should 'endeavour to implement' EPPO recommendations. The PRA documents are available on the EPPO website (www.eppo.org).

So far, of the nine species recommended for regulation by EPPO, only *Hydrocotyle ranunculoides* is regulated: its possession and trade are prohibited in The Netherlands. These preventive measures are implemented in a single country, and may be compromised if efforts by neighbouring countries are inadequate (Burgiel *et al*. 2006). The recommendations made by EPPO on invasive alien plants are fairly recent, and time will be needed before national (or EU) regulations are implemented. It is in principle possible to regulate invasive alien plants under the IPPC, and EPPO has taken the first steps in creating a situation in which the European countries (and the EU) can do so.

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