Crop Protection Compendium

Risk Assessment of Weeds

Chris Parker
Weed Science Consultant, Flat 4, 5 Royal York Crescent, Bristol BS8 4JZ, UK.
E-mail: chrisparker5@compuserve.com

May 2004

1. Summary
2. Background
3. Recent development of ISPM No. 11, revision 1
4. The main elements of a WRA
5. Existing WRA systems
6. Are these existing WRA systems adequate?
7. Improving WRA systems
8. Sources of information
9. Conclusions
10. References

---

1. Summary

Very few countries as yet use any formal Weed Risk Assessment process in deciding which plant species to exclude under their quarantine regulations, but all will be under increasing pressure to do so to satisfy international trade conventions. Recent revisions to international guidelines for the development of pest risk analysis are detailed. The systems already in use in Australia, USA and New Zealand are described and found wanting in some respects. The possibilities for improvements are considered in relation to the available literature on prediction of invasiveness and the main elements of any proposed system are outlined.

2. Background

International agreements of relevance to the problem of invasive species include the Convention on Biological Diversity (CBD) which undertakes to 'prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats and species'. Control over the importation of potentially invasive species is generally based on legislation, backed by inspection procedures, and most countries have regulations to restrict the entry of further invasive aliens, usually through the declaration of lists of prohibited species. While it will always be impossible to prevent all further introductions of undesirable species, the chances of prevention are greatly improved by the existence of regulations which at least make their entry illegal (Parker, 2001). The prohibited lists are usually made up mainly of insect and disease organisms. Plant species are often included only as potential carriers of plant diseases and relatively few weeds are listed. EPPO (2003, 2004) provides relevant lists of ‘categorized’ species, variously quarantine pests and ‘invasive alien species’ for many individual countries or for regions covered by a single regulatory body. The lists of quarantine weeds often include only parasitic genera, *Cuscuta, Orobanche, Striga*, etc., (Brazil, Argentina, Chile, Albania, Tunisia) or just the single genus *Arceuthobium* (dwarf mistletoes) (in the EU) plus some aquatics e.g. *Myriophyllum* spp. (in Canada). Countries with longer lists include China (parasitic genera plus *Lolium temulentum* and some *Sorghum* spp.), Russia and Ukraine with lists of about 20 species, and USA with about 90 species and genera. Australia and New Zealand each have long lists of prohibited plant species (Anon., 2000; New Zealand, Ministry or Agriculture, 2004) but are now following a ‘clean list’ or ‘white list’ approach, declaring any un-clean-listed species prohibited until assessed at the expense of the importer, after which they may be refused entry, or can be added to the ‘clean’ list (see e.g. Walton, 2001).

At the present time, very few of these lists of species have been based on any formal pest risk analysis (PRA) and this situation is open to challenge as there is increasing pressure to ensure that any restriction on the entry of plants is based on a thorough scientific appraisal and thus cannot be exploited to interfere with legitimate trade. The International Plant Protection Convention (IPPC) is responsible for harmonizing phytosanitary regulations and issues guidelines in the form of International Standards for Phytosanitary Measures (ISPMs). These are now being designed to conform as fully as possible to the World Trade Organization (WTO)’s Agreement on Sanitary and Phytosanitary Measures (generally known as the SPS Agreement). The SPS Agreement requires that quarantine policy should be the least trade-restrictive available to achieve the country’s ‘Appropriate Level of Protection’ (ALOP) (Anderson et al., 2001). Hence, quarantine restrictions are expected to be based on very thorough pest risk analysis, justifying any exclusion or prohibition on thorough economic or environmental grounds. In the case of potential pests of agriculture, possible costs of crop loss and/or costs of control have to exceed potential value of the species if imported and cultivated or used in some other way. In the case of species threatening natural environments, especially if they also have value as ornamentals, the economic arithmetic is inevitably more difficult (Mumford, 2001).

With growing realization of the problems from invasive weeds, there is likely to be increased interest in adding further weeds to the quarantine regulations, but deciding which species will be listed and regulated should depend on some means of PRA, or in the case of plants, what may be referred to as Weed Risk Assessment (WRA). The specifications for a WRA include: (a) identifying/excluding species with potential to do economic or environmental harm in the recipient country, while at the same time (b) NOT identifying/excluding species which are harmless and might be of economic or other benefit. WRA may also be used to set priorities for control of weed species already present in a country, or smaller region within a country, but the special needs of this type of WRA will not be considered in this paper.

Back to Top

3. Recent development of ISPM No. 11, revision 1

In the past few years, there has been an increase in the publicity/prioritization of threats posed by the movement of invasive plants which has resulted in the involvement of more organizations in some type of weed risk assessment. The International Standard for Phytosanitary Measures No. 11, Pest Risk Analysis for Quarantine Pests, was revised in 2003 to include a new supplementary section which provides more detail on 'the analysis of environmental risks' (see **ISPM No. 11**). The IPPC has historically focussed on agriculture and food security but is now applying its guidelines to the protection of uncultivated plants and habitats. Of particular significance for weeds is the new emphasis on 'indirect pest effects'. Although broadly covered in the previous edition of ISPM No. 11 and the earlier ISPM No. 2, focus was mainly on direct effects of pests on crop production.

Introduction to ISPM No. 11, Revision 1

"This standard provides details for the conduct of pest risk analysis (PRA) to determine if pests are quarantine pests. It describes the integrated processes to be used for risk assessment as well as the selection of risk management options. It includes details regarding the analysis of risks of plant pests to the environment and biological diversity, including those risks affecting uncultivated/unmanaged plants, wild flora, habitats and ecosystems contained in the PRA area. Some explanatory comments on the scope of the IPPC in regard to environmental risks are given in Annex 1.

Annex 1. (Comments on the scope of the IPPC in regard to environmental risks state that the scope of the IPPC also extends to organisms which are pests because they:

- *Directly affect uncultivated/unmanaged plants.* Introduction of these pests may have few commercial consequences, and therefore they have been less likely to be evaluated, regulated and/or placed under official control. An example of this type of pest is Dutch elm disease (*Ophiostoma novo-ulmi*).
- *Indirectly affect plants.* In addition to pests that directly affect host plants, there are those, like most weeds/invasive plants, which affect plants primarily by other processes such as competition (e.g. for cultivated plants: Canada thistle (*Cirsium arvense*) [weed of agricultural crops], or for uncultivated/unmanaged plants: purple loosestrife (*Lythrum salicaria*) [competitor in natural and semi-natural habitats]).
- *Indirectly affect plants through effects on other organisms.* Some pests may primarily affect other organisms, but thereby cause deleterious effects on plant species, or plant health in habitats or ecosystems. Examples include parasites of beneficial organisms, such as biological control agents. To protect the environment and biological diversity without creating disguised barriers to trade, environmental risks and risks to biological diversity should be analyzed in a PRA."

The relevance of the changes in these international guidelines and how they relate to the work of National Plant Protection Organizations was recently debated at an international workshop on 'Invasive Alien Species and the International Plant Protection Convention' held in Braunschweig, Germany in September 2003. Where to start with the assessment of environmental risk using ISPM No. 11, Revision 1, was detailed by Quinlan et al. (2003).

Back to Top

4. The main elements of a WRA

It is important to note that WRA is part of PRA, i.e. the process of evaluating biological or other scientific and economic evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it (IPPC, 2002). Some countries have found it convenient to develop a framework that addresses plant issues specifically, but these schemes aim to fit within the international guidelines for PRA (ISPM No. 11, Revision 1).

The main elements of such formal WRA include a range of criteria for assessment, which can be classified into their inherent invasiveness, likelihood to survive and thrive, impacts, and likelihood of entry. Based on assessments of existing systems, an ideal WRA should contain the following criteria:

Invasiveness

- record of invasiveness elsewhere
- rapid (juvenile) growth
- high reproductive (including vegetative) potential
- dispersal mechanisms
- stress (e.g. drought, shade) tolerance
- escape from natural enemies

Climatic/ecological match

Damaging effects

- competition with crops or natural vegetation
- allelopathy
- nitrogen fixation
- response to fire
- damage to man or livestock
- undesirable interaction with crop pests/diseases
- difficulty/expense of control

Likelihood of introduction

- likelihood of survival in transit
- likelihood of accidental introduction
- likelihood of deliberate introduction
- ease of detection

Back to Top

5. Existing WRA systems

Among the very few countries currently applying a formal WRA as a part of their regulatory process are Australia (see Case Study '**Weed Risk Assessment in Australia**'), New Zealand and USA.

Australia

A system developed by Pheloung and others (e.g. Pheloung et al., 1999) is based on a series of 49 questions in three groups, the answers leading to varying positive, zero or negative scores. Not all questions need to be answered but a minimum number in each must be (2, 2 and 6 in sections A, B and C).

- Section A relates to domestication/cultivation, climate and distribution and weediness elsewhere;

- Section B relates to undesirable traits;

- Section C relates to plant type, reproduction, dispersal mechanisms and persistence attributes.

Scoring of some questions depends on answers to others and the scoring is somewhat complex. Highest adverse scores are 5 for any aquatic weed and 4 for weediness elsewhere (not too clearly defined). A final score over 6 requires rejection. Any other positive score (1-6) requires further evaluation. A zero or negative score is acceptable.

The Pheloung system has now been adopted officially in Australia and has been proposed as the basis for a system for developing countries, still under development by FAO (see Williams, 2003). It is also used to make recommendations for species introductions into Hawaii and the mountainous islands of the Pacific, as the basis for the Hawaii Weed Risk Assessment Protocol (PIER, 2003).

New Zealand

The Pheloung system has been adopted in New Zealand for terrestrial weeds, while an alternative method has been proposed for aquatic weeds. For these, Champion and Clayton (2000) have devised a system based on 13 questions relating to: environmental versatility, competitive ability, dispersal, capacity to cause obstruction, damage to natural ecosystems, potential New Zealand habitat not yet occupied, resistance to management, weediness in different aquatic/wetland habitats, seed production/persistence, vegetative spread, weediness elsewhere, maturation rate, and ‘other undesirable traits’ (including health risks, weediness in terrestrial situation). Each of these is scored on a scale of e.g. 0-10, or 0-3 or 5 for the final five questions. This system was compared by Champion and Clayton on a range of species with the standard Pheloung model above, and while the latter satisfactorily identified all noxious species as undesirable it was inferior in terms of quantitative comparison of risk.

USA

The USDA ‘Weed Risk Assessment Guidelines for Qualitative Assessment’ version 5.2 (USDA, 2004) are based on five elements:

- habitat suitability (0-1, 2-3 or at least 4 climatic ‘hardiness’ zones in USA);

- dispersal potential (based on reproductive potential and/or other characters);

- economic impact (affecting crop yield, commodity value and/or loss of market);

- environmental impact (types of impact on vegetation, health, etc.);

- likelihood of introduction.

Each of the first four questions leads to a ranking score (maximum 3) and the summation of these to a ‘Consequences of Introduction Risk Rating’, a total of 9-12 indicating high risk, 6-8 medium risk and 2-5 low risk. These categories lead to ‘risk scores’ of 3, 2 and 1, respectively. Scoring for entry potential involves quantifying the likelihood of entry, survival, detection and establishment via a range of different possible routes. This process leads again to summary scores of 3, 2 or 1 for high, medium and low risk of entry which is then multiplied by the ‘Consequences of Introduction Risk Rating’ to give a final score in the range 0-9. Scores of 9, 6 and 4 indicate High, Medium-High and Medium risk respectively, while 3 or lower indicates Low risk.

Back to Top

6. Are these existing WRA systems adequate?

A question at this point is whether these systems already in use are meeting the required specifications and are adequate in terms of successfully identifying the truly dangerous invasive species, while at the same time avoiding the listing and possible exclusion of harmless species which could be of commercial or other value.

The Australian system has been quite critically evaluated in Australia. Pheloung himself concluded that it was more than 80% accurate in identifying species that needed to be excluded (Pheloung, 1995) while a later independent analysis by Smith et al. (1998) came to a slightly less favourable conclusion that it was less than 80% accurate when more use was made of literature searches in the evaluation process. However, it has been in use for some years without further serious challenge, and has also been found over 90% accurate when applied to a selection of invasive and non-invasive species in Hawaii (Daehler and Carino, 2000). The latter authors found that about 10% of non-invasive species could be wrongly excluded by the system but noted that, even if some of these were of economic value, in many cases native species could be substituted for the same purpose.

The USDA system has not been the subject of any such critical evaluation, though another method from North America, that of Reichard and Hamilton (1997) (see below), was also tested by Daehler and Carino (2000) for Hawaii. This was found almost as accurate as the Pheloung system but is only applicable to woody species.

It must be noted that existing systems are designed to assess the risk of introducing a new species to the country in question, whether intentionally and/or accidentally, and are not designed to assess the risk posed by species already present. Many invasive species have only become invasive several decades after their initial introduction, often ‘triggered’ by some other external factor. This ‘time-lag’ means that a percentage of a country’s future invasive weeds are already either cultivated or naturalized. It may require the introduction or a suitable pollinator, dispersal agent, climatic anomaly, etc., to trigger invasion, and such factors are extremely difficult to assess and even more difficult to control.

Back to Top

7. Improving WRA systems

The precision of any WRA depends on our ability to predict just which species will or will not become invasive, and thus the characters and factors we choose to include in our risk assessment model. Unfortunately, in spite of the very substantial volume of literature that has appeared on the subject, the prediction of invasiveness is still a very imperfect art, a reliable answer requiring ideally an enormous amount of information on the conditions at the recipient site as well as on the biological characteristics of the species itself, including its natural enemies in its native area.

Among the plethora of conferences, books and journals on the topic, many originate from the IUCN (International Union for Conservation of Nature) Scientific Committee on Problems of the Environment (SCOPE) whose project 'Ecology of Biological Invasions' began in 1982 (e.g. Groves and Burdon, 1986; Drake et al., 1989; Mooney and Hobbs, 2000). Another series of meetings, specifically on invasive plants has been held under the title 'Ecology and management of alien plant invasions' (EMAPi), the most recent, 7th International Conference held in Florida, USA, in November 2003. A meeting specifically on WRA was held in 2001 (Groves et al., 2001) while another meeting considered the economics of quarantine and the SPS agreement (Anderson et al., 2001). A further relevant publication is the 'Toolkit' on alien invasive species (Wittenberg and Cock, 2001).

Among this abundant literature on invasive weeds there have been many efforts to define the characteristics of invasive plants and predict which are most likely to become new problems.

Reichard (1997) summarized the 28 characteristics used in six different predictive models (three specifically related to woody spp.) and the number of studies in which they proved either useful or not useful. The most useful proved to be rapid juvenile growth rate (useful in four out of six studies). Others proving useful in three out of six studies were invasiveness elsewhere, and (small) seed size. Seed production, seed bank longevity, seed dispersal and vegetative reproduction were each useful in two out of six studies.

One of those six studies was her own in conjunction with Hamilton (Reichard and Hamilton, 1997) applying discriminate analysis to a range of characteristics of 114 species of North American woody plants) in which the most important characters were invasiveness elsewhere, rapid vegetative spread, being exotic to the region (not just the country/locality), not a sterile hybrid, belonging to a family or genus with species known to be invasive in the country, short juvenile period, and dormancy.

Another was that by Richardson et al. (1994) relating to *Pinus* spp. in South Africa. They found small seeds, short juvenile period and short intervals between large seed crops were the most important. Rejmánek and Richardson (1996) further refined these initial conclusions and devised an equation based on the three major factors (see also Richardson, 1997).

Characters emphasized by other authors include:

- Early germination, early maturation, drought tolerance, dormancy, leafy shoots, deep root systems and indefinite longevity (Newsome and Noble, 1986, after applying cluster analysis to a set of invasive/noxious plants in Victoria, Australia).
- Prolific seed production, winter photosynthesis, shade tolerance, mycorrhizal symbiosis enhancing growth on poor soils, phenols reducing herbivore pressure, and vigorous growth (Rotherham, 1990, considering the invasiveness of *Rhododendron ponticum* in the UK).
- High seed output, low seed dormancy, rapid germination and ability to germinate at low temperatures and low light (Luken and Thieret, 1996, discussing the importance of *Lonicera maackii* in the USA).

The differing conclusions from different studies emphasize the shortage of really reliable characters for predicting invasiveness but do reinforce the importance of invasiveness elsewhere, juvenile growth rate, vegetative spread, and the complex of seed size, production, longevity and dispersal. However, most papers do also warn of the difficulties and uncertainties of the process and the need to consider the issue according to the habitat threatened.

Apart from these purely biological characteristics, and the clear need to see a match between the climatic/ecological conditions from which the target species originates, and those in the recipient territory, international protocols (for PRA in general, rather than specifically WRA) also emphasize the importance of appraising the potential pathways and risk of entry of the species, as well as the degree of economic and environmental damage caused after entry. These are detailed in ISPM No. 11, Revision 1 (IPPC, 2003).

With these observations as a background, can it be concluded that either or both of the Pheloung and USDA WRAs are fully adequate?

The Pheloung system considers well the great majority of the biological characteristics listed above, as well as the issues of climatic match, invasiveness elsewhere, and damaging effects (via 'undesirable traits'), but does not address the question of entry pathway and risk of entry. The reason for a risk assessment for plants, as opposed to other pest types, is often a request to introduce a new plant for cultivation or horticultural purposes (i.e. intentional introduction) where the decision is whether to permit or prohibit importation. For other pest groups, the PRA is most often needed to assess the risk of contamination of a commodity/product, not the intentional introduction of the herbivore, plant pathogen or its vector. The Australian system is only designed to be applied to species whose deliberate importation is being sought. Thus it is not suitable for considering the risks from accidental introduction.

The USDA system considers most of the biological characteristics mentioned above but in a much less detailed and systematic way, leaving the assessment of individual characters to be made rather more subjectively. Invasiveness elsewhere is also not very specifically addressed. However, risks of economic or environmental damage are given separate clear consideration, while entry pathways and risks are also well covered. The USDA system continues to be the official method used in USA, but may be subject to further modification in the light of a study being undertaken in conjunction with the Weed Science Society of America. Parker (2003) has provided a preliminary description of a system designed specifically to identify and rank potential future invasive weeds of USA.

Back to Top

8. Sources of information

The preparation of a prohibited weed list might start with the accumulation of a list of candidate species to be considered, and then require more detailed information on each of these species. For the first preliminary listing, the most useful sources might include the Geographical Atlas of World Weeds (Holm et al., 1979) for mainly crop weeds; the Global Invasive Species Database (ISSG, 2004) for mainly environmental weeds; Binggeli (1999) for invasive woody species of the tropics; Weber (2003) for a selection of 450 invasive environmental weeds of the world. Other important sources of information include: Li and Xie (2002), Henderson (2001), USDA (2000), Anon. (2000), Owen (1996) for lists of species prohibited or regarded as noxious in China, South Africa, USA, Australia and New Zealand, respectively.

For sources of further information on individual species, an extremely wide range of literature may need to be searched but useful leads can be found via the Crop Protection Compendium (CABI, 2004a); Weed Abstracts (CABI, 2004b); the Global Compendium of Weeds (Randall, 2004); the GRIN taxonomy site (USDA-ARS, 2004); the Hawaiian Ecosystems at Risk Project (HEAR, 2004).

Back to Top

9. Conclusions

It could be concluded that the ideal WRA system, incorporating the best features of the available systems, has yet to be developed. Many, if not most of these factors could, and would need to be refined where a specific district or habitat is involved, rather than the national or regional area, and also dependence on whether agriculture or natural vegetation is the main concern. Further research will no doubt throw more light on the general characteristics of invasive species but no generalized WRA will ever provide completely reliable results. For such reliability there is no substitute for in-depth research on individual species in the habitat/environment which is threatened.

---

10. References

Anderson K, McRae C, Wilson W, eds, 2001. The Economics of Quarantine and the SPS Agreement. Centre for International Economic Studies, Adelaide and AFFA Biosecurity Australia, Canberra, Australia, 414 pp.

Anon., 2000. Noxious Weeds List. http://www.weeds.org.au/noxious.htm.

Binggeli P, 1999. Invasive Woody Plants – Highly Invasive Species. http://members.lycos.co.uk/WoodyPlantEcology/invasive/di3.htm.

CABI, 2004a. The Crop Protection Compendium. 2004 edition. Wallingford, UK: CAB International. http://www.cabi.org/compendia/cpc/.

CABI, 2004b. Weed Abstracts. Wallingford, UK: CAB International.

Champion PD, Clayton JS, 2000. Border control for potential aquatic weeds. Stage 1. Weed risk model. Science for Conservation, No. 141:48 pp.

Daehler CC, Carino DA, 2000. Predicting invasive plants: prospects for a general screening system based on current regional models. Biological Invasions, 2:93-102.

Drake J, Mooney HA, Di Castri F, Groves RH, Kruger FJ, Rejmanek M, Williamson M, eds, 1989. Biological Invasions, a Global Perspective. Scope 37. New York, USA: Wiley, 525 pp.

EPPO, 2003. PQR database (version 4.2). Paris, France: European and Mediterranean Plant Protection Organization.

EPPO, 2004. Plant Quarantine. EPPO activities on plant quarantine. http://www.eppo.org/QUARANTINE/quarantine.htm.

Groves RH, Burdon J, eds, 1986. Ecology of Biological Invasions. Cambridge, UK: Cambridge University Press, 166 pp.

Groves RH, Panetta FD, Virtue JG, eds, 2001. Weed Risk Assessment. Proceedings of the 1st International Workshop on Weed Risk Assessment, Adelaide, Australia, 1999.

HEAR, 2004. Hawaiian Ecosystems at Risk Project (HEAR). http://www.hear.org/.

Henderson L, 2001. Alien Weeds and Invasive Plants. A complete guide to declared weeds and invaders in South Africa. Plant Protection Research Institute Handbook No. 12. Pretoria, RSA: Agricultural Research Council, 300 pp.

Holm LG, Pancho JV, Herberger JP, Plucknett DL, 1979. A Geographical Atlas of World Weeds. New York, USA: John Wiley and Sons, 391 pp.

IPPC, 2002. ISPM No. 5. Glossary of Phytosanitary Terms. Rome, Italy: International Plant Protection Convention, FAO.

IPPC, 2003. ISPM No. 11, Revision 1. Pest Risk Analysis for Quarantine Pests including Analysis of Environmental Risks. Rome, Italy: International Plant Protection Convention, FAO.

ISSG, 2004. Global Invasive Species Database. University of Auckland, New Zealand: Invasive Species Specialist Group. http://www.issg.org/database/species/search.asp?st=100ss&fr=1&sts=.

Li ZY, Xie Y, 2002. Invasive Alien Species in China. Beijing, China: China Forestry Publishing House, 211 pp.

Luken JO, Thieret JW, 1996. Amur honeysuckle, its fall from grace. BioScience 46(1):18-24.

Mooney HA, Hobbs RJ, eds, 2000. Invasive Species in a Changing World. Island Press: USA, 457 pp.

Mumford JD, 2001. Environmental risk evaluation in quarantine decision making. In: Anderson K, McRae C, Wilson W, eds. The Economics of Quarantine and the SPS Agreement. Australia: Centre for International Economic Studies and AFFA Biosecurity, 353-383.

Newsome AE, Noble IR, 1986. Ecological and physiological characters of invading species. In: Groves RH, Burdon J, eds. Ecology of Biological Invasions. Cambridge, UK: Cambridge University Press, 10-20.

New Zealand, Ministry and Agriculture, 2004. Plants Biosecurity Index (Version: 1.2.0). New Zealand Ministry of Agriculture. http://www1.maf.govt.nz/cgi-bin/bioindex/bioindex.pl.

Owen SJ, 1996. Ecological weeds on conservation land in New Zealand: a database. Wellington, NZ: Department of Conservation, 118 pp. http://www.hear.org/weedlists/other_areas/nz/nzecoweeds.htm.

Panetta FD, 1993. A system of assessing proposed plant introductions for weed potential. Plant Protection Quarterly, 8(1):10-14.

Parker C, 2001. Prediction and prevention of plant invasions – what is feasible? In: Riches CR, ed. The World's Worst Weeds. British Crop Protection Council Symposium Proceedings No. 77, 91-106.

Parker C, 2003. Weed risk assessment – an attempt to predict future invasive weeds of USA. In: Labrada R, ed. FAO Expert Consultation on Weed Risk Assessment. Report of a meeting in Madrid, Spain, 11-13 June 2002. Rome, Italy: FAO, 33-40.

Pheloung PC, 1995. Determining the weed potential of new plant introductions to Australia. Agriculture Protection Board, Western Australia. 26 pp.

Pheloung, PC, Williams PA, Halloy SR, 1999. A weed risk assessment model for use as a biosecurity tool evaluating plant introductions. Journal of Environmental Management, 57:239-251.

PIER, 2003. Information on Risk Assessments. Pacific Island Ecosystems at Risk. http://www.hear.org/pier/wralinks.htm.

Quinlan MM, Pasiecznik NM, Sastroutomo SS, 2003. Assessing the environmental risks of invasive species using ISPM No. 11 (Rev. 1): where to start. International Workshop on Invasive Alien Species and the IPPC (International Plant Protection Convention), 22-26 September 2003, Braunschweig, Germany.

Randall R, 2004. A Global Compendium of Weeds. Draft version. http://www.hear.org/gcw/.

Reichard SE, 1997. Chapter 15: Prevention of invasive plant introductions on national and local levels. In: Luken JO, Thieret JW, eds. Assessment and Management of Plant Invasions. New York, USA: Springer-Verlag, 215-227.

Reichard SH, Hamilton WH, 1997. Predicting invasions of woody plants introduced into North America. Conservation Biology 11:193-203.

Rejmánek M, Richardson DM, 1996. What attributes make some plant species more invasive? Advances in Invasion Ecology, 77:1655-1661.

Richardson DM, 1997. Forestry trees as invasive aliens. Conservation Biology, 12:18-26.

Richardson DM, Williams PA, Hobbs RJ, 1994. Pine invasions in the southern hemisphere: determinants of spread and invasability. Journal of Biogegraphy, 21:511-527.

Rotherham ID, 1990. Factors facilitating invasion by Rhododendron ponticum. In: The Biology and Control of Invasive Plants. Ruthin, Wales, UK: Richards, Moorhead and Laing Ltd, 86-94.

Smith CS, Lonsdale WM, Fortune J, 1998. Predicting weediness in a quarantine context. 6th EWRS Mediterranean Symposium 1998, Montpellier: 33-40.

USDA, 2000. Pest Detection and Management Programmes: Noxious Weeds. **http://www.aphis.usda.gov/ppq/weeds/**.

USDA, 2004. Weed-Initiated Pest-Risk Assessment Guidelines for Qualitative Assessments, version 5.2. Riverdale, USA: US Department of Agriculture; Animal and Plant Health Inspection Service. **http://www.aphis.usda.gov/ppq/weeds/Wragui5-2.pdf**.

USDA-ARS, 2004. GRIN Taxonomy. **http://www.ars-grin.gov/cgi-bin/npgs/html/index.pl**.

Walton CS, 2001. Implementation of a permitted list approach to plant introductions to Australia. In: Groves RH, Panetta FD. Virtue JG, eds, Weed Risk Assessment. Proceedings of the 1st International Workshop on Weed Risk Assessment, Adelaide, 1999, 93-99.

Weber E, 2003. Invasive Plant Species of the World. A Reference Guide to Environmental Weeds. Wallingford, UK: CAB International, 548 pp.

Williams PA, 2003. Proposed guidelines for weed-risk assessment in developing countries. In: Labrada R, ed. FAO Expert Consultation on Weed Risk Assessment. Report of a meeting in Madrid, Spain, 11-13 June 2002. Rome, Italy: FAO, 71-112.

Wittenberg R, Cock MJW, eds, 2001. Invasive Alien Species: a Toolkit of Best Prevention and Management Practices. Wallingford, UK: CAB International, 228 pp. **http://www.gisp.org/downloadpubs/Toolkiteng.pdf** or **http://www.cabi-bioscience.ch/wwwgisp/**.

Back to Top

Back to Contents page