# REVIEW OF PROGRESS ON INVASIVE SPECIES

**Final Report to**
**Department of Environment and Heritage**

**12 April 2005**

**by**

**Agtrans Research**
**in conjunction with**
**Noel Dawson**

AGTRANS RESEARCH
Suite 36, Benson House, 2 Benson Street,
Toowong, Brisbane, Australia
PO Box 385, Toowong Qld 4066
Telephone: (07) 3870 4047 or (07) 3870 9564
Facsimile: (07) 3371 3381
E-mail: info@agtrans.com.au
A.C.N. 010 605 964

The views and opinions expressed in this publication are those of the authors and do not necessarily reflect those of the Australian Government or the Minister for the Environment and Heritage.

# CONTENTS

# ACKNOWLEDGMENTS

The authors of this report acknowledge the assistance from various members of the Task Group in direction and sourcing of material. Staff of the Australian Government Departments of Environment and Heritage (DEH) and Agriculture, Fisheries and Forestry (DAFF) and their agencies are acknowledged for identifying many of the various reports of relevance to this review as well as facilitating contact with a range of helpful individuals within Australian Government and State Agencies and other non-government organisations.

Comments from a range of personnel in Commonwealth and State agencies as well as from members of the Task Group have been incorporated into this final report and are gratefully acknowledged.

Other persons contacted whose assistance is particularly acknowledged include:
Bob Clements, Executive Director, Crawford Fund
Andreas Glanznig, WWF Australia
John Irwin, Director CRC for Tropical Plant Protection
Rachel McFadyen, Director of CRC Weeds
Tony Peacock, CEO, Pest Animal Control CRC
Mark Ramsey, Animal and Plant Control Commission, South Australia
John Thorp, National Weeds Facilitator
Sally Vidler, CRC Weeds
Bill Winter, Australian Centre for International Agricultural Research

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AAHL | Australian Animal Health Laboratory |
| ABARE | Australian Bureau of Agricultural and Resource Economics |
| ACIAR | Australian Centre for International Agricultural Research |
| AHA | Animal Health Australia |
| ANZECC | Australian and New Zealand Environment and Conservation Council |
| APCC | Animal and Plant Control Commission (South Australia) |
| AQIS | Australian Quarantine and Inspection Service |
| ARMCANZ | Agriculture and Resource Management Council of Australia and New Zealand |
| AWC | Australian Weeds Committee |
| AWHN | Australian Wildlife Health Network |
| b | billion |
| BA | Biosecurity Australia |
| BRD | Bovine Respiratory Disease |
| BRS | Bureau of Rural Sciences |
| CALM | Conservation and Land Management (Western Australia) |
| CRC Weeds | Cooperative Research Centre for Australian Weed Management |
| CRCTPP | Cooperative Research Centre for Tropical Plant Protection |
| DAFF | Department of Agriculture Fisheries and Forestry |
| DDMRB | Darling Downs-Moreton Rabbit Board |
| DEH | Department of Environment and Heritage |
| DNA | deoxyribonucleic acid |
| DNR&M | Department of Natural Resources & Mines (Queensland) |

| | |
|---|---|
| DPI&F | Department of Primary Industries and Fisheries (Queensland) |
| EA | Environment Australia |
| EAD | Emergency Animal Disease |
| EADP | Emergency Animal Disease Preparedness |
| EHB | European House Borer |
| EPA | Environmental Protection Agency (Queensland) |
| EPBC Act | Environmental Protection and Biodiversity Conservation Act (Commonwealth) |
| FMD | Foot and Mouth Disease |
| ha | hectare |
| IPMC | Interdepartmental Pest Management Committee |
| IRAs | Import Risk Assessments |
| IWS | International Wool Secretariat |
| m | million |
| MRC | Meat Research Corporation |
| NAQS | Northern Australia Quarantine Strategy |
| NFACP | National Feral Animal Control Program |
| NHT1 | Natural Heritage Trust (first phase) |
| NHT2 | Natural Heritage Trust (second phase) |
| NMG | National Management Group (Emergency Animal Disease) |
| NRM | Natural Resource Management |
| NSW | New South Wales |
| NT | Northern Territory |
| OCPPO | Office of the Chief Plant Protection Officer |
| OIE | World Organisation for Animal Health |
| OFPWG | Ornamental Fish Policy Working Group |
| OCVO | Office of the Chief Veterinary Officer |
| PAC CRC | Pest Animal Control Cooperative Research Centre |
| PCR | Polymerase Chain Reaction |
| PHA | Plant Health Australia |
| PIAPH | Product Integrity Animal and Plant Health |
| PMSEIC | Prime Ministers Science Engineering and Innovation Council |
| Qld | Queensland |
| R&D | Research and Development |
| RCD | Rabbit Calicivirus Disease |
| RCV | Rabbit Calicivirus |
| RIFA | Red Imported Fire Ant |
| SA | South Australia |
| SHB | Small Hive Beetle |
| SoE | State of the Environment |
| SPS | Sanitary and Phytosanitary |
| Sq km | square kilometre |
| SSM | Strategic Sustained Management |
| States | Includes Territories |
| TAPs | Threat Abatement Plans |
| Tas | Tasmania |
| Vic | Victoria |
| VPC | Vertebrate Pests Committee |
| WA | Western Australia |
| WONS | Weeds of National Significance |

# EXECUTIVE SUMMARY

This review addresses the impacts of invasive species, the distribution and abundance of invasive species, and reports activities undertaken in Australia in relation to prevention of entry, surveillance, emergency response and eradication, and containment and control.

The invasive species covered in this review include:

- weeds (both terrestrial and aquatic);
- plant diseases and invertebrate pests of plants;
- vertebrate animal pests, both terrestrial and aquatic; and
- animal diseases and invertebrate pests of animals.

Marine pests and diseases are excluded as are native species that cause negative economic or ecological impacts.

Australian efforts to manage invasive species over the past ten years have been considerable and effective. Much of this progress is presented in this review. A continuous improvement culture has been evident, enhanced coordination developed, and some outstanding technical and economic successes achieved.

Globalisation and reduced trade barriers will increase pressure from invasives even more in the future. Even small gaps that currently exist in current strategies could well have significant consequences in the future. Hence this review attempts also to identify the gaps that may be addressed in future in order to maintain the effective management record that has been displayed in the past few years.

**Impacts of Invasive Species**

The economic, environmental and social impacts of invasive species are reported as well as, where possible, the monetary values of impacts at the national level. State level impacts have been addressed in less detail but a range of examples of impacts is provided. Regional level impacts have not been addressed.

*Economic Impacts*

1. Invasive species are costing Australia many billions of dollars annually mainly in costs of control and value of production foregone. Estimates of the different costs are incomplete and those that have been made need refinement and further justification if they are to be used for policy purposes in order to prioritise and stimulate further action on invasive species. The estimates made largely exclude the values of environmental or social costs of invasive species. The economic impacts reported in this review for the individual groups of invasive species are summarised as follows.

Summary of Economic Impact Estimates for Invasive Species

| Invasive Species Group | Economic Impact Reported | Costs and Benefits not included |
|---|---|---|
| Weeds | $4.1 billion | Cost and benefits to the environment such as biodiversity; social impacts such as human health costs. Benefits from weeds not included eg. benefits to the bee industry |
| Pest animals - vertebrates | $0.72 billion including some environmental costs | Social impacts such as human health costs and most environmental impacts not included. Benefits from pests not included eg. sale of goats. |
| Plant diseases and invertebrate pests of plants | At least $0.70 billion per annum. Total is likely to be a multiple of this figure, perhaps at least $2 billion per annum. | $0.70 billion based on studies for wheat, sugar, two horticultural crops, sunflowers, and cotton. Excluded from the $0.7 billion are diseases and invertebrate pests of pastures, nearly all of horticulture, all other grains, cotton, forestry etc. Also excluded are environmental and social impacts.<br><br>$2 billion estimate made from loss estimate of 7.5% of the $17 m average gross value of plant industries, plus fungicides and insecticides sales of about $0.5 m, plus application costs. |
| Animal diseases and invertebrate pests of animals | At least $1.2 billion per annum. | Based on production loss of 5% of a $16 billion per annum animal industry plus value of animal health product sales.<br><br>Excluded are diseases and invertebrate pest impacts on the environment. |
| Other invertebrate pests | No estimates identified or made. | |

Note: The figures in this table for the economic impact of plant and animal diseases and pests are broad estimates only and are not based on published material.

2. The quantitative monetary estimates of economic impact made here are only partial in that they do not include:
   - most values for most environmental or social impacts;
   - values of indirect costs of control measures; or
   - impacts and potential impacts on industries other than primary industry (eg. the tourism industry).
3. Improved estimates are required in order to provide an authoritative total estimate of what invasives are costing Australia. Trends in these costs over time would also be useful to monitor.
4. The positive economic impacts of invasives are usually neglected in quantitative impact analyses; even in the vertebrate pest economic impact study they were not comprehensively analysed.
5. It is likely that the aggregate monetary costs of these invasives have increased over the past ten years (period 1994 to 2004) through both spatial spread,

increased emphasis on managing the problem and increasing costs of control. However estimates of change at this aggregate level are difficult to make and few estimates of aggregate costs by species group have been identified.

6. These increases in monetary impacts would be in spite of reductions in costs being made through successful measures including mechanical, chemical and biological control. As well, large potential future costs have been avoided due to improvements in border protection, surveillance and detection, eradication, and containment and control measures.

*Environmental Impacts*

1. Assessing and quantifying impacts is difficult as knowledge of the precise contribution of an invasive species to the impact on native species or the wider ecosystem is not always particularly well understood or described. Indirect negative impacts and positive impacts also need inclusion.
2. Valuing environmental impacts and potential benefits from action is desirable due to the potential use of values in ranking and priority setting. An alternative approach is to make assessments qualitatively (eg. impact on biodiversity).
3. There is no commonly accepted method of valuing environmental impacts in dollar terms for purposes of priority setting among alternative activities and for integration with activities that lessen industry impacts. Willingness to pay methods of valuation have improved recently but are still used only sparingly by planners and policy makers.
4. Tourism deserves more attention with regard to current or potential impact of invasives eg. south west WA, Kakadu. Relationships between tourism experiences and native fauna and flora and invasives are not well understood.

*Social Impacts*

1. There are few studies that have identified in specific or quantitative terms the health, safety and quality of life/choice impacts of invasive species. A review could be undertaken of the seriousness of these impacts, particularly those involving human health and safety.
2. The most important social impacts are likely to flow from serious economic impacts on regions highly dependent on a narrow range of plant or animal species that are attacked by a new disease or invertebrate pest.

**Changes in Distribution and Abundance**

*Weeds*

1. The maps of the current and potential distribution of the weeds carried out for the Weeds of National Significance program is the principal information set available at a national level on the distribution of weeds.
2. The States have the major responsibility for control and containment of weeds and most if not all assemble data on the distribution of the important weeds that exist in their state.
3. There is no nationally comparable approach between States to monitoring the distribution of existing weeds. Some standardised methods for surveying are available.
4. Less is probably known about environmental weeds in some States as local boards focus more on weeds with agricultural and pastoral impacts.

5. Some weeds are spreading and some weeds are being contained, but there is no generalised information available on the broad picture of spread and containment. The impression is that the total number and area of weeds is increasing.
6. There is a case that can be made for a national audit of weeds that reports on the distribution of major weeds. This may be achieved either by States using comparable methods or by existing data from the States being assembled and integrated every five or ten years.
7. Data on weed distribution and abundance is most valuable for specific weed control and containment programs, for frontier management, for accountability purposes, for priority setting, benefit-cost analyses and model building and validation.
8. There is a trend towards an increasing rate of plant naturalisation based on the past 25 years of data. It is therefore likely that the number of new weeds will also increase in the future.

*Vertebrate pests*

9. The information on distribution is relatively good for vertebrates at a national and State level. For some vertebrate pests changes in distribution over time are also available (albeit sometimes long time frames of up to 100 years).
10. There is some information on the abundance of established animal pests, but it is patchy and inconsistent; data interpretation is hampered by changes in seasonal conditions, and trends are not easy to identify.
11. Abundance and distribution information is important for determining success or otherwise of control programs and for monitoring frontiers.
12. In the main the national distribution and abundance of terrestrial vertebrate pests has not been largely reduced by management in the past ten years, except for the decline in rabbit numbers due to Rabbit Calicivirus Disease. However the distribution and abundance of some vertebrate pests has increased in the past decade eg. cane toads, camels, deer, foxes and feral pigs. There has been an increase in the number and distribution of aquatic vertebrate pests.

*Invertebrate pests and diseases*

13. Knowledge regarding the distribution of plant and animal diseases is comprehensive at national and State levels compared to that for weeds.
14. There is no significant trend in the establishment of new insect pests or diseases of plants, at least between 1971 and 1995. For other invertebrate pests no trends were reported in the literature surveyed.
15. Some existing plant diseases have continued to spread over the past ten years (eg *Fusarium* in cotton, *Phytophthora* in native species). New plant diseases and invertebrate pests have continued to appear although some new incursions have been eradicated or contained.

*General*

16. Monitoring the distribution of weeds and animal pests on a national scale would be most informative but its practicality and cost-effectiveness would need scrutiny given the number of species involved. Most monitoring of established pests is carried out at State level and it may be possible to produce a national picture of major pests every few years through aggregating State data.

**Institutional Arrangements**

The Australian Government and State governments together with industry have increasingly recognised the importance of greater coordination in managing invasive species over the past ten years. Coordinating mechanisms have been developed between industry and government and between and within State and Australian Governments in some areas. While some agricultural-environment integration has developed, most of the institutional strengthening has been within the agricultural arena rather than the environmental arena. Specifically, the most significant changes have been:

*Plants*

1. In 2000 the scope of the Australian Weeds Committee was extended to include all weeds (those of primary industry, forestry and the environment).
2. The development of the National Weeds Strategy between 1992 and 1997 was a major achievement in coordination between the Australian Government and the States and Territories.
3. The Weeds CRC established in 2001 (and its forerunner) have provided a focus for weeds research and a degree of national coordination.
4. The CRC for Tropical Plant Protection established in 2000 (and its forerunner) has produced valuable outcomes in terms of diagnostics and improving resistance to important plant diseases.
5. The Office of the Chief Plant Protection Officer was established in 1997 and has provided a focus for the national coordination of plant protection activities.
6. Plant Health Australia, established in 2000, has provided a focus for centralising information and coordination of plant health functions involving and affecting governments and a range of industries.

*Animals*

7. Animal Health Australia was established in 1996 with the aim of improving the national capability, standards and performance of Australia's animal health system, animal disease surveillance, and emergency animal disease preparedness.
8. The Pest Animal Control CRC (established in 1999) has pursued scientific approaches to the management and control of Australia's established pest animal species.
9. The National Feral Animal Control Program was established in 1996 with funding provided through the Natural Heritage Trust for national level support. It has focused on capacity building through extension and training, as well as developing improved approaches to vertebrate pest control.
10. The Vertebrate Pests Committee has expanded to include freshwater fish species and native pest species causing negative economic or ecological impacts. It is also currently in the process of developing a National Pest Animal Strategy.
11. The OFPWG was established in 2003 to develop a national strategic approach to ornamental/exotic fish. The draft strategic approach to the management of ornamental fish in Australia will soon be released for consultation.
12. The OCVO was established in 1995 and provides national leadership and coordination of animal (including aquatic animal) health activities.

*General*

13. The establishment of Biosecurity Australia in 2000 has separated the policy and market access functions of government from that the operational activities of AQIS. Also, the creation of Biosecurity Australia as a prescribed agency occurred in December 2004.
14. States (including Territories) have developed various institutions and strategies over the ten years including weed strategies, animal pest strategies, exotic fish strategies and in Queensland an interdepartmental pest management committee.
15. Gaps in institutional arrangements include:
    - There has been no national vertebrate pest strategy or national strategies that deal with exotic freshwater pest fish, however a National Pest Animal Strategy including terrestrial vertebrates and freshwater fish is currently being prepared. Also a national strategy for ornamental fish is currently being developed.
    - There is no institution that focuses on invertebrate pests that cause mainly social or environmental impacts.
    - The institutional arrangements for handling environmental and social pests are generally less well developed than those for agriculture that have evolved over many years.
    - With the delivery of many government resources for on ground NRM activities being through regional groups in the future, arrangements for ensuring coordination of invasive investment and activities will be required, for example integrated regional plans and state agency / scientist input.

**Prevention of entry**

1. AQIS has continued to develop programs to increase awareness of the Australian community of the importance of quarantine and some of these programs have been highly successful.
2. Australian initiatives pre-border such as research and other forms of assistance to other countries has contributed to Australian knowledge, experience and preparedness as well as reduced threats to Australia by strengthening quarantine services in neighbouring countries.
3. A large increase in the budget for border protection in 2001 led to an increase in Australia's quarantine intervention and substantially strengthened border control with higher interception and effectiveness levels reported by AQIS.
4. Improved risk assessment processes were introduced for animal pests in the early 1990s and re-evaluated in 2003.
5. AQIS changed to a three tier system for assessing imported plants and seeds in 1997 that included a permitted list, an improved import risk analysis process, and a prohibited list. The change has been viewed by most as a highly effective policy, but some flaws have been identified as detailed below.
6. Some progress has been made in identifying sources of entry of weeds to Australia. At least 65% of naturalised species over the period 1971 to 1995 emanated from earlier ornamental introductions.
7. Gaps identified include:

- It is not clear whether many of the pre-border activities excluding those of NAQS and AQIS take account of overall priorities that may have been set in Australia regarding invasive species, for example, the activities of ACIAR.
- Some listings of plants on the permitted list for imports are by genus and not by species or variety, leaving entry open to weed species in particular genera (the schedule 5 loophole); an accelerated review of the permitted list is now underway.
- Importation can sometimes be allowed for a plant that is prohibited as it may fall within a permitted genus into which it had been previously classified (different name).
- Both changes to classification and listings of genera of fish can cause confusion of the status of species in relation to importation. In addition the physical capacity of agents on the border to be able to accurately identify over 400 different species of fish can be a limitation to the border security process.
- There is perceived lack of independence of vertebrate risk assessments as due to constraints on knowledge there is a subjective component to risk assessments that requires input by suitably qualified experts. Applicants often pay for a risk assessment and it is considered by some that arrangements are not yet in place to ensure that an independent and technically qualified /accredited authority undertakes the risk assessment for the import of exotic vertebrates.
- The prevention of entry by invasives through direct seed ordering from overseas may constitute an area of risk.

**Surveillance**

1. Surveillance has been successful with a number of new pests detected, identified and sometimes eradicated over the ten year period.
2. Diagnostic capacity has been important in enabling eradication and containment of plant diseases over the ten year period and in supporting quarantine measures, for example in assessing imports of rooted plant material.
3. AWC has been attempting to better coordinate the different legislation, regulations and structures throughout Australia that contribute to weed plants still being traded. Nationally consistent legislation regarding sale and importation from other states is being developed, albeit slowly, with some States responding more quickly than others. The approach to date of seeking voluntary removal from sale of known garden invasives has increased awareness of the issue but has not been effective overall.
4. Sleeper weeds have been identified and prioritisation for eradication has been undertaken but not agreed by jurisdictions; priorities are based only on BRS studies at this stage.
5. Alert lists for high priority invasives have been developed for both weeds of primary production and of the environment; however, a comprehensive national list of potential and actual eradication targets for priority environmental and agricultural weeds has not been agreed nationally and used.
6. Some high risk invasive plants that are not yet present in Australia have been identified using criteria of history overseas, pathways for entry and potential

impact. Various other high profile pests that are not yet present in Australia have been targeted in surveillance programs.

7. A high level of community awareness has proven to be an important part of monitoring and surveillance. For example, communication and raising awareness regarding fire ants has resulted in the identification of more established nests outside the official surveillance zone.
8. The likelihood of early detection of invasive plant pests should be increased through the implementation of a national reporting system, a targeted awareness program and the establishment of a free hotline to encourage reporting by the public
9. Gaps identified include:
    - Current State legislation (with the exception of Tasmania) does not oblige landowners or diagnostic laboratories to report suspicious new incursions of potential invasives. Also, the cost recovery policy of AQIS may dissuade some reporting.
    - Invasive species that do not directly threaten primary production generally have not been strongly targeted for surveillance at a national level, largely due to a lack of clarity of institutional roles and responsibilities, and undeveloped institutional structures and budget processes. Surveillance is weaker for environmental pests, social insects and fish. Examples include fire ants, cats and cane toads. In some cases methods for surveillance are also undeveloped.
    - A national policy for pest and disease surveillance could be considered that addresses awareness raising in communities at a generic level, as well as funding, targets, surveillance levels, methods, and training for specific invasive species and groups of species.
    - While further investment in diagnostic capacity has been made in the past ten years, particularly through DNA libraries and molecular testing, there have been examples of delays from not having a nationally agreed and accepted diagnostic procedure in place prior to an incident.
    - While it has been recognised that there is a need to restrict trade nationally in weedy species, only two states prohibit the sale of all 20 Weeds of National Significance. Further, many potential weeds are already in Australia but are traded and kept without restrictions in gardens and nurseries. These potential weeds could be made subject to risk assessments so that priorities can be formed for the development of approaches to reduce the threat to the environment and agriculture.
    - Apart from nurseries, other sources of potential weeds that exist in Australia are the Genetic Resource Centres, botanic gardens, arboreta and tree seed collections. These facilities contain a significant number of plant accessions that have legally passed through quarantine. Most have not been subject to a weed risk assessment and few jurisdictions insist on a risk assessment before germplasm is released to plant breeders or the wider environment.
    - Resources and action to eradicate or contain sleeper weeds have been lacking despite the likely cost- effectiveness of such a strategy.
    - The compilation of a national list of invasive and potentially invasive plant species in Australia using a more systematic approach to identify high risk species has been promoted for selecting targets for pre-emptive action and for increased surveillance.

- The alert list for environmental weeds has been criticised as not being useful to regional groups as a number of species are not of concern to government agencies or the community, there was inadequate consultation involved, and the basis for the selection of weeds on the list was not made clear; the list is not recognised nationally.
- There is a need for an equivalent formally recognised "alert list" for weeds that can impact on agriculture and or/the environment. Such a list could address both species that are not yet present in Australia as well as those species that have entered Australia and could become weeds.
- There is no national alert list for vertebrate pests or invertebrate pests that are not specifically pests of agricultural animals, however there are sometimes individual warnings or alerts put out, for example for the giant African snail and red-eared slider turtle.
- While the Vertebrate Pests Committee has attempted to list all exotic vertebrates present in captivity or in the wild in Australia, relatively few of these species have had a risk assessment conducted to determine the threat they pose, even though they are already past quarantine barriers. The cost and responsibility for conducting such risk assessments is an issue that has not been resolved. A similar situation may apply to invertebrates that are primarily social or environmental pests.

**Emergency Response and Eradication**

1. Over the past ten years, formal response arrangements have been developed and implemented for managing exotic pest and disease incursions affecting animal and plant health. The Department of Agriculture, Fisheries and Forestry, through the OCVO and OCPPO, has led the development of these arrangements and, in actual emergencies, leads the national response.
2. Arrangements to manage pest and disease incursions that have the potential to impact upon Australia's primary industries have been established, in the case of parasites and diseases affecting animals through AUSVETPLAN and the Emergency Animal Disease Preparedness Program managed by AHA.
3. The animal industries approach to National Emergency Animal Diseases is considered an excellent model on which to base responses to incursions in other industries or sectors (eg. plants, vertebrate and invertebrate pests).
4. Wildlife health is monitored through the Australian Wildlife Health Network which was established in 2002 in order to develop a coordinated national program focused on the health and diseases of free-ranging wild animal populations to better prepare Australia for serious disease outbreaks in its wild and feral animal populations.
5. Nationally consistent guidelines for emergency pest incursions affecting Australia's plant industries (PLANTPLAN), based on AUSVETPLAN have been drafted recently by Plant Health Australia.
6. Eradication of some new plant diseases and weeds has been achieved in the past ten years. Most have been in the early stages of developing into pests. Early eradication of an invasive species has been shown to be far preferable in terms of cost effectiveness as the feasibility and cost of eradication increases as the invasive spreads. There are few examples of any weed or invasive animal pest that has been eradicated once it has become widespread. Exceptions are successes on islands, including cats on Macquarie Island, and

the weed Kochia has been eradicated in Western Australia (considered to have been widespread).

7. Principles for assessing the likely success of a weed or animal pest eradication program have been developed. Useful information has been assembled regarding the costs and feasibility of weed eradications that should be useful in considering future eradication options.
8. The National Information Manager's Technical Group is developing surveillance, quarantine, control and recovery software for use in emergencies. The same application interface will be used for animals, plants, pests, weeds and incursion incidents.
9. Historically, detection and management of invasive species has been the responsibility of primary industries and related government agencies due to the large and noticeable economic impact on such industries. Invasive species with a largely environmental or social impact have tended to be given less attention in relation to detection, surveillance, R&D, and control actions. This is partially due to a lack of a funding and skills base for such activities.
10. Gaps identified include:
    - Preparedness plans for incursions generally do not exist for pest and disease incursions that do not have a significant primary industry impact. Environment interests have not been well integrated into the development of decision making on response arrangements for plant health.
    - Preparedness plans also do not exist for responding to new incursions of pest animals (either for species with potential primary industry or environmental impacts).
    - The importance of not having cost sharing agreements in place has been stressed and demonstrated over the past ten years. However, as of October 2003, cost sharing arrangements were not in place for weeds, vertebrate or aquatic pests, but were in place for animal diseases, and under development for plant pests.
    - The principle of beneficiary pays has not been incorporated effectively into response arrangements with regard to the environment and broader social beneficiaries (eg. human health). Although taxpayers via governments are responsible and ultimately provide resources, the specific channels and institutional structures used for funding and cost sharing are not well developed and can cause delays.
    - There are no preparedness funds held in reserve by governments specifically for eradication or containment of newly discovered invasive species.
    - The Queensland Government's experience with fire ants demonstrates that there is a lack of clarity in roles and responsibilities when dealing with a pest with very broad-scale impacts across social, environmental and production sectors. This can lead to delays in pursuing an eradication or control program.
    - There are gaps in legislation in some states and territories whereby few State and Territory governments have specific powers to control or eradicate across all land types, immediately establish quarantine measures, destroy healthy plants if necessary or establish buffer zones.
    - If an incursion of an invasive is considered beyond eradication, then there is no system for joint Australian Government/State action of joint funding for any containment program within one State or more. This constitutes a

gap in the arrangements when it may well be in the national interest to contain the species.
- There may be bias in the States and Territories of eradication programs towards weeds of primary production as opposed to environmental weeds. This should be confirmed and reasons for this situation identified.

**Containment and Control**

1. In general terms the National Weeds Strategy has been highly successful in providing a focus for a concerted effort on containing or controlling some weeds (WONS) coordinating across jurisdictions, and identifying sleeper and alert weed lists.
2. The WONS program, together with the National Facilitator, have generally been seen as excellent initiatives and provide examples of coordinated activities between the States.
3. Nine species have been listed as key processes that threaten the environment and threat abatement plans (TAPs) have been developed or are being developed, and are administered by DEH.
4. The ten years has demonstrated that bio-control offers great promise and has already achieved much with biological control agents being dispersed to assist in the management of a range of invasives. Bio-control investment has been shown to be highly cost-effective.
5. While there have been no examples of eradication of vertebrate pests on mainland Australia, there are some success stories in relation to control of vertebrate pests which has resulted in the recovery of native vegetation and endangered fauna.
6. The most successful control of a vertebrate pest species in Australia in the pest ten years is most likely the rabbit, through the release of the Rabbit Calicivirus Disease.
7. The ecological impact of control actions and programs in relation to vertebrate pests is not well documented due to a lack of appropriate monitoring and evaluation associated with such control actions and programs.
8. Benefit-cost analyses of a number of invasive species control projects have demonstrated high returns to investment.
9. A number of decision making aids have been developed over the past few years to assist with on resource allocation.
10. The last ten years has seen an increasing focus by government agency and industry groups on the involvement of the community and their level of awareness in the efficient and effective control of invasives.
11. Gaps identified include:
    - The WONS initiative has suffered from inadequate funding in some areas including aquatic weeds and implementation of the initiative in some areas has been slower than anticipated.
    - The WONS reports do not appear to provide much information even on a species basis as to the overall trends in success or otherwise since each strategy was implemented (eg. increase or decrease in areas or density, benefits or likely benefits or reduced impact achieved for the investment to date, and little emphasis on quantitative outcomes).
    - TAPs have been criticised as being slow to develop, do not include adequate consultation, are under resourced, and not fully implemented.
    - The regulation of biological control agents can provide a disincentive to researchers. The rate of biological control agent release has slowed in the past

14 years, despite there being virtually no non-target impacts since appropriate non-target risk assessment procedures were implemented. On the other hand, the rarity of non-target impacts could be an indication of the effectiveness of the regulatory controls.

- In terms of setting national priorities for containment and control on an objective basis there are issues in decision making associated with assessing the importance of species that impact on primary industries versus those that impact on the environment or social infrastructure and amenities such as waterways and water storages, or where there are impacts such as human health and safety involved. Key questions are who should pay and what process can be used to identify appropriate responsibilities and cost sharing.
- The management of invasives in non-agricultural areas or without agricultural significance sometimes falls to government agricultural structures as this is where there is the most significant expertise and structures for organisation and management. This suggests a gap exists as these agencies do not necessarily have the formal responsibility to manage and fund response and control activities for such incursions. They may however be the best agencies to undertake this work because of their skills and protocols.
- There is no national coordination of control of vertebrate pests already present in Australia. This is with the exception of where there is significant national interest. However, the Vertebrate Pests Committee is currently preparing a National Pest Animal Strategy. Also, a national strategic approach to ornamental/exotic fish is currently being drafted.

**Illustration of Themes**

The case studies have been chosen to illustrate specific themes. A summary of the implications evident from the case studies for the management of invasive species include:

1. The importance of an effective and ongoing surveillance network.
2. Surveillance can be an excellent investment due to the increasing costs that are usually incurred if an invasive species is not detected early.
3. The importance of awareness, education and community involvement in surveillance, detection and eradication.
4. The importance of early detection, identification and quarantining.
5. Cooperation between industry, State and Australian Governments allowing them to act quickly.
6. The importance of diagnostic tests and the maintenance of capacity and experience in state agencies.
7. The value of early intervention; if intervention is not early enough, eradication is extremely unlikely and containment made more difficult.
8. Continuing commitment to an eradication program is essential for success.
9. The importance of the enforcement of compliance in gaining confidence of communities in being involved in invasive programs.
10. The importance of an integrated and ongoing approach to pest control that considers whole-of-ecosystem issues.
11. The importance of a pre-existing preparedness or cost-sharing arrangement for pests that do not clearly impact on only one industry, but rather on the environment and community as a whole.
12. The use of agencies with good skills in control / eradication programs in combating new invasives.

13. The positive economics of investment in bio-control and its positive interaction with other methods of control.
14. The benefits from national coordination when an invasive species established in one State may threaten another State.

**General Issues**

1. Public resources committed to invasive species appear to be small, particularly in the context of:
    - Expenditure on other natural resource management issues faced by Australia and the respective economic and environmental impacts of invasives compared with other issues.
    - The relatively high benefit-cost ratios reported from analyses of invasive species R&D and other invasives programs.

    Specific resourcing issues include:
    - The uncertainty created by short-term funding of R&D, particularly for bio-control programs, where long term commitment is required.
    - Lack of resources for the identification of potential weeds where introduced plants are already in Australia, preventing introduced plants from becoming naturalised, and identifying and responding to sleeper weeds and new weed incursions.
    - Lack of resources for invasive species that predominantly impact on the environment.
    - Lack of resources for pests that impact wholly or jointly on society with relatively small environmental or industry impacts.
    - Inadequate knowledge and reporting of what resources are invested in invasive species programs as a whole.
2. There are both commonalities and differences between the different invasive species groups; overall, it may be possible to take advantage of the commonalities to develop a common invasive species strategy while still recognising differences. This would lessen the likelihood of non-agricultural pests being neglected. A National Invasive Species Strategy may be appropriate to ensure those invasives that do not easily fit within one of the existing 'silos' are firstly able to be detected, and secondly that any program to eradicate, contain or control such species is funded and managed by the appropriate agencies and/or funding base. It would be useful to have a national strategy for invasive pests that involves different government sectors to facilitate sharing of experiences between sectors.

# 1. Introduction

## 1.1 Background

The objective of the current review is to provide information to assist the Natural Resources Management Standing Committee Invasive Species Task Group. In general terms the review addresses the first term of reference with which the Task Group has been charged. This focuses on progress in the prevention and control of pests and weeds over the past ten years in terms of reduction in extent and impact, control methods, avoiding new incursions and the awareness of the community and landholders regarding pest control.

The increasing volume of trade between countries as well as personal travel have both increased the risk of invasive species introductions into Australia. Much attention has therefore been recently focused on border control. However, regardless of how stringently controls are applied some invasive species will still penetrate the border.

While the economic impacts of invasive species have continually been recognised by the primary industries sector, there has been a growing realisation of the damage that invasive species are imposing on the natural environment and the importance of the natural environment to the national economy. There has been also a recognition of the need for strategies and coordination between different parts of governments, industry and the community that have an interest in combating the threats imposed.

Some progress has been made over the past ten years through investment in activities in containment and control. There has also been progress made in process and institutional change where benefits may take longer periods to become evident.

There has been some speculation as to why governments have been slow to respond in terms of resources and improved coordination, despite the cost effectiveness of activities against invasive species being demonstrated. Reasons potentially include the perception of the area constituting a “black hole” and the likelihood of depletion of scarce natural resource management budgets of the States and Australian Governments, poor understanding and awareness of the benefits and costs (particularly at different stages of the invasion), the difficulties of developing cost-sharing arrangements and the long time-frame often required to make visible progress.

The approach to this review has been to focus on the achievements that have occurred, as well as constraints to greater progress and lessons learnt from experiences over this past period.

Much of the literature surveyed has been concerned with what should occur and these normative discussions have not been a focus of the review. The focus is on achievements and the principal findings emanating from those achievements, as well as the constraints that remain and the gaps that are evident.

## 1.2 Terms of Reference

The aim of the project is to report on national progress of invasive species prevention, detection, eradication and management over the last 10 years.

The report will take into consideration:

- Non-native species invasive to the environment and primary industries, both of terrestrial and freshwater environments, including vertebrates and invertebrate pests, weeds and disease; and
- Management activities and other outcomes, including prevention, detection, eradication, and ongoing management.

The report will, for the period of the past 10 years, review and describe:

- The impacts of invasive species; and
- Changes in the distribution and abundance of invasive species resulting from management strategies (including eradication and control actions).

For the above two points the consultants will also use a selection of key invasive species (environmental and agricultural) in terrestrial and freshwater environments to illustrate these themes:

- Research and development of control and management options for invasive species;
- Avoidance of new incursions, including through detection, prevention of establishment and the management of invasive species;
- Mitigation of the impacts of sleeper species; and
- Levels of awareness and capacity of the community and landholders in the management of invasive species.

Existing information to be used should include, but not be limited to, the following:

- Australian Weeds Committee and Vertebrate Pest Committee reports;
- State and Australian State of Environment Reports;
- Report of the Cooperative Research Centres for weeds, vertebrate pests and freshwater ecology;
- Department of Environment and Heritage commissioned project reports on invasive species management;
- Submissions made to the Senate Committee hearings on invasive species;
- Reports of non-governmental organisations, such as the World Wildlife Fund;
- Data/reports from risk assessment processes; and
- The National Land and Water Resources Audit.

## 1.3 Structure of Report

Section 2 of this report presents a brief framework for analysis and reporting of achievements and constraints in the overall management of invasive species. Section 3 provides information on the economic, environmental and social impacts of invasive species and identifies some of the difficulties of estimating such impacts at the aggregate level. Section 4 provides a review of the changes in distribution and abundance of invasive species, again with a focus on progress made over the period

and some of the issues faced in considering improving information on the spread of invasive species.

The framework developed in Section 2 is used to provide a description of progress in managing invasive species in the past ten years. This is presented in Section 5 and is the longest section in the review. It covers briefly institutional arrangements and then focuses on achievements, constraints and gaps across a range of activity areas.

Section 6 illustrates a number of themes evident in this progress by way of examples chosen to illustrate issues across the framework. Section 7 provides the principal findings from the review regarding progress and achievements, as well as some gaps and constraints that are evident.

# 2. Framework for Reporting

## 2.1 Scope

The review covers the following invasive species:

- weeds (both terrestrial and aquatic);
- plant diseases and invertebrate pests of plants;
- vertebrate animal pests, both terrestrial and aquatic; and
- animal diseases and invertebrate pests of animals.

Marine pests and diseases are not included. Also, only non-native plants, animals and pathogens are included. Native plants and animals that have become pests to primary industries or the environment are excluded.

A central part of the review necessarily focuses on activities that have been undertaken to combat invasive species and how successful these activities have been. Some of the progress reported therefore relates to activities in the area of control, eradication, surveillance or prevention of entry. However, other progress is reported in terms of improved institutional arrangements that may have been fundamental to progress made. It needs to be recognised that some of the impact of these institutional changes may not have been manifest to date.

Associated with reviewing progress and achievements is a focus on what has not worked well, and the principles and lessons learnt from both successes and failures over this period.

While the emphasis is on the last ten years, there is some reference to earlier periods for contextual and comparison purposes. Ten years is not a long period to assess changes in impact due to investment and organisational activities nor to report changes in distribution and abundance for many invasive species, especially in the containment and control areas.

There is an emphasis on a national perspective rather than a local or regional perspective. This means that the activities of agencies and coordinating mechanisms of the Australian Government and States and Territories are given central focus, rather than those of industry and community groups where most of the on-ground control and containment activities occur.

Finally, while the impacts of invasive species on primary industry production have been evident for a long time, the realisation of the impacts on the environment has been more recent. Hence the institutional and resourcing structures are less developed and the associated capacity for analysis and preparedness is still growing. This has meant that there may be more constraints and gaps associated with the institutional response to environmental impacts of invasive species such as weeds than with primary industries.

## 2.2 Activity Areas

From the viewpoint of assessing progress, activities are grouped into four categories:

- Prevention of entry
- Monitoring and surveillance
- Emergency response and eradication
- Containment and control

Prevention of entry includes both pre-border initiatives and as well as border quarantine. Monitoring and surveillance includes the activities of government agencies as well as those activities undertaken by industry and the community to ensure that invasive species that breach quarantine or those that are legally imported but become troublesome are quickly reported so that management responses can be most effective.

Emergency response focuses on the institutional preparedness for communication and decision making once an invasive species is detected and which may result in a decision to eradicate where feasible. Detection is an outcome of surveillance but also includes diagnostic testing and confirmation. Eradication activities are also covered in this activity category.

Containment and control is the major on-ground investment area for invasive species but includes planning and priority setting activities at a range of spatial scales.

Some activities do not necessarily fall clearly into one of these four activity areas. Where this occurs, an activity is discussed in one area only and reference made to its relevance to other activity areas. For example sleeper weeds are discussed in monitoring and surveillance activities but are also relevant to eradication activities.

Outputs and outcomes for reporting progress are wide ranging and rely to a large extent on what information is reported in the literature reviewed. Reporting of achievements is not restricted to changes in impact or in distribution and abundance as indicators of progress in these areas are quite difficult to measure for many invasive species.

## 2.3 Sources of Information

Most information used in this review has been obtained from previously published and unpublished material. Much of this material has been identified or supplied by personnel in the Australian Government and State governments. A list of the material consulted is provided in the reference list. Limited time was available for consultation with individuals, so that some information presented may not always be the most recent.

# 3. Impacts of Invasive Species

The impacts of invasive species have been grouped into economic, environmental and social impacts. Within these categories, impacts have been grouped into those from weeds, vertebrate pests, diseases and invertebrate pests of plants, and diseases and invertebrate pests of animals and other invertebrate pests (not necessarily related to plants and animals eg. social pests).

## 3.1 Economic Impacts

### 3.1.1 Weeds

Combellack (1987) provided the first comprehensive estimate of the cost of weeds to Australia. The financial loss estimate included both direct expenditure in control as well as indirect yield and quality losses. The study covered agriculture and horticulture, forests, national parks, aquatic weeds and infrastructure, but did not include environmental costs. The total cost estimate was $2.096 billion for the year 1981-82.

Two unpublished estimates of the economic costs of weeds have been made since 1987 and reported by Groves (1998). These included a $3.3 billion estimate in 1995 and just under $5 billion in 1996.

The most recent authoritative estimate was that carried out by Sinden et al (2004) for the Cooperative Research Centre for Australian Weed Management (CRC Weeds). This study estimated the annual cost of weeds over the period 1997/98 to 2001/02 at $3.927 billion measured as producer and consumer costs. The cost to consumers was 18.6% of the $3.9 billion per year, with the majority of costs being borne by producers. An additional $112 million was estimated for government expenditure on weeds. The total cost estimate was therefore $4.039 billion. This estimate did not include any allowance for community volunteer costs or labour of owner-occupiers of land. The final estimate can be considered to be a significant underestimate as the environmental and wider social impacts of weeds were not included.

In the same study, the impact was estimated also from control costs and yield losses by primary industries. This resulted in a similar total estimate with the proportion from yield losses contributing about 60% of the total. Control costs were a higher proportion than losses in cropping and horticulture while the opportunity costs of weeds in pastoral industries dominated where the economics of control are generally less favourable.

The economic impact of weeds includes both costs and benefits. Sinden et al (2004) recognise some benefits (eg. from prickly acacia and blackberries) but the benefits from weeds as a whole have not been accounted for quantitatively in the cost estimates made. However, the beneficial impacts of weeds are likely to be small in relation to the total negative impacts.

In general, while the positive benefits from some weeds in terms of environment (eg. providing habitat for native fauna and erosion control), as well as production benefits

and agricultural use (eg. pasture plants, medicinal herbs etc) have been recognised, there has been no attempt identified in the literature to estimate the aggregate economic or environmental benefits from invasive species. In some cases the environmental benefits may be quite significant, for example, the naturalisation and spread of *Bothriochloa pertusa* or Indian couch grass in central and north Queensland (Bill Winter, pers. comm. 2004). Weeds can provide shelter for pest animals and can provide food for native animals and habitat for threatened species such as lantana for the threatened Brown Bandicoot (SoE South Australia, 2003). Groves (1998) notes the positive impacts of some weeds, for example their use in herbal medicine and contribution to the bee industry.

The important issue is that the implications for the impact on the associated broader ecosystems need to be accounted for when considering weed management options. It is interesting to note that most economic and environmental impact studies appear to take a narrow view and mostly concentrate on direct negative impacts.

Compared to estimates of impact of other forms of land degradation such as salinity and sodicity, the conservative estimate of $4 billion annual impact of weeds is far greater (Sinden et al, 2004), suggesting weeds could deserve a larger share of public funds than currently is the case. This proposition is based on the total cost impact alone, and ignores the relative prospects of making progress in the different resource problem areas and any differences in appropriate public /private cost shares that might apply to different land degradation issues.

Another recent study also identified the importance of invasives. The Prime Minister's Science Engineering and Innovation Council (PMSEIC) recently evaluated 18 options for investment in reducing the diminishing value of natural systems. The authors found that one of the top rated four options was "limiting the spread of pests, weeds and imported diseases" (Possingham et al, 2002).

In the 2003-2008 Management Plans for the Australian Weeds Committee (AWC) there was by June 2004 to be a collated list of Australian weed impact studies undertaken complete with further information and contacts and position papers. This was associated with economic and environment assessment and a review of current State/Territory economic and environmental weed impact assessments. This has not yet been achieved (John Thorp, pers. comm., 2004).

Identifying and measuring economic impacts at a national aggregate level can be of value in highlighting the extent and seriousness of a natural resource management issue. At a less than national level impact estimates can be useful as inputs into priority setting and management processes such as risk assessment.

Some additional predominantly economic impacts reported for weeds are shown in Table 3.1.

Table 3.1 Economic Impacts Reported

| Source | Impact |
|---|---|
| Lonsdale (1994) as cited in SoE Australia, 2001 | Greater than 99% of pasture species introduced between 1947 and 1985 considered useful for pasture production caused weed problems in both cropping and conservation areas in N. Australia. |
| Groves, 1998 | The cost so far for Siam Weed found near Tully in 1994 has been $460,000 in direct costs to eradicate and contain it. |
| Groves, 1998 | Kochia (deliberately introduced from US in 1990 as a forage plant suitable for saline areas) has cost so far $530,000. |
| Groves, 1998 | Despite quarantine, species of parasitic weeds (golden or field dodder) have continually been introduced as a contaminant of seed of various herbs, especially sweet basil. These were not picked up in international seed testing protocols; These species were found three times in the last 25 years in 1981, 1988 and 1990. The 1981 incursion has cost at least $600,000 so far with the species last found near Keith (SA) in 1993. |
| Jones and Verer (1998) as cited in CRC Weeds, 2003a | $40 m is the annual cost of serrated tussock in NSW pasture. |
| Thorp and Lynch, 2000 | $50 m per annum is expended to control 11 of the 20 Weeds of National Significance (WONS). |
| Jones et al (2000) as cited in CRC Weeds, 2003a | $1.2 b estimated as the annual national cost of weeds to cropping farmers in annual winter grain regions. |
| State of Environment Australia, 2001 | Of the 20 WONS species, five are a major threat to agriculture and nine have both agricultural and environmental impacts. |
| State of Environment Australia, 2001 | Of the 20 WONS species, 14 impact on the pastoral industries, 9 on the cropping industries, and 17 on forestry management. |
| Groves, 2002 | Financial estimates of costs of other individual alien species in South Australian pastures are also available for 2 cases studies where biological control was proposed: Patersons curse and blackberry. |
| AEC Group, 2002 | State plus local government authorities in Queensland spent approximately $24 m in 2002-03 on declared weed and pest animal management ($10 m from Queensland Department of Natural Resources & Mines (DNR&M) and $14 m from local government). |
| Victorian Catchment Management Council (2002) | The direct costs of weeds in Victorian agriculture was estimated at more then $360 m pa. |
| BRS, 2003 | The potential impact on agricultural systems for individual sleeper weeds is significant. Total revenue was at risk of from $88 m to $9,000 m per annum (the latter figure is three times the cost of weeds at present). |

| | |
|---|---|
| State of Environment, South Australia, 2003 | The estimated cost of weeds to agriculture in South Australia is $650 m annually. |
| State of Environment, Tasmania, 2003 | In 1996 it was estimated that weeds cost Tasmania $33 m per year due to losses and costs of control (Ministerial Working Group, 1996). |
| BRS, 2003 | Serrated tussock reduces the livestock carrying capacity of southern Australian pastures and incurs an annual cost of $40 m in NSW and about $5.1 million (for 1997) in Victoria. Victorian costs could escalate to $15 m in 10 years. |
| Groves, 1998 | For new plant invasions in 98% of cases no information was readily available for the cost of individual weeds in Australia. |
| DAFF, 2003 | During the first phase of the Natural Heritage Trust (NHT1) some $12.9 m was provided through the national weeds program to support the National Weeds Strategy, and implementation strategy for Weeds of National Significance. |
| Victorian Department of Primary Industries, 2003 | The cost of lost grazing to serrated tussock in Victoria was $5 m per year. In 1997 the estimated area of serrated tussock in Victoria was 130,000 ha, but its potential spread was predicted to be 4.6 m ha. |
| CRC Weeds, 2004b | Serrated tussock cost around $50 m per year for pastures in NSW and Victoria. |
| Kemp, 2004 | With a $28.5 m investment made under the first phase of the NHT, the Government has focused on key world heritage areas and national parks and there has been considerable success in eliminating and controlling a range of invasive pests and weeds. |
| Thorp & Lynch (2003) as cited in AWC (2001) | Effort and money expended on weed control is increasing (Thorp and Lynch, 1999, 2000). |

### 3.1.2 Vertebrate Pests

***Terrestrial Vertebrates***

In 2002, the Bureau of Rural Sciences (BRS) reported that pest animals cost Australia at least $420 million each year, mainly as direct short-term losses of agricultural production (Hart, 2002). They also reported that attempts to control non-native vertebrate pests costs governments and landholders more than $60 million annually, with a further $20 million spent on research (Hart, 2002).

In April 2004 the Pest Animal Control Cooperative Research Centre (PAC CRC) reported the results of a study to determine the overall impact on the economy, environment and society of invasive animals (McLeod, 2004). It is a conservative study that sought to calculate the minimum likely costs of 11 vertebrate pest species (ten terrestrial and one aquatic). Included in economic costs is any cost to industries (particularly agricultural), any control costs and research costs. The commercial value of pest animals harvested for meat or pelts is not usually included as a positive impact. The study also included the freshwater fish species carp, however the impacts

of carp and other freshwater animal pests are discussed in the aquatic vertebrates subsection.

Based on the McLeod study, the total economic impact of ten terrestrial vertebrate pests is at least $369.9 million and these are predominantly industry costs. It should be noted that this does not take into account all economic impacts, and was a conservative study. For example for cane toads and wild horses, only the research cost has been calculated. McLeod did also not include a number of vertebrate invasive pests such as deer, donkey, rats and birds.

Table 3.2 summarises the economic impact of the 10 terrestrial vertebrate species considered in the McLeod report. Where appropriate, information on the economic impact of the species obtained from other sources is also included. These other sources of information are referenced where appropriate.

Table 3.2: Economic Impact of Terrestrial Vertebrate Pests

| Animal | Impact |
|---|---|
| Fox | • Economic impact of foxes is $37.5 million per annum (calculated by McLeod, 2004).<br>• Foxes take up to 30% of lambs in some areas (McLeod, 2004).<br>• For purposes of the economic impact analysis it was assumed an average fox density of 2 foxes per square kilometre, and a total Australian fox population of 7.2 million (McLeod, 2004).<br>• The fox pelt industry was worth $8 million in 1984. Prices fluctuate and have fallen over the last 20 years (McLeod, 2004).<br>• Sheep production losses are $17.5 million per annum (McLeod, 2004).<br>• Foxes are not yet established in Tasmania. However it is estimated the economic losses of livestock from fox attacks could equate to as much as $34.5 million per annum for the Tasmanian sheep industry alone (SoE Tasmania, 2003).<br>• Estimated domestic stock comprises 80% of all food eaten by the 10 to 30 million foxes on mainland Australia (SoE Tasmania, 2003). |
| Feral cats | • Economic impact of feral cats is $2.0 million per annum (calculated by McLeod, 2004).<br>• Cats do not impact on agriculture but management cost is estimated at $1 million per annum and research cost at $1 million per annum (McLeod, 2004). |
| Rabbit | • Economic impact of rabbits is $113.1 million per annum. This is made up of $35.4 million sheep production loss, $34.39 cattle production loss, $18.3 million cropping industry loss, $20 million control cost and $5 million research cost (McLeod, 2004).<br>• Competition by rabbits results in the carrying of less livestock, lower wool production per animal, reduced lambing percentages, lessened wool quality and higher stock mortality during periods of feed scarcity (McLeod, 2004).<br>• Cost of rabbits to sheep-pastoral industries is lower than previously estimated due to the decline in Australian sheep |

| | |
|---|---|
| | numbers in response to declining real prices for wool (McLeod, 2004).<br>• Rabbit skin and meat industries are estimated at $10.1 million per year in 1996 (McLeod, 2004).<br>• Australian impact of rabbits estimated at $600 million before Rabbit Calicivirus (RCV) (Queensland Government, 2003).<br>• Before RCV was released average densities of rabbits annually consumed 10 tonnes of dry pasture per sq km (Bomford and Hart, 2002).<br>• Rabbits also cause extensive losses to forestry and tree plantations, preventing regeneration and damaging tree plantings. This increases the cost of tree planting programs because of the need to erect tree guards. Damage from browsing rabbits can approximate one year's loss of growth, equivalent to $800/ha at clear felling and rabbit control costs in private forests can run as high as $80/ha during the period when trees are vulnerable to rabbit damage (Bomford and Hart, 2002).<br>• The RCV induced decline in rabbit numbers has been estimated to result in a benefit of at least $165 million a year to wool and sheep producers in Australia. It is probable that annual losses to sheep and wool production due to rabbits post RCV are around $100 million per year. Total agricultural losses due to rabbits may still be at least $200 million a year (Bomford and Hart, 2002). |
| Feral pigs | • Economic impact of feral pigs is $106.5 million per annum. This is made up of $100 million per annum cost to agricultural production, $5 million per annum control cost and $1.5 million per annum research cost (McLeod, 2004).<br>• Feral pigs impact on agriculture through predation of newborn animals, reduced grain and cane yields, competition with livestock for pasture land and damage to infrastructure such as fences (McLeod, 2004).<br>• Predation rates on lambs are as high as 35% (McLeod, 2004).<br>• An estimate of damage to the NSW wheat crop is 3% loss in production (McLeod, 2004).<br>• The loss to Queensland's sugar cane production was estimated at 25,000 tonnes per annum (McLeod, 2004).<br>• Feral pigs can act as vectors for a number of wildlife diseases that affect livestock and humans. Can also act as reservoirs for Foot and Mouth Disease (FMD) and Japanese encephalitis (McLeod, 2004).<br>• Commercial value of game meat is $10 to $20 million annually and is exported to Europe (McLeod, 2004).<br>• Recreational hunting of feral pigs is also a valuable industry (McLeod, 2004).<br>• Economic losses from feral pigs have been estimated at $100 million annually with the feral pig game meat worth over $20 million (Choquenot et al 1996 in Newsome, 2001). |
| Wild Dogs | • The economic impact of wild dogs is estimated at $66.3 million per annum. This is made up of sheep production losses estimated |

| | |
|---|---|
| | at $15.9 million per annum, cattle production losses estimated at $32.4 million per annum, control costs of $6.5 million (baiting etc), fencing cost of $10 million per annum and research cost of $1.5 million per annum (McLeod, 2004).<br>• A Qld State govt report states wild dogs cost Qld approximately $33 million per year made up of livestock losses ($18.3 million), disease spread by wild dogs ($9 million loss of cattle due to hydatidosis and *Neospora caninum*) and control costs ($5.4 million, 30% from State govt). Urban impacts not measured (Agribox News Headlines, 2004).<br>• The prevalence of hydatidosis, a fatal disease in humans, is often linked to sylvatic cycles in wild dogs and wildlife. It also leads to the condemnation of offal from up to 90% of slaughtered cattle from endemic areas in Victoria. In South East Queensland, bovine hydatidosis prevalences of 2.2 to 55.7% have been reported. Prevalences of 0.5 to 7% were found in North East Vic despite an extensive hydatid control program aimed at domestic and farm dogs (Bomford and Hart, 2002).<br>• Governments spend an estimated $4 million or more on wild dog control annually and landholders probably spend at least $2.5 million in direct control; in addition maintenance of the wild dog control fence costs as much as $10 million per year. Research & development (R&D) is $1.5 million per year (Bomford and Hart, 2002). |
| Mouse | • The economic impact of mice is estimated at $35.6 million. This estimate includes $22.79 million annual impact to cropping industries and $0.32 million annual impact to other farming through losses. Control cost estimated at $10 million and research cost at $2.5 million (McLeod, 2004).<br>• House mice impact crops and stored grain, disrupt intensive livestock production and also damage fodder, horticultural crops, buildings, farm equipment, electrical wiring, stored wool and retard the performance of poultry and pigs and spread disease. There are also urban economic impacts to houses and shops and restaurants and accommodation facilities (McLeod, 2004). |
| Feral goats | • The economic impact of feral goats is estimated at $7.7 million per annum. This includes $1.85 m per annum sheep production loss, $2.39 million cattle production loss, $2 million control cost and $1.5 million research cost (McLeod, 2004).<br>• There are about one million goats mustered each year for abattoir slaughter. Gross value to feral goat exporters in 1993 was $29 million (McLeod, 2004).<br>• Farmers captured about $6 million annually from feral goat sales, of which about $2 million is spent on mustering costs (McLeod, 2004).<br>• At a density of two per sq km feral goats annually consume 0.73 tons of dry matter per km (Bomford and Hart, 2002).<br>• Rangelands with 240 mm of annual rainfall can on average support at least 20 goat-sized herbivores per sq km. Therefore |

| | |
|---|---|
| | feral goats would consume about 10% of the food eaten by the suite of large herbivores present (Bomford and Hart, 2002).<br>• In 1997-98 the average cost of harvesting a feral goat was around $2 and the farm gate price was $16 to $38 per goat (Bomford and Hart, 2002).<br>• There are costs of keeping feral goats from mating with quality domestic goats and costs to production foresters caused by goat damage to seedlings (Bomford and Hart, 2002).<br>• Goats can damage fences and contaminate bodies of water and can contribute to outbreaks of exotic diseases of livestock (Bomford and Hart, 2002).<br>• Annual losses to agricultural production are estimated at around $20 million per year. In addition, $2 million is spent annually by governments on feral goat control and $1.5 million is spent annually on R&D (Bomford and Hart, 2002).<br>• Feral goats cost $25 million annually but at current valuations of $25/head supports a $29 million industry employing about 500 people (Parkes et al 1996 in Newsome, 2001).<br>• The costs of feral goats include damage to fences approximating $800 to $1300 per property per year. The income to graziers from feral goats in south west Qld is between $750,000 and $2.3 million each year depending on seasons. The benefits to the local community are even greater due to jobs created at Charleville and Bourke abattoirs (Miller et al 1998 in Newsome, 2001). |
| Cane toads | • The economic impact of cane toads has not been calculated, however the estimated research cost is $0.5 million per annum (McLeod, 2004).<br>• Cane toads take bees around commercial hives but the economic costs are unquantified (Bomford and Hart, 2002).<br>• No other economic impacts reported in literature surveyed. |
| Wild horses | • The economic impact of wild horses has not been calculated, however the estimated research cost is $0.5 million per annum (McLeod, 2004).<br>• The cost of control is not known however there is a range of control methods including immobilisation using drugs delivered by dart rifle; mustering and trapping; ground shooting and shooting from helicopters (McLeod, 2004).<br>• Other economic impacts of wild horses on industry not quantified however horses on rangelands destroy fences, foul watering points and consume fodder (Bomford and Hart, 2002).<br>• There is a significant horsemeat export industry, some of which is from wild harvested feral horses. |
| Camels | • The estimated economic impact of camels is $0.2 million per annum. In pastoral areas in times of food scarcity camels can compete with sheep and cattle for herbage; however, they generally have different dietary preferences. Impact estimated at $0.05 million per annum for sheep and $0.16 million per annum for cattle (McLeod, 2004).<br>• Camels can damage fences and watering points (Bomford and |

| | |
|---|---|
| | Hart, 2002).<br>• The Central Australian Camel Industry Association has been slaughtering around 300 camels per year since 1995 with an average total wholesale value of $250,000 (McLeod, 2004). There is also a live export camel industry which was valued at approximately $1.25 million in 2001/02 (IBC, 2005) |

In addition to the above ten species, some information on the economic impact of other terrestrial vertebrate pests is available. This information is largely qualitative. Table 3.3 provides a summary of the economic impact of these other species.

Table 3.3: Economic Impact of Other Terrestrial Vertebrate Species

| Animal | Impact |
|---|---|
| Feral Deer | • Main impact is competition for pasture; risk of exotic disease (SoE NSW, 2003). |
| Introduced Rats | • Black rats cause losses as high as 30% in macadamia orchards in some years, equivalent to around 100 tonnes or $350,000 worth of nuts on some individual farms. Total national damage is of the order of $3 million per year (average loss per farm of 5%) (Bomford and Hart, 2002).<br>• Also damage citrus, avocado and banana crops (Bomford and Hart, 2002). |
| Donkey | • Donkeys compete with livestock for water and pasture in northern Australia (Bomford and Hart, 2002).<br>• Newsome (2001) reports Cook (1998) as having looked at the impact of feral donkeys in the Kimberley and gives a "best-bet" figure of 8,000 cattle displaced with an average damage cost of $40/head of cattle. |
| European starlings | • European starlings cause high levels of damage to fruit crops, particularly grapes and stone fruit and they attack winter-sown cereals at germination (Bomford and Hart, 2002).<br>• Average bird damage losses to grape crops have been estimated at around 10% and starlings would be a significant contributor to this total damage. Can also cause secondary spoilage through yeasts, bacteria etc. (Bomford and Hart, 2002).<br>• Starlings can also take feed from cattle feedlots, piggeries and poultry farms and also spoil feed they don't take (Bomford and Hart, 2002).<br>• Could also assist in spread of diseases such as salmonella and tuberculosis (Bomford and Hart, 2002).<br>• Nest in roof and ceiling cavities causing fire hazards and parasite infestations, and deface buildings with their droppings (Bomford and Hart, 2002).<br>• Likely to cost agriculture at least $10 million per year in losses (Bomford and Hart, 2002).<br>• $3 million or more per year is spent on bird control and half of this is directed at introduced birds such as starlings (Bomford and Hart, 2002). |
| House | • Damage fruit, vegetable, grain and oilseed crops. Also deface |

| | |
|---|---|
| sparrows | buildings and block gutters and downpipes. Take and spoil food in feedlots (Bomford and Hart, 2002). |
| Indian mynah | • Minor pests of some fruit (Bomford and Hart, 2002).<br>• Disperser of seeds of weeds such as lantana (Bomford and Hart, 2002). |
| European blackbird | • Damage grapes and stone fruit; also spread weeds and damage garden plants (Bomford and Hart, 2002). |

While the economic impacts of vertebrate pests on primary industries are reasonably well documented, some discrepancies between estimates of economic impact by species from different sources are apparent. This is usually due to different methods, different time periods, and the inclusion of a different range of impact types or industries in the analysis. For example, McLeod's estimate of the economic impact of rabbits is $113.1 million per annum while the Queensland government quotes an annual Australia-wide impact of $600 million. The difference between these two estimates is that the higher estimate refers to the impact prior to the release of the rabbit calicivirus disease (RCD).

Also, the positive economic impact of pest species is often not included in such studies. For example goats, pigs, horses, camels etc can provide significant incomes to landholders and hunters. These are often noted but not included in studies. One case in which the positive impact of an introduced species may be higher than its negative impact is the European honeybee.

***Aquatic Vertebrates***

Many introduced fish have been introduced into Australia for recreation, commercial, biological control and aquarium purposes. A number of these species have escaped into rivers, creeks and dams and become pests. The best known of these is carp.

The McLeod study (2004) estimated the economic impact of carp. It found that the economic impact was at least $4.0 million per annum. This was made up of an estimated $2 million per annum spent by the public sector on carp control and another $2 million per annum on research. Other economic impacts were not quantified, however it was noted that carp impacts on commercial and recreational fishing, water quality, tourism, decline in native fish species, and some agricultural impact through damage to irrigation channels. It was noted that the total gross value of the carp industry in 2002 was $1.7 million (use in fertilisers and fish meal etc) (McLeod, 2004).

In an analysis of the effects of carp in the Gippsland Lakes in Victoria, a rough estimate of the costs to the community over 5 years was $175 million. This included losses to native commercial fishery and losses to recreational fishing, tourism and commerce (Bomford and Hart, 2004). There is a large discrepancy between this estimate and that of McLeod. This could be partly explained by the fact that McLeod only included public sector control costs and research, and did not calculate the impact on tourism, and commercial and recreational fishing.

In addition to carp, there are a number of other introduced freshwater aquatic vertebrate species that have become invasive and that are having a negative impact on native fish and other aquatic species. Examples of these introduced species include:

- Eastern Gambusia/Mosquitofish (*Gambusia holbrooki*)
- Redfin Perch (*Perca fluviatilis*)
- Rainbow Trout (*Oncorhynchus mykiss*)
- Brown Trout (*Salmo Trutta*)
- Tench (*Tinca tinca*)
- Swordtail (*Xiphophorus hellerii*)
- Mozambique tilapia (*Oreochromis mossambicus*)
- Weather loach (*Misgurnus anguillicaudatus*)

These species potentially have a negative economic impact in terms of reducing stocks of natural fish available for recreational fishing, and through general irrigation and agricultural impacts due to a reduction in water quality. However, there were no estimates identified of the economic impacts of introduced freshwater aquatic vertebrates other than for carp.

It should be noted that introduced fish species that are pests such as rainbow trout and brown trout, are also valued by recreational fisherman and provide some economic value through this industry.

### 3.1.3 Diseases and Invertebrate Pests

***Pests and Diseases of Plants***
The review did not identify any readily available single estimate of the aggregate economic impact of plant diseases and invertebrate plant pests in Australia. However, there are estimates of the economic impact of specific diseases/invertebrates or the cost of diseases/invertebrates in general to particular plant industries. Some of these are described below to illustrate the range and magnitude of these impacts.

*Cereals and oilseeds*
Brennan and Murray (1998) quantified the impact of major diseases to the Australian wheat industry and found that *Septoria nodorum* blotch had the highest annual economic cost of $58 million, followed by crown rot ($56 million), take all ($52 million), yellow spot ($49 million), cereal cyst nematode ($37 million) and root lesion nematode ($36 million). The total cost of diseases for wheat was estimated at about $300 m per year.

The average production of sunflowers in Australia over the past five years (to June 2003) was 104,000 tonnes (ABARE, 2003). There are yield losses from either *Alternaria* or rust of about 20%, or 26,000 tonnes per annum valued at about $9 m per annum (Agtrans Research, 2004).

*Phytophthora*
The cost of phytophthora for Australia have been estimated at $223 m per year (as of 1993) in direct losses in production in horticultural, ornamental and pasture crop industries, with losses in forestry industries and native vegetation additional to this figure (Cahill, 1993). However, some phytophthora species included may be Australian natives.

*Sugar*

McLeod (1996) estimated the costs of key diseases to the sugar industry in 1996 and found that soil borne pathogens had the largest impact. Of a total annual cost of $98 million, soil pathogens accounted for $83.2 million in reduced cane production losses.

*Fusarium*

*Cotton*

One estimate of $57 million per annum for the cost of fusarium wilt for the 1999/2000 season for cotton was made recently for the Darling Downs region. This was from a survey of growers, consultants and Queensland Cotton on the losses. The loss estimate included the loss of total crop in some fields, loss in yield, loss of associated production costs and reduction in property value due to the cost of the disease (Joe Kochman, pers comm, 2003). As this estimate was only for the Darling Downs, the $57 m per annum is likely to significantly underestimate the cost of fusarium wilt to the Australian cotton industry (Joe Kochman, pers comm, 2003).

*Horticulture*

*Avocados*

The Australian avocado industry is currently worth $60 million per annum, with a production volume of 30,000 tonnes. The annual cost of anthracnose control through fungicides is estimated to be $430 per hectare. With 150 trees per hectare and 100 kg production per tree, the cost per kg of avocadoes produced is estimated to be $0.03 per kg per annum (Cooke, 1995). The value of this control cost is therefore just under $1 m per annum.

*Apples and Pears*

Agtrans Research (1999) estimated the total cost of pest control (diseases and invertebrates) in the apple and pear industry as $12 million. This estimate excluded yield losses.

*Summary*

A total of the reported estimates of the economic impacts above is $700 million. As these estimates cover only a portion of Australian plant industries, the total impact will be far greater.

The major direct economic impacts of plant diseases and pests are both control costs and production losses despite those control costs. Indirect costs may include impacts such as trade restrictions and secondary impacts from control measures. For example, Ardley (1999) estimates the total public cost to Australia of pesticides is around $6.5 b per year. The Australian Bureau of Agricultural and Resource Economics (ABARE) (2003) reports the total annual value of sales of fungicides and insecticides at $515 million.

Chakraborty et al (2002) estimated the loss of gross value of all crops alone to be of the order of $2,350 m per year if plant pests and diseases are assumed to reduce crop values by 15%. To this would need to be added control costs for crops and all losses for other industries such as pasture production and forestry. With chemical material costs above estimated at over $0.5 billion, it would not be surprising therefore to find that the total economic impact of plant diseases and pests to Australian primary

industries was greater than $2 b per annum allowing for some reduction in the 15% loss assumed by Chakraborty et al.

***Pests and Diseases of Animals***

Significant invasive diseases and invertebrate pests of animals in Australia include bovine respiratory disease, swine fever, bird and poultry diseases (eg. Newcastle disease), tick-borne diseases, buffalo fly, lice etc. From the literature surveyed, no aggregate economic impacts were found of animal diseases and invertebrate pests. Generally impacts include lost production through deaths, reduced productivity, reduced product quality, and control costs including containment, surveillance and treatment.

For example, Bovine Respiratory Disease (BRD) currently costs the Australian feedlot industry around $60 million a year. It is also known as 'shipping fever' and is a complex form of pneumonia in which infections with viruses can predispose animal to bacterial infection (CSIRO Livestock Industries, 2004).

The economic costs of cattle tick include (Canyon et al, 2002):

- Direct effects of the tick on cattle: loss of condition, anemia and deaths, susceptibility to drought, damage to hides, slow growth rate
- Effects of dipping on cattle: loss of body weight, loss of milk production, deaths during drought, loss of young calves, toxicity
- Control costs including increased stock handling and costs of acaricides
- Market effects including restrictions on cattle movement
- Costs of tick-borne diseases including deaths, slow growth, vaccine costs, treatment costs, handling costs

Estimates have been made of the costs of cattle tick at different points in time. Estimates were that the cost was $87 million for 1959, $87 million for 1973 and $134 million for 1995. The earlier estimates did not take into account government costs associated with control strategies and the costs of dipping yards. On average acaricides accounted for 11% of the costs, additional labor for 35%, and production losses and animal deaths for 32%. A quarantine barrier was established on the border between New South Wales (NSW) and Queensland to halt the southward spread of cattle tick and is maintained at an annual cost of around $3.3 million. The savings and benefits of this quarantine barrier are estimated at $41.5 million a year (Canyon et al, 2002).

For only two pests of livestock (BRD and tick-borne diseases) the annual economic impact to the livestock industries is estimated to be $194 million. The total impact of pathogens and vertebrate pests of animals is likely to be far greater. For example, in 2002/03 the gross value of Australian livestock slaughterings and products was estimated to be $16.8 billion (ABARE, 2003). If it is assumed that animal diseases and invertebrate pests of animals result in 5% yield losses through mortality, reduced growth rates or reduced quality then the impact of these pathogens to livestock industries could be conservatively estimated at $840 million. In addition to production losses, sales of animal health products in 2001 were $382.5 million (ABARE, 2003). The overall economic impact of animal pests and disease could be at least $1.5 billion per annum.

***Other Invertebrate Pests***

It is difficult to value the economic impact of invertebrate pests as they often also play a positive role in terms of ecosystem processes such as pollination, aeration of the soil and as a source of food for other organisms (SoE NSW, 2003). For example, the control of the European Honeybee is difficult as it was introduced for commercial purposes (SoE Australia, 2001) and it has been determined that while there are some negative impacts of this species, it has a net positive impact due to the size of the Australian honey industry (Canyon et al, 2002). The European wasp however has no positive economic impact, and it has been estimated that the cost to Victoria is $2 million annually including effects on horticultural industries, health care, national parks, tourism and direct costs of nest destruction (Canyon et al, 2002).

Examples of recent incursions to Australia of invertebrates include the Red Imported Fire Ant (RIFA) (*Solenopsis invicta*) and the Crazy Ant (*Anoplopepis gracilipes*). Possible impacts of fire ants include damage or removal of seeds; damage to roots, tubers, stems and fruit, protection of injurious plant-sucking hemiptera; interference with biological control; present a hazard to hand labourers; damage irrigation systems; build mounds that interfere with mechanical harvesters; and harass livestock, especially young animals. They can also damage electrical equipment and cause structural damage due to undermining (Canyon et al, 2002). The actual economic impact of fire ants to Australia since their incursion has not been calculated, however a Benefit-Cost Analysis was undertaken by ABARE in 2001 into the proposed eradication program. It found that the cost to the community if the fire ant was not controlled would be $8.9 billion over a 30 year period. Major costs were from loss of property values, cost of household repairs, cost of household treatment and the cost to agriculture (Queensland Government, 2003). The study showed that the eradication program would provide a benefit-cost ratio of 25:1 based on a $124m program over five years (Queensland Government, 2003).

Crazy ants are a major environmental and secondary agricultural pest in the tropics and subtropics. The first major infestation of crazy ants was detected in Queensland in Cairns in April 2001. Three agencies, Queensland DNR&M, Queensland Environmental Protection Agency (EPA) and the Queensland Department of Primary Industries and Fisheries (QDPI&F) provided a cash budget of approximately $120,000 together with considerable in-kind coming from the contributing agencies in order to eradicate the ant (Queensland Government, 2003).

## 3.2 Environmental Impacts

The environmental effects of invasive species has generally been aggravated / accelerated by other land use and management practices such as clearing, grazing and agricultural chemical use (to combat invasives) and the combination of these has made evaluation of the impacts difficult. However as some of these land management practices have dramatically increased over the last 20 or so years we could be seeing some major changes and threats to the environment. There is a real lack of data on the interaction between land use / land management and invasive species and the impact on the environment.

### 3.2.1 Weeds

The exclusion of the environmental loss from weed impact economic studies is most significant. These impacts include most importantly biodiversity of both plants and animals, aesthetics, and the loss of valuable ecosystem functions including water quality. An important question is whether it is possible and meaningfully worthwhile to value environmental losses in monetary terms.

In cases where environmental impacts have a direct effect on industry (eg. a loss to the tourism industry), the impact is easier to value than when the environmental impact is purely of a public good nature. Also, while the current costs of control in environmental areas provide a minimal estimate of impact, the true impacts of biodiversity loss are much more difficult to value.

Estimates of willingness to pay by the community for environmental values are being increasingly used to value non-market impacts. Contingent valuation, and more recently, choice modelling have been used to identify community willingness to pay. For example, contingent valuation has been recently used for management and control programs for environmental weeds in Queensland, specifically lantana and Singapore Daisy within areas of high conservation values such as national parks. Other willingness to pay studies have been used in a range of valuations for non-market goods including Lockwood and Carberry (1998), Evans (2000), Bennett et al (2004) and van Beuren and Bennett (2004). This last reference covers value estimates for endangered native species, countryside aesthetics and country communities. Adamowicz (2004) reviews trends in development and use of environmental valuation.

While it may be possible to value the avoidance of species extinction or some other measure of biodiversity, the difficulty may still be faced of attributing negative impacts on biodiversity to the weed or invasive species as quite often the invasive species may be only one factor in the observed impact. Hence it is important that causal relationships are determined with evidence and objectivity.

For example, after reviewing a number of journal papers that provide quantitative data on the impacts of invasive plant species on Australian ecosystems Grice et al, (2004) found that many papers did not evaluate the effect on fauna and they made a case for more quantitative information and generalisations about how invasive plants affect natural ecosystems.

For environmental weeds, both qualitative outcomes and a few quantitative analyses have been identified that report environmental impacts. Some are reported in Table 3.4

Table 3.4 Impacts Reported that are Predominantly Environmental

| Source | Impact |
|---|---|
| Vidler, 2004 | Synthesis of currently available information on the relationships between weeds and threatened species. Identifies weed threats to 41 threatened species. Provides case studies of where weeds have been involved in threatening processes: eg. mountain pygmy-possum, the Bathurst copper butterfly, the |

| | |
|---|---|
| | Richmond birdwing butterfly and the Proserpine rock wallaby. |
| SoE South Australia, 2003 | Weeds have a major impact on biodiversity but impacts are difficult to measure in economic terms. |
| SA Animal and Pest Control Commission, 2003 | Feral olives are an example of a productive plant that can become an environmental weed that is impacting seriously in South Australia. |
| Weed Management Society of SA, 2003 | Feral olives are providing a conflict of interest between economic growth and environmental protection. |
| SoE Tasmania, 2003 | The cost of weeds to the urban environment, amenity and health values, tourism and the conservation of biodiversity and natural ecosystems has been estimated by some biologists at $66 m per year. (Ministerial Working Group, 1996). |
| Groves and Willis (1999) as quoted in SoE Australia, 2001 | Environmental weeds have been implicated in extinction of four Australian plant species. |
| CRC Weeds, 2004b | At least 29 plant species, 4 birds, 1 reptile, 3 mammals and 4 butterflies are threatened by weeds. |
| CRC Weeds, 2003a | Weeds are implicated in the extinction of at least four native plant species, and are known to be adding to pressure for a further 57 now under threat eg. the rare Richmond birdwing butterfly is a species threatened by invasive plants. |
| SoE Australia, 2001 | Of the 20 WONS species, six are a major threat to the environment, five a threat to agriculture and nine have both impacts. |
| SoE Australia, 2001 | Of the 20 WONS species, eleven impact on water quality and supplies. |
| SoE Tasmania, 2003 | Weed impacts include fire hazards; diminished aesthetic values and visibility; quantity and quality of water resources. |
| SoE Western Australia, 1998 | Over 1032 plants in WA are weeds of which 558 are present in bushland and at least 50 are very serious threats to biodiversity. |
| Groves, 2002 | Weeds have affected the population of two rare or threatened native plant species. Bridal creeper matches the phenology of the sandhill greenhood orchid. Also the phenology of a low shrub *Pimelea spicata* on the Cumberland Plain west of Sydney matches that of bridal creeper. The bridal creeper smothers its shoots and competes for water and nutrients. |
| Groves, 2002 | Data on economic impacts of alien species on natural ecosystems are few and indirect. Some exist as cost effectiveness studies on control programs for alien species eg. the financial costs of controlling broom; cost benefit analysis for bitou bush gave a benefit to cost ratio of about 20 to 1. |

### 3.2.2 Vertebrate Pests

***Terrestrial Vertebrates***

While environmental impacts of terrestrial vertebrate species have been reasonably well documented, few attempts have been made to translate these environmental impacts to an economic value. However, McLeod (2004) quantified the environmental impact for foxes and cats. Table 3.5 provides a summary of some of the environmental impacts of terrestrial vertebrate invasive species that have been reported.

Table 3.5: Environmental Impact of Terrestrial Vertebrate Species

| Animal | Environmental impact |
|---|---|
| Fox | • The environmental impact cost was estimated as $190 million per annum. This was based on the assumptions that the total Australian fox population is 7.2 million, the live bird off-take by foxes per year is 190 million per year, and the value of the birds to the community is $1 each (McLeod, 2004).<br>• The fox is Australia's number one predator threatening the long term survival of a range of native wildlife (PAC CRC, 2004a ).<br>• There are 11 fauna species known to be threatened by foxes and 23 fauna species perceived to be threatened by foxes (McLeod 2004).<br>• Animals endangered due to the fox include the Rock-wallaby, numbat, brush-tailed bettong and bilby (PAC CRC, 2004a).<br>• The fox is the single most devastating threat to Tasmania's native mammals and birds (SoE Tasmania, 2003). |
| Feral cats | • The environmental impact cost of feral cats was estimated as $144 million per annum. This is based on the assumption that there are 18 million feral cats in Australia, that each kills 8 native birds per year, and that each bird is valued by the Australian community to the value of $1 (McLeod, 2004).<br>• Feral cats are vectors for diseases that affect native animals (eg marsupials) such as large tape worm, toxoplasmosis and sarcosporidiosis (McLeod, 2004).<br>• Cat predation is threatening the very restricted population of the endangered Eastern Barred Bandicoot near Hamilton, Victoria (Olsen, 1998).<br>• On the Australian mainland 38 species of mammals, 47 species of birds, 48 species of reptiles and 3 species of amphibians have been recorded in the diet of feral cats (Bomford and Hart, 2002).<br>• 19 species of endangered or vulnerable mammals, 6 species of endangered birds and 2 species of endangered or vulnerable reptiles are at high risk from feral cat predation on mainland Australia (Bomford and Hart, 2002). |
| Rabbit | • Indirect environmental impacts of rabbits include disease transmission to native animals and degradation of rangelands (McLeod, 2004).<br>• Environmental impacts include competing with native wildlife and destroying native plants, contributing to soil erosion and displacing |

| | |
|---|---|
| | native species through competition. Rabbits contribute to the populations of feral foxes by provision of a food source (McLeod, 2004).<br>• Rabbits can kill shrubs by ring-barking them (PAC CRC, 2004b).<br>• Rabbits threaten the survival of at least 17 native plants (Bomford and Hart, 2002).<br>• The destruction of sandhill canegrass by rabbits reduces populations of birds (Bomford and Hart, 2002).<br>• Even at low densities rabbits cause environmental damage by restricting regeneration (SA Animal and Plant Control Commission, 2003). |
| Feral pigs | • Damage habitat and compete for feed with natives, feed on seeds of native fruits and plants (McLeod, 2004).<br>• Contribute to soil erosion and land degradation (SoE NSW, 2003).<br>• Listed as a Threatening Process of endangered species and ecological communities (PAC CRC, 2004c).<br>• Feral pigs may help spread root-rot fungus which is responsible for dieback disease in native vegetation (Bomford and Hart, 2002). |
| Wild Dogs | • Wild dogs have a negative biodiversity impact through predation on native mammals; however dingoes have been integrated into established predator-prey relationships and may play a constructive ecological role in regulating populations (McLeod, 2004).<br>• Also are responsible for killing introduced species of predators eg foxes, feral cats and feral pigs, goats, rabbits and rodents. This is a possible benefit (McLeod, 2004). |
| Mouse | • Environmental impact is usually due to poisoning of mice and subsequent impact of poison on predatory native birds and reptiles (McLeod, 2004). |
| Feral goats | • Contribute to land degradation (McLeod, 2004).<br>• Impacts on native vegetation; competition for pasture; risk of exotic disease (SoE NSW, 2003).<br>• Provide competition for native fauna for food, water and shelter and contribute to changes in ecosystems (Bomford and Hart, 2002). |
| Cane toads | • The true impact of cane toads is not clear. Some studies have shown that while numbers of native frogs snakes and goannas do decline after invasion, their populations tend to recover after a few years (Olsen 1998).<br>• May compete with native species for habitat (Bomford and Hart, 2002).<br>• Diet is mostly arthropods and effects on invertebrates have not been quantified. They may compete for food with native species (Bomford and Hart, 2002).<br>• May also eat native frogs and their eggs although this appears uncommon (Bomford and Hart, 2002).<br>• Can poison native predators that attempt to eat them including their eggs or tadpoles (Bomford and Hart, 2002).<br>• There is anecdotal evidence that four quoll species and 16 goanna species that eat cane toads are threatened but there is little clear evidence that cane toads are the principal cause of decline in these |

| | |
|---|---|
| | species (Bomford and Hart, 2002). |
| Wild horses | • Environmental impact through general land degradation, trampling, spreading weeds and competition (McLeod, 2004).<br>• Grazing and fouling of water may also impact on native species (Bomford and Hart, 2002). |
| Camels | • Impacts of camels include damage to areas of cultural and ecological significance by grazing, trampling and pugging, altering vegetation structure, soil erosion. Trampling and rolling can cause damage to Aboriginal sites (SoE SA, 2003).<br>• Also reduce shelter for small desert mammals (Bomford and Hart, 2002). |
| Feral deer | • Threat to native vegetation; risk of exotic disease (SoE NSW, 2003). |
| Black Rats | • Prey upon native birds, reptiles and invertebrates (SoE Tas, 2003).<br>• Potential to introduce diseases that affect native animals (SoE Tas, 2003).<br>• Devastating impacts on smaller sea bird populations as they prey on the eggs, chicks and adults (SoE Tas, 2003).<br>• Potential impact on owls from the use of anticoagulant rodenticides in orchards has raised concern (Bomford and Hart, 2002).<br>• On offshore islands rats predate on native species including eight native birds, two reptiles and one insect. Thought to have contributed to extinction of two bird species. Competition may also adversely affect two mammal species (Bomford and Hart, 2002). |
| Ferret | • Very successful predators – prey on ground nesting and burrowing birds and native mammals (SoE Tas, 2003).<br>• Have potential to introduce disease (SoE Tas, 2003). |
| Donkey | • Can denude ground cover and contribute to erosion; habitat destruction may be a problem (Bomford and Hart, 2002). |
| Water buffalo | • Prior to their widespread control, feral buffalo extensively damaged freshwater swamps by forming trails between tidal rivers and floodplains that allowed sea water to enter and kill large areas of paperbark forest. They also selectively ate native grass and changed the structure of monsoon forests (Bomford and Hart, 2002).<br>• Water buffalo trampled nesting grounds of the rare pig-nosed turtle (Bomford and Hart, 2002). |
| Indian mynah | • Compete with native birds for shelter (SoE Qld, 2003)<br>• Compete with crimson rosella and the sugar glider for nest hollows (Bomford and Hart, 2002). |
| European Starling | • Occupy and degrade nesting hollows needed for breeding of native birds (SoE Tas, 2003).<br>• Compete with native birds for food and nesting hollows (Bomford and Hart, 2002). |
| European blackbird | • Are aggressive toward native birds and may compete for food and displace them (Bomford and Hart, 2002). |
| Mallard | • Interbreed with the native Pacific black duck and the hybrid offspring are fertile so are therefore a conservation risk for this native duck (Bomford and Hart, 2002). |

| | |
|---|---|
| Nutmeg manikin | • Compete with native birds for food and may be replacing native finches in some areas (Bomford and Hart, 2002). |

***Aquatic Vertebrates***

Carp impact on commercial and recreational fishing, water quality, tourism, and on native fish species. Carp decrease water quality by contributing to increased nutrients, algae and suspended-sediment concentrations (Bomford and Hart, 2002). This has a detrimental impact on aquatic plants and invertebrates. There may be some competition between carp and native fish for food and habitat, and carp may make aquatic habitats less suitable for other fish (Bomford and Hart, 2002). Carp may have contributed to the decline of several threatened species including dwarf galaxies, trout, cod, Yarra pygmy perch and variegated pygmy perch (Bomford and Hart, 2002).

The value of the environmental impact of carp has been estimated by McLeod (2004) at $11.8 million per year. This value comes from two sources. Firstly, the annual cost of water turbidity and the cost of sedimentation were estimated to be $28 million (Possingham et al cited in McLeod, 2004). McLeod assumed that if 10% of this cost was contributed by carp, the impact of carp-related sedimentation and heightened water turbidity would be about $2.8 million per year. Secondly, the impact of carp on recreational fisheries of $9 million was estimated using a 'willingness to pay' of $50 per household over 0.6 million recreational fishers, with carp contributing to a 30% decline in prized fish species (McLeod, 2004).

Other introduced fish also have a negative impact on the environment. These include:

- Eastern Gambusia/Mosquitofish (*Gambusia holbrooki*) attack native fish, aggressively compete for food and prey on native fish and frog larvae. Reductions in native fish populations have been observed in most places where mosquitofish have been introduced (Bomford and Hart, 2002)
- Redfin Perch (*Perca fluviatilis*) are predators of native fish species (SoE SA, 2003)
- Rainbow Trout (*Oncorhynchus mykiss*) feed on a wide range of aquatic insects, crustaceans, mollusks, terrestrial insects and native fishes (SoE SA, 2003)
- Brown Trout (*Salmo trutta*) are aggressive predators of native fish, tadpoles and invertebrates (SoE SA, 2003)
- Tilapia prey on native fish species and compete with them for food and habitat. They also remove plants. Tilapia pose a major threat to native fish species in Australia but are still in the early stages of establishing (Bomford and Hart, 2002). However the Tilapia is now considered well established in Queensland and there is a risk of it spreading south (Alex McNee, pers comm., 2005)
- Swordtail (*Xiphophorus hellerii*) is an omnivorous feeder and there has been found to be a negative trend in the relationship between the abundance of *X.helleri* and seven native species (Kailola, 2000).

In an unpublished report to DEH, Kailola (2000) found that impacts on native fishes have been recorded by mosquitofish, swordtails, redfin perch, brown trout, rainbow trout, European carp, goldfish and possibly oriental weatherloach. There are an additional fourteen established non-native fish species in Australia, and the effects of these species are unknown. Kailola (2000) found that the impact of non-native

freshwater fishes on ecosystem functioning is still largely unknown, however there is circumstantial evidence of some impacts, as identified in the list above.

***Valuing the Environmental Impact of Vertebrate Pests***

The total value of environmental impacts of foxes, cats and carp has been estimated as $345.8 million per annum (McLeod, 2004). The combined impact of all vertebrate pests would obviously be far greater.

McLeod (2004) notes that Environment Australia (2003) estimated that biodiversity within Australian terrestrial ecosystems provides a contribution in the vicinity of $US245 billion per annum to the Australian economy. Therefore the threat of vertebrate pests to that biodiversity will impact on this value.

As mentioned earlier, placing an economic value on environmental impacts through the use of willingness to pay studies is increasing. McLeod (2004) identified a number of studies that have sought to value biodiversity in this way. Relevant references include Jakabsson and Dragun (2001), Rolfe et al (2000) and Pimental et al (2000).

Another difficulty with identifying environmental impacts of invasive species is attributing the decline of a species or an ecosystem or decline in some other natural resource to a single pest species. Compounding this further is the interactions between invasive species. For example, rabbits are a primary food source for cats and foxes. If one or the other is controlled, a balance problem within the food chain of both natives and invasives can develop.

### 3.2.3 Diseases and Invertebrate Pests

Many of the diseases and invertebrate pests of Australia's native flora and fauna are themselves native to Australia. However, there are some introduced pathogens and pests that attack native vegetation and fauna and hence can have a significant impact on the environment. Many of the introduced pests and diseases of crops also impact on and compete with native species. However while these impacts have been recorded the documentation of these impacts is poor. A thorough review of the literature would be needed to provide a better picture on the impact and the seriousness of these invasives. Some examples of other introduced species that are impacting on the environment are earthworms, bees, bumblebees, snails and ants. There are some good examples overseas of the serious impacts of invertebrate pests on the environment and this highlights the need to better understand the likely impacts of these species in Australia. This area has not received a high priority however some examples are provided in the remainder of this subsection.

*Phytophthora cinnamomi* is the only pathogenic taxon specifically cited in the 1996 strategy for the Conservation of Australia's Biodiversity. It is listed as a key threatening process under the Environmental Protection and Biodiversity Conservation (EPBC) Act.

Some of the stated environmental impacts of phytophthora are listed in Table 3.6.

Table 3.6 Impacts Reported in Relation to Phytophthora

| Source | Impact |
|---|---|
| SoE Australia, 2001 | Much of Western Australian native vegetation is at risk from phytophthora. At least 10% of the remaining jarrah forest in WA is infected with dieback disease. It is also a problem in the east, northern Australia and Tasmania. |
| SoE Western Australia, 1998 | Phytophthora spread in WA is a biological disaster of global significance; a number of plant species face extinction unless recent phosphite treatment and germplasm storage are effectively implemented and sustained along with hygiene and quarantine measures. Within the 400 plus mm rainfall zone of the SW land division approximately 15 percent of the forested region is infested, with some national parks having 60-70 percent of their area infested. |
| SoE Tasmania, 2003 | Phytophthora is the most significant threat to conservation of native species in Tasmania. At least 39 of Tasmania's threatened species are susceptible to phytophthora. Some threatened species are known to be declining as a result of root rot. Permanent monitoring plots have recorded appreciable mortality in selected rare or threatened species during 1996-1999. This included the death of an average 26 to 48% of three different threatened species within the plots. |
| SoE Tasmania, 2003 | The impact of phytophthora root rot over time in Tasmanian natïve vegetation types is yet to be scientifically documented. To gain an accurate picture requires monitoring over long time periods (20-30 years); it is also difficult to keep maps up to date as this relies on laboratory identification. |
| SoE Tasmania, 2003 | Phytophthora is key disease causing die back in native vegetation. A Threat Abatement Team has been established in Tasmania. |
| SoE South Australia, 2003 | The key plant pathogen in South Australia is phytophthora which is continuing to spread throughout high rainfall areas. The disease was first recognised in the Mt Lofty ranges in SA in the 1970s. |
| SoE New South Wales, 2003 | The threat to biodiversity from phytophthora led to its recent listing as a key threatening process under the Threatened Species Conservation Act 1995. |

Myrtle wilt is the most significant disease of myrtle which is the dominant tree species in many Tasmanian cold temperate rainforest communities (SoE Tasmania, 2003). The most recent average annual rate of mortality for myrtle trees measured between 1992 and 2000 of approx 0.25 trees per year has now reduced from the previous average rate measured between 1989 and 1992 of approx 1 tree per year (SoE, Tasmania, 2003 and Stephen Waight, pers comm., 2004).

The serious disease termed Mundulla Yellows is continuing to spread in South Australia. However, there is uncertainty as to whether the cause is a biological or environmental factor (or both).

Also, there can be significant indirect environmental impacts of the control methods used for combating plant diseases through chemical use.

The Australian State of the Environment Report (2001) states that there are about 500 introduced invertebrate species thought to be changing the environment. Examples of these include:

- European honeybees turned feral compete with smaller, typically solitary Australian native bees for shelter (SoE Qld, 2003).
- European wasps prey upon many native invertebrates with as yet unstudied consequences (SoE Tas, 2003).
- Crazy Ants that were introduced to Christmas Island in the 1930s only recently became a major threat to biodiversity. They are now seen as a direct threat to as many as 20 animal species including sea birds, land birds, mammals, reptiles and three species of crabs. Millions of Christmas Islands's famous Red Crabs have been killed, and these crabs are critical to the dynamics of the unique rainforest communities on the island. Crazy ants can lead to canopy dieback. They are a threat because of their extremely broad diet, the formation of super-colonies and they forage in three dimensions (SoE Australia, 2001).
- Fire Ants Impact on biodiversity as a result of direct attack, reduction in food supply for mammals that are insectivorous, as well as a change in foraging and sleeping behaviours of mammals (Queensland Government, 2003). Fire Ants prey on the hatchlings of a wide range of ground-nesting bird species and all egg laying reptiles are also susceptible to attack while in the nesting cavity as are amphibians due to where they burrow and lay eggs (Queensland Government, 2003).

There are likely to be few environmental impacts of exotic animal diseases affecting agricultural industries, except for where those diseases can also affect native animals. Not much is known about the potential for such diseases however one example is that aquarium species of fish are thought to have introduced diseases that affect native frog populations (SoE Qld, 2003). There is strong evidence that a chytrid fungus is associated with the death of some frogs, but it is not known if it is the direct cause of mortality or an indication of other environmental stress (SoE Australia, 2001). In addition the transmission of toxoplasmosis to native mammals by exotic species such as cats is considered a threat to the populations of some species, for example the Eastern Barred Bandicoot (Maxwell et al, 1996).

Other reported diseases of native animals including kangaroos, Tasmanian devils and bats are not thought to be introduced diseases.

## 3.3 Social Impacts

The social impacts of invasives are considered together rather than split into species groups as there are a number of commonalities and the amount of material reviewed is not extensive.

Invasives have human health and safety impacts as well as impacts on recreational activity, social infrastructure, job opportunities, quality of life and cultural heritage. It is apparent that there has been little analysis of the extent and seriousness of the social impacts of invasive species in general. Some of the impacts that have been reported are listed in Table 3.7.

Table 3.7 Impacts Reported that are Predominantly Social

| **Source** | **Impact** |
|---|---|
| *Weeds* | |
| SoE Australia, 2001 | Of the 20 WONS species, 10 have an impact on human health and safety |
| SoE South Australia, 2003 | Reduced recreational and aboriginal use |
| SoE Tasmania, 2003 | Impacts include fire hazards; human and animal health via consequences of control methods (eg. chemical use); reduced recreational values; diminished aesthetic values and visibility; and structural damage to facilities. |
| CRC Weeds, 2004c | Many weeds are injurious to animals and humans |
| CRC Weeds, 2004a | The aquatic weed, cabomba, has infested Lake MacDonald (SE Queensland) for the past 10 years and now covers about 75% of the lake. The lake is used for water supply and for recreation. |
| CRC Weeds, 2004a | Many weeds have impact on human health including asthma and respiratory problems, stings, scratches and toxins, and entangling water weeds. Of the 23 weeds that pose respiratory or toxic risk only parthenium weed has received federal funding. No economic damage estimates of health impacts have been made for these weeds. |
| Groves, 2002 | Some introduced plants have poisonous impacts on animals as well as on humans (eg. ryegrass and phalaris staggers). There are some social benefits in that many weeds are a source of herbal compounds (eg. horehound, St Johns Wort, variegated thistle and pennyroyal). |
| WWF Australia, 2003a | Health impacts of parthenium weed include respiratory problems, dermatitis and asthma in people. Cabomba affects water quality. |
| Sinden et al, 2004 | Weeds cause allergies and sickness; poison and injure domestic pets; affect quality of drinking water, increase the risk of bushfire; and affect recreational use of natural areas. |
| | |
| **Species** | **Impact and Source** |
| *Vertebrate animals* | |
| Fox | The fox is a potential carrier of infectious diseases posing a risk to human and animal health (PAC |

| | |
|---|---|
| | CRC, 2004a). |
| Feral cats | Feral cats are a potential carrier of infectious diseases posing a risk to human and animal health eg. tape worm and toxoplasmosis (McLeod, 2004). |
| Dogs | Impact through dog attacks and impact on human health and ability to use recreational facilities where dogs are a threat. |
| Feral pigs | Impact through attacks on humans and ability to use recreational facilities where feral pigs are a threat. Disease carrier and pollutes drinking water. |
| Mouse | Social impact is as a disease carrier, household goods destruction and general unpleasantness. |
| Camel | Can cause damage to sites of aboriginal cultural significance through rolling and trampling (Bomford and Hart, 2002). |
| Cane toads | Death of household pets through poisoning. |
| Indian mynah and other exotic birds | Can nest in building cavities and bring bird mites into buildings (Bomford and Hart, 2002). |
| Invasive fish species | Water quality decline and reduction in native fish species leads to social impacts through reduced recreational fishing opportunities, limits on other water recreational activities, and tourism. |
| *Invertebrate pests and diseases* | |
| Fire Ants | The biggest concerns for human impacts of fire ants are the safety of small children and the loss of the ability to use their yards as places of relaxation, unable to garden or have pets (Queensland Government, 2003). Health risks range from sting-site pustules and secondary infections to severe late-phase responses and even life-threatening anaphylaxis (Canyon et al, 2002). Internationally, it has been estimated that fire ants sting more than 50% of the people living in endemic areas each year (Canyon et al, 2002). |
| Honeybees and wasps | It is estimated that there were at least 43 fatalities in Australia attributed to both honeybees and wasps during the 19-year period to December 1997. This was second only to snakebite fatalities (Canyon et al, 2002). |
| Animal diseases | Animal diseases impact on humans when the disease is adaptable to humans. Examples of established diseases include swine fever (from pigs) and toxoplasmosis (from cats). Examples of less established diseases include Equine Morbillivirus Disease which has been responsible for the death of at least two humans in Queensland in the 1990s. |
| *Invasive species in general* | |
| SA Animal and Plant Control Commission, Submission to | The public safety and welfare risks can be significant but difficult to quantify. Introduced toxic plants can |

| | |
|---|---|
| Senate Inquiry, 2003 | cause allergies and poisoning of people and uncontrolled keeping of exotic venomous reptiles and carnivorous animals can threaten public safety. |

A major social impact of diseases and invertebrate pests are likely to become apparent through regional impacts on primary industries or on the environment where regions are economically dependent on a narrow range of plant species. This social impact may be through complete destruction or contraction of an industry, either temporally or permanently. For example, social impacts may be felt through a disease widely attacking a major plantation forestry area or a tourist dependent World Heritage Listed Area in North Queensland or Tasmania succumbing significantly to phytophthora.

As discussed earlier under economic impacts, there are indirect impacts of chemical control methods for pests and disease that include human health issues.

## 3.4 Summary

**Economic Impacts**

1. The economic impacts reported in this review for the individual groups of invasive species are summarised in Table 3.8
2. Invasive species are costing Australia many billions of dollars annually mainly in costs of control and value of production foregone. Estimates of the different costs are incomplete and those that have been made need refinement and further justification if they are to be used for policy purposes in order to prioritise and stimulate further action on invasive species. The estimates made largely exclude the values of environmental or social costs of invasive species.

Table 3.8 Summary of Economic Impact Estimates for Invasive Species

| Invasive Species Group | Economic Impact Reported | Costs and Benefits not included |
|---|---|---|
| Weeds | $4.1 billion | Cost and benefits to the environment such as biodiversity; social impacts such as human health costs. Benefits from weeds not included eg. benefits to the bee industry |
| Pest animals - vertebrates | $0.72 billion including some environmental costs | Social impacts such as human health costs and most environmental impacts not included. Benefits from pests not included eg. sale of goats. |
| Plant diseases and invertebrate pests of plants | At least $0.70 billion per annum. Total is likely to be a multiple of this figure, perhaps at least $2 billion per annum. | $0.70 billion based on studies for wheat, sugar, two horticultural crops, sunflowers, and cotton. Excluded from the $0.7 billion are diseases and invertebrate pests of pastures, nearly all of horticulture, all other grains, cotton, forestry etc. Also excluded are environmental and social impacts. |

| | | |
|---|---|---|
| | | $2 billion estimate made from loss estimate of 7.5% of the $17 m average gross value of plant industries, plus fungicides and insecticides sales of about $0.5 m, plus application costs. |
| Animal diseases and invertebrate pests of animals | At least $1.2 billion per annum. | Based on production loss of 5% of a $16 billion per annum animal industry plus value of animal health product sales.<br><br>Excluded are diseases and invertebrate pest impacts on the environment. |
| Other invertebrate pests | No estimates identified or made. | |

Note: The figures in this table for the economic impact of plant and animal diseases and pests are broad estimates only and are not based on published material.

3. The quantitative monetary estimates of economic impact made here are only partial in that they do not include:
    - most values for environmental or social impacts;
    - values of indirect costs of control measures; or
    - impacts and potential impacts on industries other than primary industry (eg. the tourist industry).
4. Improved estimates are required in order to provide an authoritative total estimate of what invasives are costing Australia. Trends in these costs over time would also be useful to monitor.
5. The positive economic impacts of invasives are usually neglected in quantitative analyses; even in the vertebrate pest study they were less than comprehensively analysed.
6. It is likely that the aggregate monetary costs of these invasives have increased over the past ten years (period 1994 to 2004) through both spatial spread, increased emphasis on managing the problem and increasing costs of control. However estimates of change at this aggregate level are difficult to make and few estimates of aggregate costs by species group have been identified.
7. These increases in monetary impacts would be in spite of reductions in costs being made through successful measures including mechanical, chemical and biological control. As well, large potential future costs have been avoided due to improvements in border protection, surveillance and detection, eradication, and containment and control measures.

**Environmental Impacts**

1. Assessing and quantifying impacts is difficult as knowledge of the precise contribution of an invasive species to the impact on native species or the wider ecosystem is not always particularly well understood or described. Indirect negative impacts and positive impacts also need inclusion.
2. Valuing environmental impacts and potential benefits from action is desirable due to the potential use of values in ranking and priority setting. An alternative approach is to make assessments qualitatively (eg. impact on biodiversity).
3. There is no commonly accepted method of valuing environmental impacts for purposes of priority setting among alternative options and integration with industry impact reduction. Willingness to pay methods have improved recently

and could be used more and more by planners and policy makers. Multi-criteria analysis is another option.

4. Tourism deserves more attention with regard to current or potential impact of invasives eg. south west WA, Kakadu. Relationships between tourism experiences and native fauna and flora /invasives are not well understood.

**Social Impacts**

1. There are few studies that try to identify in specific or quantitative terms the health, safety and quality of life/choice impacts of invasive species. A review could be undertaken of the seriousness of these impacts, particularly those involving human health and safety.
2. The most important social impacts are likely to flow from serious economic impacts on regions highly dependent on a narrow range of plant or animal species that are attacked by a new disease or invertebrate pest.

# 4. Invasive Species Distribution and Abundance

## 4.1 Weeds

**Status**
In the last 200 years there have been about 28,000 foreign plants introduced to Australia including accidental introductions, for ornamental plants, and for agricultural and pastoral use (CRC Weeds, 2004b). This number is more than the total number of native species.

Approximately 2,700 of these foreign plants have naturalised (established in the wild) and at least 300 are now having a serious impact on Australia's natural environment (CRC Weeds, 2004b). In general terms, about 10% of naturalised plant species later become weeds that cause significant economic and environmental damage (Williamson and Fitter (1996) as cited in AWC, 2001).

It is estimated that there are 1,060 environmental weeds in Australia (Swarbrick and Skarrat (1994), as cited in SoE Australia, 2001).

**Rate of naturalisation**
Naturalisations of non-native species have averaged around 11 per annum since European settlement (Csurthes and Edwards (1998) as cited in AWC, 2001).There is an increasing rate of weed naturalisation or establishment (Groves (1997) and Panetta, (1993) as cited in AWC, 2001).

Groves (1998) reports that different data sets suggest that over the past 200 years there have been about 10 to 30 species per year of newly naturalised plants. This was taken as a base to assess the past 25 years and whether the rates have changed (1971-1996). A total of 290 taxa were recorded as being naturalised in Australia over the past 25 years. Groves reports that there is a trend of an increasing number of naturalisations over the last 25 years when considered yearly or in five year periods. However, most taxa naturalised in the last 25 years are still localised in their distribution rather than having become widespread.

Over 10 new species of exotic plants have become established each year and this number is increasing (Groves, 1998). Based on the data in Groves, the number of recent incursions is double the annual rate of the last 100 years of 4-6 species (WWF Australia, 2003a).

As not all naturalisations lead to the plant becoming a weed, it has been suggested that about 10% of naturalised plants eventually become weeds. As the number of naturalisations has increased over the pass 25 years, it is likely that the number of new weeds will also increase in the future.

**Methods of introduction and spread**
It has been estimated that 94% of introduced plants to Australia were intentionally imported as garden or ornamental plants. Of these 5% have become agricultural, noxious and natural ecosystem weeds, and comprise 70% of all weed species (Glanznig et al, 2004a).

In the period 1971 and 1995, 65% of new weeds had been deliberately introduced as plants for ornamental purposes, seed contaminants 2%, agriculture7%, other 6% and unknown 20% (Groves (1997) as cited in CRC Weeds, 2003a). In 1999 over 700 species of plants available from garden centres and nurseries were identified as an invasive risk (CRC Weeds, 2004b). Hence the legal importation of new plant species with weed potential and the continued sale of weedy or potentially weedy species via nurseries are major catalysts whereby new weeds develop.

Some weeds have their origins in pasture species. Of the 460 pasture and legume species trialed in northern Australia from 1947 to 1985, 60 became weeds and now 13 are serious crop weeds (Lonsdale,1994).

On a state basis, 57% of naturalised plant species in South Australia were intentionally introduced and 24% were unintentionally introduced (no information available for the other 19%). As many as 65-70% of naturalised taxa in Victoria were deliberately introduced (Groves, 1998).

Panetta (1993) as cited in AWC, (2001) reported that at least one third of Australia's noxious weeds are escaped garden ornamentals. Csurhes and Edwards (1998, as cited in AWC, 2001) reported that approximately 73% of Australia potential environmental weeds are used as garden ornamentals.

Overall, it would appear that the majority of current weeds were introduced to Australia in the very early days after settlement. Those that have been introduced more recently have been legitimately introduced for other purposes (ornamentals, agriculture) and then have become weeds at some later stage.

Direct seed ordering from overseas via the internet is now a major new threat (CRC Weeds, 2003a).

Human activity including machinery and vehicle movements, soil, water and animal movements, and wind are the major instrument of spread. Of the 200 serious environmental weeds identified in South East Queensland, one quarter are spread by birds (CRC Weeds, 2004b).

**National Distribution**

The most significant data on national distribution of weeds are the maps of current and potential distribution of weeds for the WONS project (Thorp and Lynch, 2000). These 70 maps referred to the 1998 year, but have not been updated. Since then, there has been some spreading and contracting of different species.

Apart from the WONS maps there are no reliable comprehensive data on the national distribution of weeds across Australia by area or density. Changes in the distribution of weeds over time are therefore not available on a national scale.

The 20 WONS each occupy between 0.2 to 12.4% of Australia (Sinden at al, 2004).

As an indication of areas, some Australia-wide areas of specific weeds are shown in Table 4.1

Table 4.1 Australian Area of Specific Weeds

| Weed | Area | Source |
|---|---|---|
| Blackberry | 8.8 m ha and still growing | CRC Weeds, 2004b |
| Lantana | 4 m ha | CRC Weeds, 2003a |
| Mesquite | 800,000 ha of core infestations | CRC Weeds, 2003a |

**Within State Distribution**

The principal information sets for the distribution of weeds are held in data bases by the various herbaria within the states. States differ in their survey and reporting methods regarding the distribution of weeds and changes over time. The State of Queensland appears to have a relatively advanced survey, mapping and reporting program for weeds. The Queensland DNR&M undertakes an annual assessment of priority pest species using a grid framework and utilising expert knowledge in the regions. This provides a comprehensive assessment of more than 40 pest species in Queensland, most of which are weed species but also including some animals pests. Key output information is whether a pest is present or absent, its frequency (widespread or localised) and density (occasional, common or abundant). Secondary products are trend and movement information. Some classes of pest are assessed every year and some every 5 years (DNR&M, 2004).

Differences between States in their surveying and reporting systems can make the accurate national aggregation of data difficult, if this were required.

It is likely that less is known about the distribution of environmental weeds compared with agricultural weeds.

Table 4.2 provides some information on the status and distribution of weeds by State.

Table 4.2 Status and Distribution Regarding Areas and Abundance

| **Status / Distribution** |
|---|
| NSW<br>▪ About 1,500 plant species have been introduced to NSW since European Settlement and the rate appears to be accelerating. Of the 1,500 introductions, approx 3-4% represent a major threat to ecological and economic systems. Most have entered NSW legally for ornamental and domestic horticulture. The rate of introduction appears to be increasing (SoE NSW, 2003).<br>▪ The number and extent of weeds is not being reduced in most cases (SoE NSW, 2003a). |
| QLD<br>▪ Queensland has 15 of the 20 weeds listed as WONS (SoE Qld, 2003).<br>▪ New naturalisations are reported each year with 18 new plant naturalisations over the 1999-2001 period; plant naturalisations have occurred at a rate of 87 species per decade since 1900 (SoE Qld, 2003).<br>▪ Perennial grasses such as buffel and mission grass are spreading rapidly. Woody species including mesquite, mimosa, parkinsonia, prickly acacia, rubber vine and camphor laurel are increasing. Lantana and parthenium also continue to spread (SoE Qld, 2003). |

| |
|---|
| ▪ Hymenachne, para grass, and pond apple continue to spread and invade many of the remaining wetlands (SoE Qld, 2003).<br>▪ There were 6.6 m ha of prickly acacia in Queensland in 2002 (potentially 50 m ha nationally), 700,000 ha of rubber vine are now found across 20% of Queensland, and 100,000 ha of para grass exist in Queensland (CRC Weeds, 2003a). |
| SA<br>▪ The extent of terrestrial pest plants is increasing (SoE SA, 2003).<br>▪ SA has 11 of the 20 WONS, the most threatening in terms of the environment are bridal creeper, blackberry, boneseed, gorse and mesquite (SoE SA, 2003). |
| TAS<br>▪ One or more of the six WONS that are in Tasmania are found across an extensive range of vegetation communities and land uses (SoE Tas, 2003).<br>▪ Tasmania has 744 naturalised vascular plant species of which 162 are considered weeds. In 2001 there were at least 64 introduced plant species considered to be environmental weeds (SoE Tas, 2003).<br>▪ As of 1878 there were over 50 non-native species present but not yet naturalised. Of these 50, over 90% are now naturalised in Tasmania. (SoE Tas, 2003).<br>▪ As there is often a considerable delay (many decades) between introduced species becoming established and then becoming a pest, it is highly likely that in Tasmania the percentage of pest species will increase in future even without further introductions (SoE Tas, 2003).<br>▪ Serrated Tussock is now spreading in Tasmania (Groves, 2002).<br>▪ There are 30,000 ha of gorse in Tasmania (CRC Weeds, 2003a). |
| WA<br>▪ A new outbreak of prickly acacia was discovered in East Kimberley in 2003; this new infestation is the furthest west the plant has reached to date. WA Agriculture is now working with the local aboriginal community to develop a plan to remove the infestation along a 20 km stretch of the Durack River, threatening adjacent bushland (CRC Weeds, 2004d).<br>▪ Mardie Station in North West WA has 150,000 ha, the largest single core infestation of mesquite in Australia (CRC Weeds, 2003a). |
| VIC<br>▪ There was 78,000 ha of boneseed in Victoria in 1981; potentially there may be 6.5 m ha in Victoria alone (CRC Weeds, 2003a).<br>▪ In Victoria there are 14 declared prohibited weeds; of these the infestation sites of nine species found in the state have increased over a five year period from 1997 (Victorian Catchment Management Council, 2002).<br>▪ 1,066 weed infestations have been identified; there has been a 100% increase in the number of infestations since 1997; this is in part due to increased and more comprehensive surveillance techniques (Victorian Catchment Management Council, 2002). |
| NT:<br>▪ There are 80,000 ha of *Mimosa pigra* in the top end of NT (CRC Weeds, 2003a). |

**Improving Information on Distribution**

A Work Plan was developed by BRS for an audit of weeds under the National Land and Water Resources Audit framework (Thackway et al, 2004). The AWC is considering priorities within the work plan to undertake in 2005. The draft workplan identifies activities to assess distribution, extent of impacts and potential threats of weeds on Australia's productivity and environment.

There is a case that can be made for a national audit of weeds that reports on the distribution of major weeds. This may be achieved either by States using comparable methods or by existing data from the States being assembled and integrated every five or ten years. If such an audit is undertaken it should be effected in conjunction with the long-term project being undertaken to computerise and integrate Australia's records across its different herbaria (The Virtual Herbarium project).

Reasons for monitoring distribution and abundance include providing program investment accountability, frontier monitoring and demonstrating change and progress to governments. State level monitoring appears more important than at a national level as this is from where most resources are provided at present.

Irrespective of the need, there appears to be no nationally comparable approach to monitoring weed incursions currently that might be used in assessing the impact of the achievements that interventions are having on mitigating the impacts of weeds on agriculture or the environment. There is no consistent method applied for surveying and mapping WONS or any other group of identified weeds across multiple jurisdictions (Mark Parsons, pers comm, 2004). BRS is currently developing a field manual to provide consistency in this regard. Monitoring the distribution of all established weeds regularly on a national scale would be most informative but its practicality and cost-effectiveness would need questioning given that there are perhaps 300 weeds in Australia.

The State of Environment reports (both Australian and State) provide some useful information for reporting the distribution of invasive species. One of the core environmental indicators used in the past was: "Distribution and abundance (where possible) of non-indigenous terrestrial marine and freshwater species (plants, vertebrates, invertebrates and pathogens) identified as pests". However, reporting on these core indicators was not always feasible (Jenny Boshier, pers comm., 2004). The relevant indicators proposed for the 2006 SOE Report for Australia are:

- the change in extent of selected nationally significant terrestrial introduced invasive species, and
- a summary of measures being implemented to respond to threats to biodiversity from invasive species.

The States and Territories have been asked to respond to these two indicators (Jenny Boshier, pers.comm, 2004).

Positive developments since the last SoE report in Tasmania have included the significant improvement in systems for monitoring and reporting weed incursions and threats (SoE Tas, 2003). However, no trends and changes in the number of declared weeds were available in 2003 because of the comparatively short period for which the

legislation has been in operation. Over time, tracking the number of listed weed species will provide a measure of change in the magnitude of the declared weed problem in Tasmania (SoE Tas, 2003).

## 4.2 Vertebrate Pests

About 80 introduced animal species have established significant wild populations on mainland Australia. Some of these have become significant pests of agriculture and the environment (Hart, 2002). No widespread pest animal species has ever been eradicated from mainland Australia (Hart, 2002).

Table 4.3 shows the pest status of forty introduced vertebrate species with established widespread populations on mainland Australia. Other introduced species have only established localised populations on the mainland (34 species) or on offshore islands (10 species).

Table 4.3: Introduced (non-native) Vertebrate Species with Established Widespread Populations on Mainland Australia

| | Pest Status | | |
|---|---|---|---|
| | Serious | Moderate | Minor or non-pest |
| Mammals | European rabbit<br>Feral goat<br>Feral pig<br>European red fox<br>Dingo/feral dog<br>Feral cat<br>House mouse | Feral horse<br>Feral donkey<br>Feral buffalo<br>Feral camel<br>Feral cattle<br>Black rat | European brown hare<br>Brown rat |
| Birds | European starling<br>Indian mynah | Mallard<br>Rock dove (feral pigeon)<br>Spotted turtledove<br>Blackbird<br>House sparrow<br>European goldfinch<br>Senegal turtledove | Cattle egret<br>Skylark<br>Tree sparrow<br>Nutmeg manikin<br>Greenfinch |
| Amphibian | Cane toad | | |
| Freshwater Fish | European carp<br>Mosquitofish<br>Mozambique tilapia | Weather loach<br>Tench<br>Redfin perch<br>Rainbow trout<br>Brown trout | Goldfish<br>Guppy |

Source: Bomford and Hart, 2002

The distribution of terrestrial vertebrate species is reasonably well documented and distribution maps do exist at national and state levels for most of the 'big' vertebrate pests such as cats, foxes and goats. Some of these distribution maps provide information on changes in distribution over the long term (eg 50 year intervals), however changes in distribution in the short term are not well documented. Information on numbers and density of many vertebrate pest species was not often

detected in the material reviewed, nor was information on changes in numbers over time. Overall, management has not led to a major retraction of distribution and abundance of any widely established vertebrate species, with the exception of rabbits. However, the distribution and abundance of some vertebrate species has increased in the past decade (eg. cane toads, camels, deer, feral pigs, foxes) (Quentin Hart, pers. comm., 2004).

There have been some highly successful programs to reduce vertebrate pest density at the regional scale including Western Shield in Western Australian and Bounceback in South Australia. There have also been some examples of eradications on off-shore islands.

Examples of the status of and changes in abundance and distribution include:

- The highest number of pest species occur in south-east Australia where the human population is highest (SoE Australia, 2001).
- New South Wales still contains essentially the same group of introduced vertebrate pests that was present in the early 1900s except for the addition of the cane toad. Eighty percent of the State's reserves have at least one species of animal pest (SoE NSW, 2003).
- In Queensland, 19 mammals, 13 birds, 15 fishes, 3 reptiles and 1 amphibian have become naturalised. Unknown numbers of invertebrates, fungi and bacteria have also become established (SoE Qld, 2003).
- Six exotic mammals are declared in Queensland under the Land Protection (Pest and Stock Route Management) Act 2002 (Queensland Government, 2003).
- In Queensland there are 17 noxious fish, 162 non-indigenous fish, and 9 genera of mammals and exotic birds declared under several other pieces of legislation (Queensland Government, 2003).
- Sixty introduced vertebrate species have been recorded in Tasmania; of which 32 are recognised as pests (15 mammals, 12 birds, 5 freshwater fish) (SoE Tas, 2003).
- Since 1997 three new species recognised as pests have been recorded in Tasmania: foxes, ferrets (*Mustela furo*) and eastern Gambusia (*Gambusia holbrooki*) (SoE Tas, 2003).
- There is some information available at a regional level. For example the Northern Territory Government has undertaken aerial surveys of Arnhem Land to estimate the numbers of feral buffalo and horses in the region (Saalfeld, 1997 and 1998).

Table 4.4 provides more specific examples of abundance and distribution of specific terrestrial vertebrate pest species.

Table 4.4: Abundance and Distribution of Vertebrate Pests

| Animal | Abundance and Distribution |
|---|---|
| Fox | • Introduced in 1871 and had spread throughout mainland Australia by 1912 (McLeod, 2004).<br>• Is distributed in almost all regions of the southern states of Australia but less so in northern Australia (McLeod, 2004).<br>• Only introduced to Tasmania in 2001 and an eradication program is underway in that state (McLeod, 2004).<br>• Distribution of foxes may be affected by the presence of rabbits, |

| | |
|---|---|
| | dingoes, dingo fences and climate (McLeod, 2004).<br>• A female fox can produce more than 20 cubs over an average lifetime of 5 years (PAC CRC, 2004a). |
| Feral cats | • Feral cats were established in the wild by the 1850s (McLeod, 2004).<br>• They are widely distributed across mainland Australia, Tasmania and on many offshore islands (McLeod, 2004).<br>• There are approximately 3 million pet cats and 18 million feral cats in Australia (McLeod, 2004).<br>• Cats have been eradicated from some offshore islands using conventional control methods (McLeod, 2004).<br>• Feral cat populations in the Flinders Ranges have declined to some extent over the last few years following the introduction of RCV as rabbits are a key source of prey for feral cats (SoE SA, 2003).<br>• In peri-urban areas individuals from the domestic cat population are continually recruited to the feral population (SoE SA, 2003). |
| Rabbit | • Arrived with First Fleet. First feral populations in Tasmania from 1860 (released Victoria, Christmas Day 1859). Had spread Australia wide by 1900 (McLeod, 2004).<br>• Found almost everywhere south of the tropics. More fragmented distribution north of the Tropic of Capricorn (McLeod, 2004).<br>• Numbers reduced by 95%-100% in most of south of Australia after myxomatosis introduced in 1950 (McLeod, 2004).<br>• It is estimated that the spread of RCV has reduced rabbit numbers by an average of 75%. In arid areas the reduction has been as high as 95%, while in higher rainfall areas the impact has been lower and more variable (SoE SA. 2003).<br>• Despite the rapid spread of RCV rabbits are still Australia's most widespread and destructive pest animal (PAC CRC, 2004b)<br>• The Darling Downs-Moreton Rabbit Board (DDMRB) region in Qld is a containment zone, defended by both a fence and staff that maintains a zero rabbit tolerance policy. The DDMRB region is the only sizeable suitable habitat on mainland Australia where rabbits have never established (Queensland Government, 2003).<br>• Bulloo Downs Station in western Qld, where an estimated 25% of the states rabbits occur, appears to be the source of most rabbit reinfestation in this part of Australia (Queensland Government 2003). |
| Feral pigs | • Domestic stocks introduced with European settlement (McLeod, 2004).<br>• Problems in areas surrounding settled regions apparent in 19th Century (McLeod, 2004).<br>• Established in around 38% of the continent and estimates of their numbers in Australia range from 3.5 to 23.5 million (McLeod, 2004).<br>• Problem concentrated mostly in Qld, NSW, ACT and NT with more isolated population pockets across the other states and on Flinders and Kangaroo Island (McLeod, 2004). |

| | |
|---|---|
| | • Abundance is highest in wetlands, floodplains and watercourses where population densities may reach 10 to 20 per square kilometre or higher (McLeod, 2004).<br>• Distribution and abundance can vary markedly from year to year according to environmental conditions (McLeod, 2004).<br>• Feral pigs generally sedentary nature has slowed their spread outside their existing territories (McLeod, 2004).<br>• Spread of feral pigs to new areas is often by humans who seed feral pigs into new areas for hunting (eg. in national parks near Sydney) (Tony Peacock, pers comm., 2004).<br>• Populations are ephemeral and recede during periods of drought when little permanent water is available (SoE SA, 2003).<br>• Densities of feral pig populations are unknown (SoE SA, 2003).<br>• Choquenot et al (1996) list a range of studies reporting densities from 0.1 to >20 feral pigs per sq.km. |
| Wild Dogs | • Dingoes were brought to Australia approximately 4,000 years ago (McLeod, 2004).<br>• Prior to European settlement, dingoes occurred throughout the mainland however population management programs have shaped the geographic distribution and concentration of dingoes and wild dogs. This includes the erection of barrier fences to exclude them from agricultural regions in south-eastern Australia and areas surrounding Perth (McLeod, 2004).<br>• Estimates of population density in NSW range from 0.1 to 0.3 wild dogs per square kilometre (McLeod, 2004). |
| Mouse | • Most likely arrived on first fleet and now occur throughout Australian continent and live in a broad variety of habitats (McLeod, 2004).<br>• Usually low populations increase exponentially to plague proportions in the grain growing regions of Australia when conditions are favourable (McLeod, 2004).<br>• Factors influencing plagues include rainfall and farming practices such as stubble retention, continuous cropping and widespread usage of minimum tillage (McLeod, 2004).<br>• Prosper in grain growing regions due to lack of competition from native species (McLeod, 2004).<br>• Plagues occur on average every 3 years and are increasing in frequency (PAC CRC, 2004d).<br>• During a typical plague in southern Australia mouse densities of 1,000 per ha are common (PAC CRC, 2004d). |
| Feral goats | • Australia has an estimated 2.6 million feral goats (McLeod, 2004).<br>• They occupy about 1.21 million square kilometres, mostly in the semi-arid and arid lands used for pastoral farming of sheep (McLeod, 2004).<br>• Numbers fluctuate under the influence of extended dry periods and the effectiveness of management programs (McLeod, 2004).<br>• Main concentrations are in NSW, southern Qld, central eastern SA and WA. For example they are widespread in the Western |

| | |
|---|---|
| | Division of NSW and also found in many moderately sized populations throughout most of eastern NSW (SoE NSW, 2003). They are found throughout southern and central areas of SA, particularly the Gawler and Flinders Ranges (SoE SA, 2003).<br>• Numbers are declining in the Flinders, Gammon and Olary Ranges and parts of the Eyre Peninsula due to large-scale integrated programs being carried out in high priority conservation areas (SoE SA, 2003).<br>• Goats are declining due to recent drought conditions in combination with the current high price for goats on the export market (SA Animal and Plant Control Commission, 2003). |
| Cane toads | • Released in North Qld in 1935 (McLeod, 2004).<br>• The species is observed in the eastern and northern parts of Queensland and through to Kakadu National Park in the NT (McLeod, 2004).<br>• Within NSW they occur on the coast as far south as the Clarence River near Grafton, but isolated breeding colonies have been confirmed at Angourie near Yamba and around Lake Innes near Port Macquarie There is also an isolated community in Port Macquarie (SoE NSW, 2003).<br>• The toad is predicted to increase its geographic range throughout coastal and near-coastal regions of northern Australia to encompass an area of approximately 2 million square kilometres (McLeod, 2004). |
| Wild horses | • Introduced with European settlement (McLeod, 2004).<br>• First recognised as pests in the 1860s (McLeod, 2004).<br>• In 1992 feral horse numbers were estimated at 300,000 (McLeod, 2004).<br>• Most occur in the extensive cattle production areas of the NT and Qld, as well as in some areas of WA and SA. Smaller scattered populations occur in alpine and sub-alpine regions of NSW and Vic (McLeod, 2004).<br>• Density varies greatly and is dependent on factors such as management programs, climate and incidence of bush fires (McLeod, 2004). |
| Camels | • First introduced in 1840s to aid exploration of inland Australia (McLeod, 2004).<br>• It is uncertain when the first feral population was established but they increased substantially after the 1920s when trucks became a widespread form of transport (McLeod, 2004).<br>• Camels occupy most of Australia's desert country including the Great Sandy, Gibson, Great Victoria and Simpson deserts as well as much of the semi-desert lands (McLeod, 2004).<br>• There were approximately 200,000 camels in Australia in 1993 and in 2003 the Australian feral camel population was estimated to be in the order or 300,000 (McLeod, 2004).<br>• Estimated the camel now ranges across 2.8 million square kilometers or 37% of the Australian mainland (McLeod, 2004).<br>• The population has increased rapidly following a number of good |

| | |
|---|---|
| | seasons in central Australia and is estimated to have doubled over the past eight years (SoE SA, 2003).<br>• Another source estimated there are 600,000 to 750,000 feral camels in Australia (SoE SA, 2003).<br>• Aerial survey of camels in 2002 in Simpson Desert Region of South Australia estimated the camel population at over 10,000 animals (SoE SA, 2003).<br>• Feral camels are highly mobile, have extensive home ranges and are distributed at low densities over large uninhabited areas (SoE SA, 2003).<br>• Populations may increase by as much as 15% in good seasons, such as 1999-2000 in central Australia (SoE Australia, 2001). |
| Feral deer | • Feral deer are distributed in isolated pockets, mostly in forested areas close to urban populations. They can be found in eastern NSW, South East Queensland, South East SA, Mid North SA, Murray lands, Mount Lofty Ranges and Kangaroo Island (SoE Qld, SoE NSW and SoE SA, 2003).<br>• The number and distribution of deer has decreased in South East Queensland (SoE Qld, 2003).<br>• Populations have increased in SA in recent years and there is some potential for deer to increase in range as a result of increased deer farm enterprises and agro-forestry plantations, as well as reduced hunting efforts (SoE SA, 2003). |
| Feral donkeys | • In 1978 there were an estimated 1 million donkeys in the Kimberley, but between 1980-1988 donkey numbers in the southern east Kimberley fell by almost 90% from shooting (Long and Wheeler, 1990 cited in Newsome, 2001). |
| Water buffalo | • In 1985-86 feral buffalo numbers in northern Australia were estimated at 350,000. Since then their numbers have been greatly reduced by a large-scale control program to eliminate brucellosis and bovine tuberculosis from Australia (Bomford and Hart, 2002). |
| European starlings | • Starlings are one of the most common species in lowland suburban and cleared agricultural areas of south east of Australia. They also occur in open woodlands, irrigated pasture, feedlots, mulga, mallee, reed-beds around wetlands, coastal plains, and occasionally alpine areas. They avoid dense woodlands, forests, rainforest and arid regions. The only area of suitable habitat on mainland Australia that they have not colonised is south-west Western Australia (feral.org.au website). |

There is little published information on the distribution of introduced aquatic species. However an unpublished report to DEH in 2000 (Kailola) provides a summary of the known distribution of 22 established non-native freshwater fish species. It found that most 'officially' introduced species are present in south-eastern and south-western Australia, while most aquarium species are present in tropical and sub-tropical Australia. The South Australian State of the Environment Report noted that there is limited comprehensive information on the distribution of the introduced freshwater species having a significant impact and it is difficult to predict past or future trends

(SoE SA, 2003). The distribution of introduced fish is often influenced by the presence of changed water regimes due to river regulation as this has greatly reduced flood frequency, volume and duration, and introduced relatively stable water levels. These conditions favour introduced fish at the expense of native fish species (SoE SA, 2003).

A recently published paper (Lintermans, 2004) presents information on 34 alien freshwater fish species established in Australia, and includes the year of major/initial introduction or first record from the wild, and the reason for introduction. It also notes in which states the species is present.

Table 4.5 presents a summary of the limited information identified on the distribution and abundance of aquatic vertebrate invasive species.

Table 4.5: Abundance and Distribution of Invasive Aquatic Vertebrate Species

| | |
|---|---|
| Carp | • Released on a number of occasions in 1800s and 1900s but not widespread until released in Murray River near Mildura in 1964 (McLeod, 2004).<br>• Spread of carp through Murray Darling Basin coincided with widespread flooding in the early 1970s (McLeod, 2004).<br>• Carp also were introduced to new localities – possibly through use as bait (McLeod, 2004).<br>• Introduced carp are now the most abundant large freshwater fish in the Murray Darling Basin and are the dominant species in many fish communities in south-eastern Australia (McLeod, 2004).<br>• Carp commonly found are from 50g to 5kg in weight and can tolerate a range of water temperatures, salinity levels and polluted water (Bomford and Hart, 2002).<br>• A survey in 2003 found inland rivers had higher carp densities than coastal rivers. They were found in all inland sites surveyed below an altitude of 500 m above sea level (Bomford and Hart, 2002).<br>• Carp are still expanding their range (SoE Qld, 2003).<br>• Carp have broad environmental tolerances, thrive in disturbed habitats, can migrate at any time of year, move up to 230 km and are long living (PAC CRC, 2004e). |
| Redfin Perch (*Perca fluviatilis*) | • Found in the Murray Darling Basin, Gulf streams and the south east of SA (SoE SA, 2003).<br>• Widely stocked in dams and watercourses for recreational fishing (SoE SA, 2003). |
| Rainbow Trout (*Oncorhynchus mykiss*) | • Introduced from New Zealand in the 1890s (SoE SA, 2003).<br>• Can easily establish self-sustaining populations in the Adelaide region (SoE SA, 2003). |
| Brown Trout (*Salmo trutta*) | • Introduced in the 1860's (SoE SA, 2003).<br>• Self-sustaining populations require cool, swiftly flowing waters; generally restricted to the Australian Alps and Tasmania (SoE SA, 2003).<br>• Populations in the Mount Lofty Ranges are maintained through |

| | |
|---|---|
| | the systematic introduction of hatchery reared stock which is illegal under the Fisheries Act 1982 (SoE SA, 2003). |
| Tench (*Tinca tinca*) | • Introduced into the Murray River in 1876 and spread throughout the Murray Darling system (SoE SA, 2003).<br>• A small population is thought to occur in the Onkaparinga River (SoE SA, 2003).<br>• Numbers reduced drastically in the 1970s when carp became abundant (SoE SA, 2003). |
| Eastern Gambusia/ Mosquitofish (*Gambusia holbrooki*) | • Introduced in the 1920s for mosquito control – relatively ineffective for this purpose and now a significant pest in freshwater rivers and streams (SoE SA, 2003). |

Some specific examples related to monitoring of exotic animals in Australia include:

- Implementation of a broad scale density and trend distribution database to complement the Pest Info data collection system that has been adopted by over 90 local governments and other government agencies as well as adopted as a national standard (Queensland Government, 2003). This involves the undertaking of an annual assessment of priority pest species for Queensland, using a regular grid framework of cells, and expert knowledge to derive a qualitative value that is recorded for each species in each cell. This reports both distribution and density and has resulted in a comprehensive map series for more than 40 top priority pest species in Queensland and provide a temporal 'snapshot' for each species. The assessment is reviewed annually.
- The National Exotic Birds Registration Scheme was an initiative of the Australian Government which attempted to identify and record all species of exotic birds keeping in Australia. It required people who kept those species to have a licence and maintain records. In 2002 it was discontinued and responsibility for controlling the importation of exotic bird species was thrust back onto individual states (Queensland Government, 2003).
- The NSW Pest animal survey, in which all regions are surveyed via pest manager interviews (Quentin Hart, pers comm., 2005).
- The NSW Department of Primary Industries provides the opportunity for the public to report bird damage in horticulture and viticulture through a survey. They request information on the species involved, the damage they cause, and the costs and effectiveness of control. The survey is funded by the NFACP and the NSW DPI and is supported by various industry bodies. The aim of the survey is to direct research and development and assist in more effectively allocating research resources to crops and regions most affected by birds (NSW DPI website, 2005).

## 4.3 Diseases and Invertebrate Pests

**Plant diseases and pests affecting agriculture**

The status and distribution of plant diseases and invertebrate pests of plants used in agriculture are better known than weeds as most diseases are controlled in some way in the agricultural sector. Some diseases are endemic across Australia whereas others

are only relevant to specific industries and locations. Some plant diseases are spreading slowly, such as Fusarium Wilt in cotton (NSW and QLD) and in bananas (Foc Tropical Race 4 in the Northern Territory). Industry groups and scientific and State authorities usually have good knowledge concerning distribution of existing plant diseases and invertebrate pests of plants. For example, the distribution of known viruses of plants of Australia is well documented.

Most important to trade access and negotiations is whether a plant pathogen is actually present in Australia or not. In this regard, accurate record keeping and access is critical as is the availability of accurate diagnostic tests.

The Nairn Review found that there was no detectable increase in incursions of plant pathogens over the last 25 years (Roberts, 1999). The Nairn Review (1996) also reported the number of insect pests of plants that established between 1971 and 1995. No real trend was apparent (Table 4.6).

Table 4.6 Establishment of new insect pests of plants

| Years | Number of establishments |
|---|---|
| 1971 to 1975 | 3 |
| 1976 to 1980 | 9 |
| 1981 to 1985 | 11 |
| 1986 to 1990 | 13 (9) |
| 1991 to 1995 | 9 (7) |

Source: Roberts (1999) based on Nairn Review (1996)
Note: Number in brackets excludes NAQS

**Plant diseases affecting the environment**
The current distribution of one species of phytophthora (*Phytophthora cinnamomi*) covers many hundreds of thousands of hectares in Western Australia, Victoria and Tasmania South Australia, New South Wales and Queensland. Mapping its distribution has been attempted but has proven difficult as it is not easily detectable in the field as illustrated by the experience in Tasmania:
"The real distribution of phytophthora root rot will never be known as mapping is restricted to localised priority areas with the maps soon becoming out of date and unreliable (SoE Tas, 2003).

**Diseases and invertebrate pests of animals**
The cattle tick was introduced in 1872 by the importation of 12 Brahman cattle from Batavia. Victoria, Tasmania and SA have remained free of the cattle tick. The distribution of the tick is determined by temperature and humidity and therefore confined to northern WA, the northern half of the NT, coastal Qld and northern NSW.

In Queensland there are 18 pests of bees, 188 diseases and vectors of animal diseases declared under several other pieces of legislation (Queensland Government, 2003).

Approximately 952 invertebrate invasive species have been recorded in Tasmania, with 74 recognised as pests. Most impact on agriculture, with only 12 recognised as environmental pests (2 wasps, 2 bees, 1 yabby, 1 mussel, 1 crab, 1 clam, 1 worm, 1 seastar, 1 oyster, 1 screw shell). These numbers include marine species (SoE Tas, 2003).

There are 15 livestock diseases recognised internationally as being of significant importance to trade and are defined by the OIE (World Organisation for Animal Health) as 'List A' Diseases. Only two of these diseases are present in Australia. These are Bluetongue, which is restricted to the northern part of the country, and Newcastle diseases which was last reported in 2002 (AHA, 2004). The OIE also defines 'List B' diseases that are considered to be of socioeconomic or public health importance within infected countries and significant in international trade. There are 80 'List B' diseases, and 40 of these are present in Australia, although for a number there is only serological evidence.

**Other invertebrates**

*Fire Ants*

Fire Ants have been contained to South East Queensland and were first discovered at Fishermans Island in Brisbane in 2001. If Fire Ants were allowed to spread throughout Australia unimpeded they would occupy any land with mean annual rainfall exceeding 510 mm excepting areas that experience extremes of cold. Predictive modeling of the expected rate of spread shows that at least 600,000 sq kms and as much as 4 million sq kms would be infested by 2035 (Queensland Government, 2003).

The current total treatment area (22 November 2004) is 28, 030 hectares, with twelve rounds of treatment completed since the start of the program, and a 13$^{th}$ round currently in progress. The total surveillance area is 60,236 hectares, and there are 2,787 businesses on Approved Risk Management Plans. As at October 2003, 98% of known infestations treated over two years were fire ant free (Queensland DPI&F website, 2004).

*Crazy Ant*

Crazy Ants were discovered in Cairns in April 2001. This infestation was successfully eradicated. There was a subsequent infestation in Townville in February 2002, as well as an infestation in Brisbane, and these were both also successfully treated, with no further ants found at these sites (Queensland government, 2003). Other isolated infestations of crazy ants have been at Caboolture and Rocklea in Queensland, and Yamba in New South Wales (Queensland Government, 2004 and 2005).

Crazy Ants have also infested more than 350 hectares over a 25,000 sq km area in north-east Arnhem Land. A major eradication program is under way involving the Dhimurru Aboriginal Land Management Corporation, local Aboriginal communities, Alcan Gove, the NT Government, the Northern Land Council and CSIRO. The program is also receiving funding support from the NHT and the Indigenous Land Corporation (CSIRO, 2004).

Crazy Ants are also found on Christmas Island and have been there for some time, however the infestation is now too large to eradicate (SoE Australia, 2001).

*European wasp*

The European wasp arrived on mainland Australia in 1997 and lacks natural predators so it has expanded its range since that year. By 1991 an estimated tens of thousands of nests were being destroyed in metropolitan Melbourne annually, with wasp densities

of up to 40 per sq km being reported. These wasps are now found in Tasmania, Victoria, NSW, ACT and SA (Canyon et al, 2002).

*European honeybee*

Feral colonies of European honeybees are now widespread though patchily distributed over the Australian mainland (Paton, 1996). Quantitative data on the numbers of feral colonies in different parts of Australia is lacking, however factors that may limit the distribution of feral colonies include availability of water, availability of food, availability of suitable hollows, various bee diseases, and cold or wet weather (Paton, 1996). There are some examples of data on feral bee colonies for localised areas, particularly within National Parks (Paton, 1996).

*European House Borer*

The European House Borer (EHB) attacks untreated seasoned pine, fir and spruce. The EHB was detected in the suburbs of Perth in January 2004. The borer can live in timber for two to twelve years before it reaches maturity and emerges as a beetle. It is thought to have come into Western Australia in a piece of timber as a borer rather than a beetle. The WA Government has established a surveillance and detection program to determine the extent of the pest and how to counteract it (WA Department of Agriculture, 2005).

## 4.4 Summary

*Weeds*

1. The maps of the current and potential distribution of the weeds carried out for the Weeds of National Significance program is the principal information set available at a national level on the distribution of weeds.
2. Having the major responsibility for control and containment of weeds, most if not all States assemble data on the distribution of the important weeds that exist in their state.
3. There is no nationally comparable approach between States to monitoring the distribution of existing weeds. Some standardised methods for surveying are available.
4. Less is probably known on a State basis about environmental weeds in some States as local boards focus more on weeds with agricultural and pastoral impacts.
5. Some weeds are spreading and some weeds are being contained, but there is no generalised information available on the broad picture of spread and containment. The impression is that the total number and area of weeds is increasing.
6. There is a case that can be made for a national audit of weeds that reports on the distribution and abundance of major weeds. This may be achieved either by States using standardised methods or by existing data from the States being assembled and integrated every five or ten years.
7. Data on weed distribution is most valuable for specific weed control and containment programs, for frontier management, for accountability purposes and for priority setting, benefit-cost analyses and model building and validation.
8. There is a trend towards an increasing rate of plant naturalisation based on the past 25 years of data. It is therefore likely that the number of new weeds will also increase in the future.

*Vertebrate pests*

9. The information on distribution is quite good for vertebrates at a national and State level. For some vertebrate pests changes in distribution over time are also available (albeit sometimes long time frames of up to 100 years).
10. There is some information on the abundance of established animal pests, but it is patchy and inconsistent; data interpretation is hampered by changes in seasonal conditions, and trends are not easy to identify.
11. Abundance information is important for determining success or otherwise of control programs and for monitoring frontiers.
12. In the main the national distribution and abundance of terrestrial vertebrate pests has not been largely reduced by management in the past ten years, except for the decline in rabbit numbers due to Rabbit Calicivirus Disease. However the distribution and abundance of some vertebrate pests has increased in the past decade eg. cane toads, camels, deer, foxes and feral pigs. There has been an increase in the number and distribution of aquatic vertebrate pests.

*Invertebrate pests and diseases*

13. Knowledge regarding the distribution of plant and animal diseases is comprehensive compared to that for weeds.
14. There is no significant trend in the establishment of new insect pests or diseases of plants, at least between 1971 and 1995. For other invertebrate pests no trends were reported in the literature surveyed.
15. Some existing plant diseases have continued to spread over the past ten years (eg *Fusarium* in cotton, *Phytophthora* in native species). New plant diseases and invertebrate pests have continued to appear although some new incursions have been eradicated or contained.

*General*

16. Monitoring the distribution of weeds and animal pests on a national scale would be most informative but its practicality and cost-effectiveness would need scrutiny given the number of species involved. Most monitoring of established pests is carried out at State level and it may be possible to produce a national picture of major pests every few years through aggregating State data.

# 5. Institutional and Activity Areas: Progress, Constraints and Gaps

## 5.1 Introduction

This part of the review covers the major progress made by Australia in the past ten years in reducing the impact of invasive species. Progress includes both improvements in institutional arrangements as well as direct reductions in impact or potential impact. In addition, the review covers some of the constraints faced and apparent gaps.

Descriptions of activities, progress and gaps are organised within each of four activity areas:

- Prevention of entry
- Monitoring and surveillance
- Emergency response and eradication
- Containment and control

Some activities inevitably may span more than one of these areas (eg. research), but in general the above categorisation is useful in the description of progress. While some of the institutional arrangements are specific to one of these activity areas, by their nature most are relevant to multiple activity areas. Progress achieved through improved institutional arrangements is therefore discussed first. Any gaps in institutional arrangements are addressed later within each activity area.

## 5.2 Institutional Arrangements

Institutional roles and responsibilities are being addressed by the Task Group through another avenue and therefore are not given much prominence in this review. However, as the review addresses activities and progress, new arrangements are addressed briefly, especially where there has been a significant change in structure or function.

**Plants**

*Australian Weeds Committee*

The Australian Weeds Committee (AWC) was originally established as an agricultural production orientated committee for Australian Government and State coordination. In 2000 the scope of the committee was widened so that all weeds are now covered (primary industry, forestry and environmental). The Committee is now responsible to the Natural Resources Policy and Programs Committee. The widened committee met first in August 2000 (AWC, 2004a).

The management of weed issues now appear to take the environment into account more and more, whereas the focus used to be only on agriculture (AWC, 2004a). The extension of the scope of the AWC has provided a significant achievement in coordination for lessening the impact of weeds.

*National Weeds Strategy*

The National Weeds Strategy was developed by the AWC between 1992 and 1997 and was launched in mid-1997. Developing the agreed strategy between the States and the Australian Government was a major achievement.

The Strategy has three main goals in preventing the development of new weed problems, reducing the impact of existing weed problems and providing cost efficient and effective means for harnessing national actions on weed management (AFFA, 2003). A five year report (1997-2002) is available that covers the implementation of the strategy (National Weeds Strategy Executive Committee, 2002).

*Weeds CRC*

The advent of the CRC for Australian Weed Management Systems (1995-2001) and its successor the CRC for Australian Weed Management (CRC Weeds) established in 2001 represent a major area of progress for Australian weed management. The CRCs have given a strong focus to weeds research and some degree of national coordination in both R&D and management.

*CRC for Tropical Plant Protection*

The CRC for Tropical Plant Protection (CRCTPP) was established in 2000 to improve the management of diseases and pests of tropical crops. It succeeded the previous CRC for Tropical Plant Pathology. Both CRCs have contributed to the development of plant resistance and diagnostic testing for predominantly tropical plant diseases. A bid for a new CRC for National Plant Biosecurity has recently been successful.

*Plant Health Australia*

The advent of Plant Health Australia (PHA), established in 2000, evolved from the recommendations made in the Nairn Review of Australian quarantine for a national coordinating body to deal with plant health. PHA is a partnership between industry and government and covers both industry/industry and government/industry information provision and coordination of plant health functions. Its members are from the Australian Government, States and industry. PHA is the key adviser to industry and government. PHA promotes confidence in Australia's plant health status and plant health management systems and commissions, coordinates and manages agreed plant health programs (Cole, 2003).

*Office of Chief Plant Protection Officer*

The Office of the Chief Plant Protection Officer (OCPPO) was established in 1997 and arose from the Nairn Review (1996). The OCPPO is the Australian Government body within the Department of Agriculture, Fisheries and Forestry (DAFF) for the national coordination of plant protection activities, with a specific role in emergency outbreak management, exotic pest surveillance, for confirmation of diagnostics, database reference collections and development of plant health stakeholder networks (Cole, undated).

**Animals**

*Vertebrate Pests Committee*

The national Vertebrate Pests Committee (VPC) provides advice to governments on the threats to agriculture and the environment posed by exotic vertebrates kept in Australia or proposed for import (Bomford, 2003). The VPC has now expanded to consider freshwater fish, as well as native pest species. The VPC reports to the Natural Resources Policy and Programs Committee (NRPPC).

The VPC does not currently appear to play a major role in coordinating the management of established vertebrate pests. It is likely that the VPC could play a useful role in this regard and it is currently in the process of developing a National Pest Animal Strategy.

*Pest Animal Control CRC*

The Pest Animal Control CRC (PAC CRC) established in 1999 is pursuing scientific approaches to the management and control of Australia's established pest animal species. The aim is to develop new biological control agents for the European rabbit, European red fox, the introduced house mouse and carp. The intention is for these agents to be cost effective, environmentally friendly and reduce the impact of the pest to acceptable levels while being more humane and retaining their effectiveness over time (PAC CRC website, 2005). It has just been announced that the Australian Invasive Animal CRC has been successful in its bid and it will continue the work of the PAC CRC.

*Animal Health Australia*

Animal Health Australia (AHA) was formed in 1996 and has 24 Members including representatives of Australia, State and Territory governments, key primary industry groups and other key interest organisations. Funding is provided via annual subscriptions paid by the members and is managed via an independently selected Board of Directors. The major programs of AHA are Animal Health Services, which aims to improve the national capability, standards and performance of Australia's animal health system; Animal Disease Surveillance, which provides a nationally integrated, innovative surveillance system to underpin trade; and Emergency Animal Disease Preparedness, which enhances management approaches to deal with animal disease emergencies (AHA website, 2004).

AHA includes surveillance and response to wildlife health, as well as the health of agricultural animals and aquatic animals. It does not include invertebrate pests which do not directly impact on agriculture, such as fire ants and crazy ants.

*National Feral Animal Control Program*

BRS has jointly administered the National Feral Animal Control Program (NFACP), funded by the NHT since 1996. BRS administered the agricultural component and the Department of Environment and Heritage (DEH) the environmental component until 2002. Since 2002, BRS continues to use the NFACP title for management of agricultural pest animals. Environmental pest animals are now addressed under a separate allocation from the national component of the Natural Heritage Trust.

*Australian Wildlife Health Network.*

The Australian Wildlife Health Network (AWHN) is based at Taronga Zoo and commenced operation on 1 July 2002. The Network's aim is 'to promote and facilitate collaborative links in the investigation and management of wildlife health in support of human and animal health, biodiversity, and trade. This is to be achieved through the development of a coordinated, national program focused on the health and diseases of free-ranging wild animal populations, which will better prepare Australia for serious disease outbreaks in its wild and feral animal populations. Other activities of the network include the development of protocols and coordination of research, disease surveillance, emergency response, training and education. Core members of the Network include Australian Government, State and Territory departments of agriculture and primary industry, and environmental, wildlife and conservation organisations.

*National System for the Prevention and Management of Marine Pest Incursions*
While marine species are outside the scope of this review, it should be noted that this National System is being developed by the Australian and State and Territory Governments in consultation with industry to provide effective and efficient procedures to protect Australia's marine environment and marine industries from marine pest incursions.

*Ornamental Fish Policy Working Group*
The Ornamental Fish Policy Working Group (OFPWG) consists of representatives from State and Territory fisheries agencies, all Commonwealth agencies with responsibility for ornamental fish importation and animal health representatives of the industry and hobby sectors. It reports through the Marine and Coastal Committee to the Natural Resource Management Standing Committee. The OFPWG was established in 2003 to develop a national strategic approach on ornamental/exotic fish. The draft strategic approach to the management of ornamental fish in Australia will soon be released for consultation. The OFPWG has made a conscious decision to focus the strategic plan primarily on freshwater fish species used in aquaria. The OFPWG has been cooperating with the National Introduced Marine Pest Coordinating Group and the National Aquatic Animal Health Committee.

Office of the Chief Veterinary Office
The Office of the Chief Veterinary Officer (OCVO) was established in 1995 and provides national leadership and coordination of animal (including aquatic animal) health activities.

**General**
*Research Organisations*
In addition to the specialist CRCs, many research organisations (eg. CSIRO, the State agencies, BRS, universities), have contributed to greater understanding and development of technology across a wide range of areas of invasives. The role and achievements of these organisations are not covered in this review but are generally available elsewhere. For example, the CSIRO's activity in the area of invasives is described in the CSIRO submission to the Senate Inquiry on Invasive Species (CSIRO, 2003).

*Biosecurity Australia*

Biosecurity Australia (BA) was set up in 2000 to assess the quarantine risks associated with commodity imports (AFFA, 2003). In undertaking import risk analysis this effectively sets quarantine policy for Australia in the area of plants and animals. BA was established to distinguish biosecurity (quarantine) policy developments and market access negotiations from the operations role of AQIS (DAFF, undated). The creation of BA as a prescribed agency occurred in December 2004 and the agency is tasked with providing science based quarantine assessments and policy advice that protects Australia's favourable pest and disease status.

*NAQS*

The Northern Australia Quarantine Strategy (NAQS) is a program administered by AQIS whose mission is to protect Australia's animal plant and human health and the environment in northern Australian regions (AFFA, 2003). NAQS was established in the late 1980s.

*Within-State Coordination*

State weed strategies commenced in 1996 with the ACT and culminated in 2001 with Western Australia (Lonsdale, 2002). For example, NSW weed management plans have been developed for parthenium, alligator weed, bitou bush, branched broomrape, hawkweeds, knapweeds, miconia, Mexican feather grass and cabomba. A draft strategy has been prepared for salvinia (SoE NSW, 2003). The Tasmanian weed management strategy (Weedplan) was developed in 1996 and reviewed in 2002 (SoE Tas, 2003).

An environmental weed strategy for Western Australia was developed in 1999 (Environmental Weed Strategy for Western Australia, 1999) followed by a wider Weed Plan for Western Australia in 2002 (State Weed Plan Steering Group, 2001). The environmental strategy identified 34 weed species that were having or potentially would have a high impact on biodiversity. Of note is that only one of the 34 species was also included in the 28 species on the National Alert list for Environmental Weeds.

Queensland has developed a Weed Strategy (2002-2006), a Pest Animal Strategy 2002-2006, and a strategy for control of Exotic Pest Fishes (Queensland Government, 2003). Queensland has also initiated in 2002 a whole of government approach to invasive species through an interdepartmental pest management Committee (IPMC) to improve government coordination (Queensland Government, 2003). The IPMC is made up of senior members of the Queensland DNR&M, DPI&F, EPA, Queensland Health, Department of Premier and Cabinet, Treasury, Department of Local Government and Planning and Queensland Transport. The group meets bi-annually and a new executive officer position has been created cross-funded by four agencies.

Each Catchment Management Authority in Victoria has a weed action plan (Victorian Catchment Management Council, 2002).

Like flora, legal responsibilities for fauna rest with States and Territories and therefore State and Territory governments as well as industry and the wider community have the prime responsibility for the management of established pests.

The Rural Land Protection Boards (or equivalents) form a framework for the integrated management of vertebrate pests impacting on primary industries at a local level. Plans for the management of a particular pest problem such as wild dogs have been successfully developed and implemented using these Boards in NSW. The development and implementation of the plans includes various stakeholders including landholders, National Parks and Wildlife Service, RSPCA, landholders etc.

**Overview**
Some significant strengthening of institutional arrangements for managing invasives has been evident in the past ten years. There has been a strong culture of continuous improvement in the management agencies and this will need to be built on to cope with the significant changes associated with globalisation.

CRC's have been a key part of many initiatives by raising awareness, identifying issues, researching and providing solutions. However the issue of ongoing funding for these activities will need to be addressed.

Coordinating mechanisms have been initiated or further developed between industry and government and between State and Australian governments in some areas. Agricultural - environment coordination has also been evident but most of the institutional strengthening has been within the agricultural arena rather than the environmental arena. Also, with the delivery of many of government resources for on ground activities to be through regional groups in the future, arrangements for ensuring coordination will be required, for example ensuring integrated plans and cooperative actions for invasive species for neighbouring regions. A key issue with directing NHT funds direct to regions is the need for a requirement that state agency /scientist input is obtained for regional pest management programs (Quentin Hart, pers. comm., 2005).

Gaps in institutional arrangements will become evident as this review of progress and achievements proceeds across the four activity areas.

## 5.3 Prevention of Entry

AQIS provides the most visible role in the prevention of entry of invasive species to Australia through its border presence. The prevention of entry goes further than AQIS operations at the border. There are import policies that are developed elsewhere and put into practice by AQIS as well as other activities that are undertaken by AQIS and others and which help prevent entry.

While the central role in prevention of entry is performed by AQIS, the activities of this organisation are given less prominence in the review than what might be expected. This is mainly because there has been a number of reviews of quarantine and AQIS operations over the past ten years, most of which have been referred to in this review.

### 5.3.1 Increasing education and awareness
Important in preventing entry to Australia of invasive species is to minimise risks of species being brought into Australia unintentionally via travellers, mail and cargo,

ships and planes. A visible area of activity is increasing the education and awareness levels of domestic travellers returning from overseas. This activity also applies to foreign visitors to Australia, Australian importers and transport operators.

AQIS has continued to develop programs to increase awareness of the Australian community of the importance of quarantine. For example, a major awareness initiative was run by AQIS in 2001: "Quarantine Matters! Campaign".

Achievements include:

| |
|---|
| One survey conducted in mid 2001 by AQIS indicated generally favourable outcomes when compared to earlier surveys in 1997 and 1999. In 2001 78% of residents said they had seen or heard something about quarantine in the 12 months to mid 2001 compared to 58% in 1999. Also, 56% of Australian residents felt they were well informed about quarantine regulations – up from 44% in 1999 and 37% in 1997. There was also an improvement in ranking with quarantine improving from 8$^{th}$ out of 10 issues in 1997 and 1999 to 4$^{th}$ out of 10 in 2001. |

Source: DAFF, undated.

In addition, the AQIS International Mail Program has instituted a sender initiative whereby senders are advised of material of significant quarantine concern that what they have sent may have breached Australia's quarantine laws asking them to be aware of these matters in future. AQIS has also undertaken a "Repeat Recipient" exercise where those who have been sent several letters are further contacted by letter and, in cases of serious breaches, they are visited by an officer (AQIS, pers. comm., 2005).

### 5.3.2 Pre-border activities

AQIS conducts a number of activities pre-border that reduce the risk of entry of invasive species. These include (AQIS, pers. comm., 2005):

- Facilitated import mechanisms for commodities identified as having quarantine concern on the basis of those commodities and associated packaging being treated by AQIS approved methods prior to arrival;
- Ongoing risk profiling of commodities;
- Extensive cooperation and liaison with National Plant Protection Organisations of trade partners at technical levels to facilitate information flow, working jointly on targeted pests;
- Review and monitoring of international reporting of new pest and disease incursions through WTO/SPS notifications;
- Off shore inspections and pre-clearance mechanisms; and
- Developing compliance mechanisms and capacity building such as the Australian Fumigation Accreditation Scheme to ensure treatment efficacy and reduce the potential for contamination and reinfestation post treatment.

Other relevant activities include Australian agencies working with agencies in overseas countries, particularly those in close proximity to Australia where the invasive species are known to exist, in order to help those countries with their surveillance, diagnostic testing and control methods. Reducing incidence in this way can also lessen risk to Australia for air borne infestations and bird carried infestations.

The emphasis on neighbouring countries assumes the risk of entry is greater from neighbouring countries than from other countries. Neighbouring countries are more relevant to invasive species that may adapt to northern areas of Australia. NAQS, the

Australian Centre for International Agricultural Research (ACIAR), DAFF and AusAID, continued to operate in neighbouring and other countries providing assistance with quarantine services (eg. Papua New Guinea), with R&D, surveillance, capacity building, training overseas scientists, developing and maintaining regional reference laboratories and carrying out other forms of cooperative activities.

These activities have increased the experience of Australian scientists regarding the threats, control methods, and adaptation of organisms. Bio-control projects in neighbouring countries have helped Australia prepare for some specific invasive species incursions into Australia if and when they occur. These activities can also help in more informed import risk assessments by BA.

ACIAR have carried out considerable research in the Asia Pacific region on many species that could be a threat to Australian agriculture and biodiversity. These include Chromoleana (Siam Weed), lantana, water hyacinth, and livestock diseases.

Examples of achievements in the livestock area include the contribution of AusAID of $6.5 million to co-finance a project to control and eradicate FMD in the Philippines. Australia was also involved in setting up a multi-lateral program to control FMD in Southeast Asia. This has developed National Plans, an agreement on a zoning approach and a signing of a Memorandum of Understanding between several of the countries.

An economic evaluation of realised and potential impacts of ACIAR's biological control projects (1983-1996) analysed the impact of 15 supported research projects (including salvinia and *Mimosa pigra*, invertebrate pests, banana pests, and fruit fly) and demonstrated overall success. Only 3 of 15 discrete research activities in the area of biological control failed to generate an economic impact (Lubulwa and McMeniman, 1997).

To date there have been 10 completed bio-control projects by ACIAR in Papua New Guinea and the South Pacific region. These projects fall into the following three main groups: 4 projects made a quantifiable economic impact with rate of return ranging from 8 to 81 %; three projects made unintended positive, but quantifiable economic impacts; and three projects had no impact. The most common economic explanation for the failure to make an impact was that the industries targeted by the biological controls collapsed.

Some of the major external-to-Australia activities that have benefited Australia have been described by Bob Clements and are reproduced below. Much of the research described below was carried out by CSIRO with the financial support from ACIAR.

Biological control of insects and weeds that infest the crops of resource-poor farmers offers cheap, reliable, environmentally friendly management solutions. Among ACIAR's most spectacular success stories are management of the banana skipper in Papua New Guinea (benefits estimated at more than $200 million); salvinia water fern in Sri Lanka (the fastest control of salvinia ever achieved; 10 months from start to full control, and benefits estimated at $25 million by 1990); passionfruit scale in Samoa (rapid and complete control); water hyacinth in Thailand; breadfruit mealybug in the South Pacific; and Siam weed (Chromolaena) in Sumatra (benefits estimated at $25 million).

The banana skipper insect appeared in Papua New Guinea in 1983 and spread at a rate of 500 km per year. It was expected to reach Australia by 1995. On average it destroys 60% of the leaves of infested banana plants. With ACIAR support, the pest was controlled by 1990 in Papua New Guinea, by introducing a biological control agent (a small parasite). The estimated benefits to Papua New Guinea are $202 million, and benefits to Australia through reduced risk of entry of the insect are estimated at $223 million. The benefit-cost ratio of this research was 607:1 (See Waterhouse et al, 1998).

Fruit flies are a major pest of many horticultural crops. They reduce crop yields, reduce the quality of the products, and pose barriers to international trade. ACIAR has supported research on identification and control of fruit flies for many years, with projects in Malaysia, Thailand, many Pacific Island countries and (currently) Papua New Guinea, Vietnam and Bhutan. Cost-effective control using fruit fly baits has been developed and adopted in several countries (eg. Malaysia, Thailand, Tonga), and procedures for disinfesting harvested fruit have been developed and adopted in Thailand and Vietnam. Research on fruit fly baits had already delivered $14 million in benefits to Malaysia and Thailand by 2001, and benefits in Samoa, Vanuatu, Fiji and Tonga are estimated to reach $20 million by 2003. Importantly, this research also provided great benefits to Australia and Queensland when the Papaya fruit fly entered Australia.

FMD of cattle reduces productivity and creates trade barriers. Perhaps the single biggest benefit to Australia on this topic that emerged from activities supported by the Australian aid program was the eradication of FMD from Indonesia by AusAID.

Source: Bob Clements, pers comm, November 2004

While it is clear that many of these initiatives are directly in line with reducing the threat to Australia and building capacity to respond, it is not clear whether these activities take account overall of priorities that may have been set in Australia regarding invasive species.

### 5.3.3 Border quarantine - General

Border quarantine is the most visible barrier to entry for invasive species. AQIS have a range of mechanisms in place to reduce the risk of entry and establishment of invasive species. Some of these are (AQIS, pers. comm., 2005):

- General surveillance at wharves and airports of all non-containerised cargo;
- Random targeting of consignments for further examination on arrival;
- The External Container Inspection Regime whereby the external surfaces of incoming containers are examined for potential quarantine risk material (Soil, bark, seed, nests, spiders, Giant African Snail etc);
- Mandatory examination of containerised consignments destined for rural areas; and
- The use of Quarantine Approved Premises to unload and examine consignments that have been identified by risk profiling as being of potential quarantine concern.

The intervention and effectiveness of quarantine are the major measures used by AQIS in assessing performance in this area. Intervention is the application of quarantine measures to identify and manage items of quarantine interest. Effectiveness is the likelihood that these measures will intercept items of quarantine interest (DAFF, undated).

AQIS reports against its performance indicators every quarter. However, in reporting there appears strong emphases on export services as well as on organisational performance eg. financial performance, customer satisfaction, workplace relations, dealing with stakeholders and reviews.

A number of reports on Australian Government quarantine were carried out in the ten year period of this review. Responses to two of these, the 1996 Nairn Report and the 2001 Audit Office Report have had a significant impact on Australia's quarantine arrangements and resourcing (DAFF, undated).

A large increase in the budget for border protection occurred in 2001 stimulated by the FMD outbreak in the UK. This led to an increase in Australia's quarantine intervention supported by an increase of $596.4 m over 4 years from 2001-02. This substantially strengthened border controls (DAFF, undated).

Achievements in border quarantine include:

| **Intervention and effectiveness levels** |
|---|
| • Seizures of items of most quarantine concern at airports are currently (2002) 38,000 per month, having risen by 84% since the March quarter 2001. Over the same period, the number of on the spot quarantine fines issued increased by almost 60% and are now running at around 100 per month (DAFF, undated).<br>• Quarantine infringement notices issued to inbound air passengers and air crew in January to March 2002 averaged 1100 per month, increasing by around 60% compared with the same period in 2001.<br>• Referrals for prosecution increased and currently number about 20 per month nationally<br>• Airports: national intervention and effectiveness levels have reached 80 and 70% respectively compared with 35% intervention and effectiveness of around 39% early in 2001.<br>• Cargo: Percentage intervention levels are currently running at 100, 98 and 82 for sea, air containers and airfreight documents<br>• Ships: Intervention levels are 98% for ships and 100% of disembarking passengers (DAFF, undated).<br>• Postal: Intervention levels as of 2002 were running at between 79 and 100% and have been maintained at 100% since 2002 (AQIS, pers .comm., 2005); initial tentative effectiveness data has shown an increase from approximately 11% to around 76% for higher risk material for parcels registered and electronically monitored mail (DAFF, undated). However, ordering seeds via internet sites can escape detection (SoE Qld, 2003). The development of technology for detecting seeds in postal articles is required. Current technology does allow detection of many seed importations but small quantities sometimes prove difficult. As a response to this issue AQIS have had the Quarantine Detector Dogs trained to be alert to seeds and are engaged in discussions with X-Ray providers to enhance current equipment to enable better detections of small quantities of seeds, as well as some other difficult items, or to develop alternative technological solutions (AQIS, pers,. comm.., 2005).. |
| **General** |
| • An increased range of detection technologies has been employed in the past ten years.<br>• In June 2001, it was reported that as a result of actions taken from the review that "Quarantine operations were now markedly more effective across the Board"(ANAO report, Managing for Quarantine Effectiveness, quoted in DAFF, undated) |

The performance indicators described above are predominantly operational indicators (eg. effectiveness is measured through a sample that is checked thoroughly). While further indicators in relation to outcomes may exist in the AQIS databases, they were not reported in the literature and there was insufficient time to gather the additional information. For example, AQIS has been using increasingly systematic approaches to managing quarantine risk, both strategically and operationally (AQIS, pers. comm., 2005).

A minor proportion of recent invasive introductions has resulted from natural migration or invasion processes unrelated to quarantine policy or practice. However, overall few specific results of analyses of border protection interception data or breach follow up data to identify high risk locations or means of entry were sighted in the material reviewed. No doubt this exists in AQIS or NAQS databases and is analysed in order to assess strategies and priorities.

AQIS (pers comm., 2005) has provided examples of some more general information relevant to effectiveness:

- Declining interception rates on some commodities, in response to AQIS offshore initiatives and cooperative arrangements;
- Ongoing review and updating of import conditions;
- Establishment of national coordination centres; and
- Development of new and updated import conditions in response to improved information flow and risk profiles

### 5.3.4 Import Regulations – Animals and Invertebrate Pests

Increased global travel and lessened trade restrictions have resulted in increased rates of exotic species introductions to many countries (Bomford, 2003). It is also thought that recent moves towards free world trade are likely to increase the numbers of exotic animals imported into and kept in Australia, and hence the risk of their establishing wild exotic populations here (Bomford, 2003).

The import of exotic animal species into Australia is controlled by DAFF under the Quarantine Act 1908 and by DEH under the EPBC Act 1999. Once exotic animals are in Australia, State and Territory governments have legislative control over their trade and keeping (Bomford, 2003).

A live species can only be imported into Australia if it appears on the list of specimens suitable for live import (live import list) established under the EPBC Act and is permitted for import by DAFF/AQIS. An application can be made to DEH to add a species to the live import list and, following receipt of that application, DEH will initiate the process of environmental risk assessment required under the EPBC Act, resulting in a decision by the Minister for the Environment and Heritage. If the Minister for the Environment and Heritage decides to add that species to the live import list it will still require a permit from both DEH and DAFF. Biosecurity Australia will conduct an IRA to assess the suitability for import of a commodity (which includes live species) according to the priority established in its workplan. BA's assessment focusses on disease and pest risks associated with the commodity, however DEH provides environmental input to BA's IRAs.

Bomford published criteria in 1991 for assessing the risks of importing exotic vertebrates into Australia and these criteria were reevaluated in 2003 and presented in the report titled 'RISK assessment for the import and keeping of exotic vertebrates in Australia' (Bomford, 2003). The VPC's 'Guidelines for the Import, Movement and Keeping of Exotic Vertebrates in Australia' uses the process outlined in the Bomford 2003 document. The VPC's guidelines also outline a national strategic approach to minimise the risks posed by introduced animals, proposing a uniform system of threat assessment for introduced vertebrates relating to primary production, the environment and public safety. In part the guidelines propose that there be a uniform system of threat assessment for introduced vertebrates.

The VPC uses the risk analysis process set out by Bomford (2003) to make recommendations to governments on the threats to agriculture and the environment posed by exotic vertebrates kept in Australia or proposed for import. The risk assessment model is for use by the VPC to place exotic vertebrate species into Threat Categories which can be used as a basis for setting appropriate import and keeping restrictions for Australia. To determine a species' VPC Threat Category, three risk scores are calculated:

- Danger posed by individual animals – risk that escaped individual animals will harm people.
- Establishment likelihood – risk that a species will establish a wild population in Australia.
- Establishment consequence – risk that an established population of the species will cause harm (become a pest).

The scores are then used to determine the species' VPC Threat Category: either extreme, serious, moderate or low. The model does not assess the risk that the import of exotic vertebrates will introduce disease agents into Australia. As stated earlier this is a separate process undertaken by BA.

As at 27 July 2004 there were 24 animal and aquatic animal Import Risk Assessments (IRAs) underway and a few major policy reviews. Some of these drafts have been open for comment for a long time (eg. since 1999). These IRAs include products such as meat products, animal semen etc. They also include some species or products that are already present in Australia such as cats and dogs (DAFF, 2004).

The Queensland submission states that DEH has developed a system of public notices to notify stakeholders of proposed changes to the list of imported species under Section 303EF of the EPBC Act but that the information supplied by importers does not appear to go through an internal review before posting on the DEH web site. DEH state that the process of assessment of applications to amend the live import list established under the EPBC Act follows the accepted process for impact assessment, namely, preparation by the proponent of a report of the proposed action followed by a fully transparent and independent evaluation of that report, including several opportunities for public comment and input of independent scientific advice. The public and stakeholder comment periods allow for input from experts and other interested parties and DEH also provides research, analysis and formal advice. In developing its advice, DEH uses Bomford's 2003 risk assessment model and, for freshwater fish, DEH uses the more recent risk assessment model developed by Bomford specifically for use with that taxonomic group.

BRS (2003) comments on the possible lack of independence of risk assessments. They acknowledge that due to constraints on knowledge there is a subjective component to risk assessments that requires input by suitably qualified experts. They argue it is essential that all risk assessments be conducted by appropriate experts who act independently of either those applying to import or keep them or others with a vested interest in the outcome of the risk assessment. However, applicants often pay for a risk assessment and arrangements are not yet in place to ensure that an independent authority undertakes the risk assessment for the import of exotic vertebrates.

AQIS maintains the Import Conditions Database which provides the import conditions for all permitted live animals. There is an Australian permitted species list maintained by DEH. There are some animals that are not permitted entry under any circumstances. An example of conditions for import is for live freshwater ornamental finfish into Australia. A permit must be obtained from AQIS and imports are subject to a quarantine period. The fish must be exported from premises approved by an AQIS recognised Competent Authority and must be accompanied by a health certificate (DAFF website, Quarantine and Export Service).

Examples of detections/breaches/incursions reported over the last ten years include:

- In 1996, thousands of timber-boring beetles of two species not known from Australia (*Sinoxylon conigerum* and *Xylothrips flavipes*) were found infesting imported timber at Sydney's Darling Harbour (WWF, 2003a)
- In 1996 several frogs and toads from Hong Kong and Indonesia were intercepted at Sydney Airport, having arrived accidentally in air cargo (WWF, 2003a)
- In 1995, Formosan termites (*Coptotemes formosanus*), a major pest overseas, were detected on a boat in Sydney Harbour (WWF, 2003a)
- In 1997, eggs of the Asian gypsy moth, a pest that destroys trees in Asia and North America, were found on a passenger liner berthing in Brisbane (WWF, 2003a)
- In 1997 a rhinoceros beetle (*Oryctes rhinoceros*), a serious pest of palms, was found on a plane from Indonesia to Australia (WWF, 2003a)
- In 1996, a dog illegally imported from New Guinea to Saibai Island in Torres Strait was found to be infected with screw-worm fly (WWF, 2003a)
- In the past 7 years, Pest Control Officers have reported at least eight serious breaches/incursions to the WA Dept of Agriculture. These have included three instances of the West Indian Drywood termite (*Cryptotermes brevis*), one incident of the American Western Drywood termite (*Incisitermes minor*), one incident of the serious pest Formosan termite (*Coptotermes formosanus*), another of the related termite *Coptotermes travians*, one of another drywood termite from South Africa and one of the Tropical fire ant (*Solenopsis geminate*) (Davis and Grimm, 2003).
- An American magpie was detected in Mackay recently and was destroyed. It is unknown how the magpie entered Australia (Frank Keenan, pers. comm., 2005).
- In the past 3 years there have been 12 intercepts of an Asian toad at the Cairns port. This toad has the potential to be as serious a pest as the cane toad (Frank Keenan, pers. comm., 2005).

Some examples of possible specific gaps in the quarantine system have been identified by Davis and Grimm (2003). An example of a previous gap that has now been addressed is a change to quarantine procedures resulting from the increased risk of introduction of FMD was that the underside of containers must now be inspected. Davis and Grimm report that 80% of all interceptions (for example of tramp ants, snails etc.) on the exterior of containers are from the undersides since the upgrading of inspection requirements to reduce the risk of introduction of FMD. They state that this demonstrates a possible failure of the previous system where such inspection was not required (Davis and Grimm, 2003). AQIS comment that the underside of containers had always been inspected. What changed in procedures was an increase in the numbers of containers subject to this inspection through risk profiling (AQIS pers. comm., 2005).

### 5.3.5 Import Regulations - Plants

*Three tier system for assessing plant imports including import risk assessments*

The adoption of the three tier system (the weed risk assessment system) was in response to recommendations made in the Nairn review that Australia utilise a permitted list approach rather than a prohibited list approach that was in place at the time. This meant that a tool was needed to assess the weed potential of species proposed for importation (David Porritt, pers.comm., 2005).

AQIS changed to a three tier system for imported plants and seeds in 1997 including a permitted list and an improved import risk analysis process, while maintaining a prohibited list. If not on the permitted list, then all plant import requests have to go through a weed risk assessment process. Weed risk assessments for plants are now an important formal part of border protection which are science based and transparent.

The process is designed to detect weeds of both environmental and agricultural concern and applies to all plant imports whether they enter Australia as seeds, nursery stock or tissue culture, regardless of their use in Australia (SoE Australia, 2001). The three tier system has been generally lauded as a highly effective policy, except:

- Some listings on the permitted list are by genera and not by species, leaving entry open to weed species or variety in particular genera (the schedule 5 loophole). A review of the permitted list has recently been fast tracked (Press release, Office of Senator Hon Ian Macdonald, January 20 2005).
- Importation can sometimes be allowed for a weed type on the prohibited list as it may fall within a permitted genus into which it had been previously classified (different name).

During 2002-03 BA advised AQIS that 320 species had a high potential to become weeds in Australia and therefore should not be added to the permitted seeds list (DEH, 2003a; David Porritt, pers. comm., 2005).

*Improved import protocols*

Since being established in October 2000, BA has developed an improved risk analysis process including a stronger science input and improved consultation with industry and environment interests in partnership with governments.

Achievements of BA and further comments include:

- The publication "Guidelines for Import Risk Analysis" was developed as a technical reference document to assist staff in BA in the conduct of import risk analysis" (DAFF, undated)
- BA has improved the transparency of risk analysis processes and has encouraged greater input from its stakeholders (Cole, 2003).
- BA has come under some criticism from industry in the recent past for some of its draft decisions with previous IRAs for bananas, limes, apples, grapes and citrus being currently under revision. On the other hand, the further delay and reissuing of the IRAs for public comments have been criticised by trading partners on the grounds that decisions were being influenced by factors other than science.
- BA has recently (late calendar 2004) been distanced from DAFF and will operate as a separate agency to strengthen its independence and its focus on science.

*Import regulation weaknesses*

The main weakness in plant import policy is that the permitted list allows importation of seeds by genera, as well as by species. Of the 2916 genera on the permitted list, 24% of these contain known weed species (Spafford et al, 2004) that do not have to be subject to a weed risk assessment.

As an example of this perverse policy that operates in border protection, DEH have set up an alert list of 28 species (see later); nine of these are still able to be legally imported into Australia as the whole genus is listed as permitted (Glanznig, 2003).

Species already in Australia can only be excluded from import under the SPS Agreement if they are under an official control program (Invasive Species Council, 2003).

The National Weeds Strategy provided funding for a project including a review of both the permitted and prohibited lists that was to be completed by 1999. The schedule 5 loophole was to be closed after the proposed completion of the review, but only two plant genera have been removed from the permitted list (CRC Weeds, 2004f). It would appear that part of the project was completed but the removal of the genera was an issue that required a longer time frame (Willcocks, 2004). An accelerated review was announced in January 2005 (Press Release, Office of Senator The Hon Ian McDonald, 20 January 2005).

One solution would be to identify those species that are present in Australia and are not under a national control program. These species could then be placed on the permitted list. This would mean that all potential weed species not on the permitted list would then have to undergo a weed risk assessment (McFadyen, 2004b).

Another weakness of entry policy is that prohibited species can gain entry under another name as an importer may use an older botanical name that fits within a permitted genus. For example, Mexican feather grass (*Nassella tenuissima*), a weed relative of serrated tussock was allowed in because the importers unwittingly used an old name *Stipa tenuissima* (where the Stipa genus is on the permitted list) whereas the Nassella genus is not (Invasive Species Council, 2004; McLaren et al, 1999).

BA advises that as they become aware of any changes that may have occurred in the alignment of various species to different genera as a result of changes in taxonomic

thinking, then the appropriate changes are advised to AQIS (David Porritt, pers comm., 2005). Likewise AQIS updates all lists with synonyms as soon as they are brought to their attention.

## 5.4 Surveillance

### 5.4.1 Surveillance Achievements

The number of recent detections of invasives entering Australia are shown in Table 5.1. It appears that detections have increased over time but this may be due to either a greater number of breaches or improved surveillance techniques (or both). The northern States have the highest number of detections as might be expected.

Table 5.1 Number of Invasive Species (weeds and invertebrate pests and diseases of plants) Detected as Entering Australia since 1996

| Year | Number of detections of significance |
|---|---|
| 1996 | 6 |
| 1997 | 5 |
| 1998 | 7 |
| 1999 | 14 |
| 2000 | 15 |
| 2001 | 13 |
| Total | 60 |

| State | Number of detections of significance |
|---|---|
| QLD | 20 |
| NT | 13 |
| NSW | 8 |
| VIC | 8 |
| SA | 4 |
| WA | 3 |
| TAS | 2 |
| ACT | 2 |
| Total | 60 |

Note: Invertebrates (24), fungi (19), weeds (9) bacteria (3) and other (5) made up the 60 detections

Source: OCPPO (2002)

Surveillance for invasives are often targeted on specific areas where introductions and incursions are likely to be high (hazard areas), where specific species are expected, around frontiers of containment areas, or where impacts of invasives are likely to be very high.

Most surveillance activities are carried out by State authorities or by programs involving several states (eg. Northwatch). However, the Australian Government plays an important role in surveillance activities through NAQS and the Australian Government supports the national exotic fruit fly surveillance program and the Asian gypsy moth trapping program (OCPPO, 2002).

The detection of the red banded mango caterpillar and papaya fruit fly on Cape York Peninsula in the past 12 months demonstrates the value of early warning of exotic pests provided through surveillance and monitoring undertaken by NAQS (DAFF, undated).

Examples of new weed finds since 2001 include Koster's curse and the yellow burrhead (CRC Weeds, 2003a). Several serious weeds were discovered recently in Queensland and are under control; these include mile a minute, miconia, limnocharis, giant sensitive tree and Koster's curse (SoE Qld, 2003). Significant new incursions or invasions of pest plants in South Australia over the last few years include *Calerpa taxifolia* (aquatic weed), branched broomrake and perennial grassweeds such as Chilean needle grass and serrated tussock. (SoE SA, 2003).

An important component of surveillance is training veterinarians and others to recognize and identify exotic animal diseases. More than 400 veterinarians have undertaken a top-level exotic animal disease training at CSIRO's Australian Animal Health Laboratory (AAHL). The course prepares veterinarians to recognise diseases like classical swine fever, vesicular diseases of pigs and cattle, bluetongue and exotic diseases of poultry like avian influenza (CSIRO Livestock Industries, 2004).

NAQS plays a vital role in surveillance and screening animals for exotic diseases is an integral part of their operations. Each year NAQS submits around 100 serum samples from sentinel pig herds to CSIRO's AAHL for disease testing. The sera are tested throughout the wet season for Japanese encephalitis and at the end of the season for additional diseases including classical swine fever, porcine reproductive and respiratory syndrome, Nipah virus and Aujeszky's disease. NAQS screens sentinel pig herds stationed at high risk sites in northern Australia in order to detect new diseases early and enable Australia to eradicate or contain new diseases or to minimise the likely effects of a disease (CSIRO Livestock Industries, 2004).

For example, from 2000 to 2003 monitoring of sentinel pigs and survey work showed pigs in the central and northern Torres Strait Islands had been infected with Japanese encephalitis (CSIRO Livestock Industries, 2004).

AAHL also screens sera collected by NAQS officers from goats, feral pigs, rusa deer, buffalo, horses, chickens and dogs in Northern Australia, PNG, Eastern Indonesia and Timor-Leste. These sera are screened for diseases such as surra and avian influenza and those from Timor-Leste are also screened for FMD.

The Australian Wildlife Health Network described in Section 5.2 coordinates surveillance of diseases in wildlife.

National programs managed under the Animal Disease Surveillance Program of AHA include:

- National Animal Health Information System
- National Arbovirus Monitoring Program
- National Transmissable Spongiform Encephalopathy Surveillance Program
- Tuberculosis Freedom Assurance Program

Other national livestock disease surveillance and support programs are the Pig Health Monitoring Scheme, the National Sentinal Hive Program and the National Livestock Identification Scheme

Initiatives for surveillance for zoonotic diseases in humans include:
- National Notifiable Diseases Surveillance System
- National Enteric Pathogen Surveillance Scheme
- Japanese encephalitis surveillance

The Queensland DPI&F has biosecurity systems which deliver surveillance of major pest and disease risks to food and fibre industries (eg. FMD, mad cow, papaya fruit fly). They implement responses to detected pests either to eradicate (eg. bovine tuberculosis) or to manage a zoning of the pest to specific areas (eg. cattle tick) or where appropriate to develop Quality Assurance systems which facilitate interstate trade by certain risk management processes on farm (Queensland Government, 2003)

An example of a species for which there is an established surveillance program is the screw-worm fly which affects livestock (Bomford and Hart, 2002). The approach to the screw-worm fly threat combines risk reduction, early detection and preparedness. Risk reduction involves:
- Quarantine requirements for animals imported formally into Australia.
- Prohibiting the informal movement of animals from Papua New Guinea to the Australian Torres Strait Islands and restricting movement of animals between islands in the Torres Strait.
- Insecticidal sprays prior to arrival for aircraft and ships entering Australia.
- A cattle-free zone in Cape York Peninsula.
- Attempts to reduce feral animal populations on Torres Strait islands (Bomford and Hart, 2002).

Early detection involves:
- Education to alert Torres Strait islanders and communities on Cape York to screw-worm fly.
- Submission of diagnostic specimens from struck animals.
- Trapping of flies in traps baited with Swormlure.
- A sentinel wounded animal scheme.
- Trapping, which was instituted but is now only used to map the distribution of any introductions (Bomford and Hart, 2002).

The screw worm fly example illustrates the importance of integration of surveillance with protection measures and the imperative of early detection.

Animal Health Australia together with industry and governments release a range of exotic animal disease bulletins and campaigns to increase awareness among livestock producers and the wider community of the importance of Emergency Animal Diseases. This includes the ‘Look. Check. Ask A Vet’ Protect Australian Livestock Campaign which urges producers to remain vigilant and alert for suspicious signs, abnormalities or symptoms among their livestock (AHA, 2004). AHA also manages the Emergency Disease Watch Hotline.

AFFA and PHA have recently developed a national plant pest hotline telephone reporting system to more effectively capture potential detection through general surveillance activities (Cole, 2003).

*Gaps*
Many invasive species do not directly threaten primary production. To date these species have not been strongly targeted for surveillance at a national level. This is largely due to a lack of clarity of institutional roles and responsibilities, and undeveloped institutional structures and budget processes. Also, technical difficulties are also associated with surveillance and methods need further development (Mike Cole, pers comm., 2005).

It has been estimated that the Red Imported Fire Ant (RIFA) was present in Queensland for up to ten years before detection. Davis and Grimm (2003) make the point that this was at a time when the Queensland government moved towards a policy of charging for insect identifications. An example of the importance of early detection in such cases comes from New Zealand, which has established a National Invasive Ant Surveillance Program at a cost of $NZ400,000 that systematically surveys high risk potential invasion sites, such as ports and airports. The program resulted in the detection of an infestation of RIFA in Napier in 2004, which was estimated to have been there for about 1 year (Simon O'Connor, pers comm.).

There is no legal obligation under current state legislation (with the exception of Tasmania) for growers or diagnostic labs to report suspect new incursions (OCPPO, 2002). This constitutes a gap in the overall surveillance framework. However, OCPPO and PHA are working to improve the likelihood of early detection of invasive plant pests by implementing a national reporting system, a targeted awareness program and the establishment of a free hotline to encourage reporting by the public (OCPPO, 2002).

Davis and Grimm (2003) note that some problems inhibiting effective detection of new incursions include:

- Various State governments have at times applied fees for the identification of pests and diseases submitted by the public. For example Pest Control Officers in WA have said they don't submit specimens to the Department because they heard a fee was being charged for identification. This indicates that perceptions and communication are also important factors.
- A species can fall between the cracks if the target species is neither considered predominantly an agricultural pest nor an environmental threat. Such pests as West Indian drywood termites, other timber pests and urban nuisances such as Portuguese black millipedes and pests which attack exotic trees used extensively as amenity trees could fall in this category (Davis and Grimm, 2003). However it should be noted that the majority of commodities involving wood commercially imported into Australia have been subjected to off-shore treatment, predominantly by fumigation as part of the uptake of facilitated import mechanisms offered by AQIS (AQIS, pers comm., 2005).

### 5.4.2 Target Lists

NAQS maintains a list of animal and plant pests that are targets of NAQS surveillance and monitoring, based on their quarantine status and risk of their entry through

northern Australia (Vogelzang, 2000). NAQS is seen to provide a very good service for Queensland in weed and animal health surveys (Queensland Government, 2003), as well as other northern Australia jurisdictions.

Target lists for a number of species in north Australia have been completed eg. citrus, sugarcane, banana, eucalyptus and grapevine (Cole, undated). The surveillance for fruit fly and gypsy moth is being continued until a national policy on surveillance and monitoring is developed (OCPPO, 2000).

A need for a national policy for pest and disease surveillance was recommended in the functional review of the OCPPO in 2000 (OCPPO, 2000). Issues identified included:

- public versus private funding contributions;
- identification of targets;
- the levels of surveillance;
- analysis of interception data from AQIS;
- measures for surveillance and raising awareness; and
- how pest reports could be made and how response mechanisms are structured.

It was agreed that the identification of priority targets could be achieved through the coordinated development of target lists (OCPPO, 2000).

The inclusion of Eucalyptus species as a major focus for NAQS was an indication that the NAQS listing was being extended to cover environmental invasives as well as those likely to impact on industry (Old, 1999). While the NAQS target list does contain a number of pests that would be of concern to the environment, in general those species that do not threaten primary production are not strongly targeted for surveillance at a national level (including environmental weeds, non-production insects and some vertebrates including fish). Also, weeds are generally excluded from PHA incursion management plans as there are no direct industry or specific industry beneficiary (Queensland Government, 2003). However, the idea of developing weed incursion plans could be investigated further.

### 5.4.3 Diagnostics

Diagnostic capacity underlies surveillance capacity and rapid identification can be critical in decision making and in keeping Australia free of new pathogens.

The Australian Registry of Wildlife Health has been operative since 1985 and provides diagnostic work for the threatened species management programs, wildlife rehabilitation groups, the RSPCA and the National Parks and Wildlife Service (NSW Biodiversity Research Network, 2002).

The AAHL provides diagnostic services for Australia's animal industries, and also participates in training of overseas scientists to improve their diagnostic capabilities.

Further investment in diagnostic capacity has been made in the past ten years through the CRCTPP and other agencies, particularly through DNA libraries and molecular testing.

For example, the molecular test for phytophthora (species level developed by the CRCTPP) has been and is being used in supporting quarantine measures for imports

of rooted plant material. A quick test is particularly useful for AQIS where it can identify the species of phytophthora where material being grown out under quarantined private facilities appears suspicious (Vanessa Brake, pers comm, 2003).

The DNA test for phytophthora has been used to show that a record of a previous phytophthora species that was reported about 1981 as being present in South Australia was actually incorrect. DNA from a dried specimen of strawberry showed that the sample did not contain *Phytophthora fragariae.* It contained another species of phytophthora that was known to attack strawberries and which was already present in Australia (Agtrans Research, 2004). At that time it is unclear whether AQIS still consider *P. fragariae* to be 'prescribed', that is, whether imported strawberry plants still need to be routinely tested for the pathogen since the pathogen is not present in Australia (Don Hutton, pers comm, 2004). If introduced the pathogen could cause severe damage to strawberry production.

Reference collections holding records of economically important pests are held by numerous organisations throughout Australia. OCPPO and PHA are managing a project to improve the accessibility of such records through the development of an Australian Plant Pest Database, which links the diverse geographically scattered databases throughout Australia (Cole, undated).

The Melbourne fire blight incident highlighted the problem of not having a nationally agreed and accepted diagnostic procedure in place prior to an incident leading to an inordinate amount of time debating the initial identification. Rapid and accurate diagnosis is important (Cole, undated).

Five of the most devastating exotic plants pest and diseases are being targetted in PHAs new diagnostic standards as PHA intended to invest $1.4 m in the next two years to advance diagnostic standards (PHA, 2002b).

### 5.4.4 Trade and Distribution

Trade and distribution of weedy species is discussed here under surveillance but the area is also relevant to control or eradication.

Over the past nine years a number of high priority potential weed species have appeared in Australia despite being nominated as high priority quarantine targets in 1991. Examples are equisetum and red sesbania. These could have been smuggled in as seed or could have been present beforehand. Once through quarantine, trade and distribution of these species is poorly restricted and in some States/territories there are no barriers to trade, possession and widespread planting. Therefore certain species need to be declared in every state/territory with trade and distribution prescribed as serious offences (AWC, 2001).

Restricting trade is a next lowest cost option (after prevention of entry and eradication are no longer feasible). However, such plants usually have not had individual risk assessments on their potential for invasion if released and such assessments are required (BRS, 2003).

In 1997, the National Weeds Strategy listed 15 points of weakness in the current national legislative framework. In 1999 over 700 species available from nurseries

were identified as an invasive risk (CRC Weeds, 2004b). The AWC in 2000 developed an objective that 'nationally consistent legislation, policy and guideline needs are identified and addressed which allow States/regions variation and differences" (CRC Weeds, 2003a).

The result is that AWC is now seeking to better coordinate the different legislation, regulations and structures (CRC Weeds, 2003a). However, there are still weedy plants being traded. There is a need to work with nursery industry and consumers (CRC Weeds, 2003a).

An AWC paper proposed uniform national restrictions over the deliberate trade and distribution (includes sale and possession of plants) of certain species of invasive plants – those that have potential to become pests as well as all WONS (AWC, 2001) An AWC paper on seven principles regarding development of legislation followed. However, it was shown to be difficult to go further with complex and inconsistent approach to legislation in Australia (Thorp and Lynch (1999) cited in SoE Australia, 2001).

Arguments against national uniform restrictions included firstly, that a particular species would not grow in that State or Territory anyway and secondly, where it is endemic across large areas and where there is no control program, restricting trade would make little difference.

Glanznig et al (2004a) provide the following example of inconsistent policies:

- The Ceylon hill cherry is a plant for sale in NSW and Queensland but is a NAQS target and is prohibited for importation;
- Horsetails are declared noxious weeds in six States but not in ACT and the NT; and
- Bridal creeper was declared a Weed of National Significance in 1999 but was not prohibited for importation until 2004. It is not prohibited state-wide in NSW and could be sold.

Glanznig and Kessal (2004) identify that there is still a high degree of variability in State and Territory legal controls of invasive species. For example, they state that only Queensland and South Australia prohibit the sale of all 20 Weeds of National Significance. The weakest control was identified as the ACT as that Territory's legislation does not provide for prohibition of sale and importation of a declared invasive.

Eleven of the 20 WONS have been declared weeds in the Northern Territory. The other 9 were not declared as they do not occur in the Territory. However, there is nothing to prevent them being declared and automatically being prohibited to trade except with permits. It is understood that the Northern Territory's weed list is currently being reviewed (Roger Smith, pers comm., 2005).

Ad hoc declarations of plants on a State by State basis appear ineffective and need to be coordinated. Plants may be banned in one state but promoted in national gardening television programs and magazines. Therefore, it has been increasingly recognised that there is a need to restrict trade nationally in weedy species (AWC, 2001).

Some successful negotiations have taken place with the nursery industry to have certain species removed from sale (John Thorp, pers comm., 2004). However, it is evident that the approach to date of seeking voluntary removal from sale of known garden invasives has increased awareness of the issue but not resulted in a high level of compliance (Weed Management Society of South Australia, 2003).

The Weeds CRC in conjunction with other government agencies and the Nursery and Garden Industry, Australia produced a draft national strategy on invasive garden plants in February 1999. It addressed some of the issues associated with invasive garden plants and how to raise industry and gardener awareness (Blood, 2001). This strategy has had no significant impact in reducing trade in invasive ornamental plants (WWF, 2003b). For example, in 1999 860 invasive species available through nurseries were identified, but as of 2001, only 50 had been voluntarily withdrawn from sale (SoE Australia, 2001). Further, Glanznig et al (2004b) provides evidence to show that there has been absolutely no change in the number of "garden thug" taxa available for sale from nurseries over the period 1999 to 2002. At a State/Territory level the change has been variable with the number of 'thug' species available increasing in SA, WA and NT, and decreasing in NSW, Queensland, Tasmania and Victoria.

Consistent legislation between jurisdictions is being developed and agreement now has been reached to modify State legislation. Some States have already achieved this (Tasmania, with Queensland on the way) and NSW is currently reviewing its weed legislation (John Thorp, pers comm., 2004). Progress has been slow as it takes time to introduce weed legislation as there is greater emphasis on controlling weed problems in the State itself rather than a national approach as the weed subject to legislation may not exist or even grow in that State.

It is likely that other weeds will be added including aquatic weeds. Then in future more weeds will be added to minimise trade in weed species (John Thorp, pers comm., 2004).

Other sources of potential weeds that exist in Australia are the Genetic Resource Centres, botanic gardens, arboreta and tree seed collections. These facilities contain a significant number of plant accessions that have legally passed through quarantine. In the majority of cases this occurred prior to there being an import Weed Risk Assessment being undertaken and much of this material can be introduced directly into the field (John Thorp, pers comm., 2005). To date Primary Industries and Resources South Australia is the only department of primary industries in Australia that insists on a risk assessment before germplasm is released to plant breeders or the wider environment. According to John Thorp (pers comm., 2005) this is probably the most serious post- border weed threat present in Australia today because of the extensive use made of these plants and the risk is probably significantly greater than that made by the nursery industry.

### 5.4.5 Sleeper Species

Plant pests such as insects and pathogens have entered Australia and in some cases have reproduced quickly, been detected and recorded as introduced or naturalised within 1 to 5 years of their first appearance (Groves 1998). Sometimes this is the same for weeds but it is more likely weeds take much longer and may exceed 25 years

for this lag phase. There is some confusion with regard to weeds and their dates of introduction, naturalisations, and when incursion are first detected and therefore classified as a weed. Also there have been multiple introductions by location and time which has confused analyses (Groves, 1998).

The following refers mainly to sleeper weeds, with animal and plant diseases, and invertebrate pests less likely to "sleep" for long periods.

Sleeper weeds may become weeds in future given time or a change in conditions. These are weeds that have been naturalised but as yet have not expanded greatly in area (SoE Australia, 2001). Many weeds spend years as sleepers and seemingly erupt out of control over a few years. For example, athel pine for decades spent a quiet garden life and then exploded after the wet year of 1974; *Mimosa pigra* exploded after 70 years; stevia lay dormant from 1930 to 1960 in northern NSW and then expanded (CRC Weeds, 2003a).

Identifying and eradicating sleeper weeds before they explode and become weeds with significant impact is generally regarded as a fruitful and cost effective activity. As the magnitude of the spread increases, the cost of an eradication attempt and the chance of failure rapidly increase by orders of magnitude (BRS, 2003).

A BRS study funded by NHT identified potential sleeper weeds that could be potentially eradicated (Cunningham et al, 2003). A preliminary short list of 144 potential sleeper weeds was identified on the basis of previous work. The short list was reduced to 17 species for analysis. These 17 have been in Australia for 5 to 100 years (now not permitted for import). Of the 17, the 10 with the highest relative benefit to cost ratio were recommended for further analysis regarding eradication. The Weeds CRC is now managing field surveys of the 10 highest priority sleeper weeds to determine their extent (CRC Weeds, 2003d; CRC Weeds, 2004a).

An overall conclusion from this work is that methods for prioritising sleeper weeds in agriculture have been developed and there appears to be much evidence that eradication is likely to prove economic for these weeds. The method could also be applied to environmental weeds but this has not been done. Groves (undated) make the point that most resources go to reducing the impacts of known weeds. Fewer resources go to managing environmental weeds, but this is changing.

The PMSEIC recommended the Australian Government work with the States and Territories to rapidly eliminate newly introduced organisms and small infestation of existing introduced organisms, that are assessed as potential environmental pests, weeds or diseases (PMSEIC, 2002).

Overall, there appears to have been limited funding provided to sleeper weeds on a national scale over the past ten years (CRC Weeds, 2003b). Groves (undated) also makes the case for more attention given to sleeper weeds as the benefit-cost ratios for such investment may be high. He reports few if any formal programs for containment or eradication of sleeper weeds. Glanznig (2003) states that the institutional arrangements to handle sleeper weeds have not yet been tweaked and that the National Weeds Strategy has only recently started to address sleeper weeds through an Alert List.

Some vertebrate pest species are 'sleepers'. For example, black rats were once associated with cities and towns, farmlands and drainages, but have become much more widespread in the last 10 years. They now inhabit forests and other ecosystems far from settlement (Newsome, 2001).

### 5.4.6 Alert Lists

*Environmental Alert List*

Studies have identified potential environmental weeds that are amenable to eradication (SoE Australia, 2001). A National Environmental Alert List for environmental weeds was developed in 2000 to identify plants that are in the early stages of advancement towards becoming weeds and which have the potential to make a significant impact on biodiversity. The list is made up of 28 non–native weeds that have established naturalised populations in the wild (they include Siam weed, horsetail, kochia, and a number of broom species (DEH, 2004).

Achievements and comments on the Environmental Alert List include:

- An example of progress with the environmental alert list is use of a 1976 record for following up on blue hounds tongue found near Eden in NSW in 1976. This was followed up by contacting the local noxious weed officer. The officer armed with photos went to the original site and later found some 30ha of the weed 11 km upstream (CRC Weeds, 2004d).
- The Alert List is not considered to be useful to regional groups as a number of species are not of concern to government agencies or the community; there was no consultation involved (Queensland Government, 2003)
- The objective basis for the selection of weeds on the DEH Alert List has not been made clear (Weed Management Society of SA, 2003). Although the environmental alert list has been produced, it has not been agreed to nationally.

DEH provided funds for a study to determine the relative weed risk of species on its Alert List for Environmental Weeds (CRC Weeds, 2004a). The project has not yet been completed.

*A Wider Alert List for Weeds*

There is a need for an equivalent formally recognised "alert list" for weeds that can impact on agriculture and or/the environment. Such a list could address both species that are not yet present in Australia as well as those species that have entered Australia and could become weeds.

Some activity has been undertaken with regard to identifying high risk invasives (plants) that are not yet present in Australia. Four criteria were developed to select a priority list of potential weeds. Criteria were:

- absent or here but not naturalised;
- history overseas;
- could be sold as garden ornamental, medicinal herbs, fodder plants etc; and
- predicted to have a national impact or an impact of national significance.

Particular attention was given to new garden ornamentals as this avenue of introduction is the most significant source of additional weed species (AWC, 2001).

These criteria were applied to 700 species defined as part of a review initiated by AQIS. The highest ranked species were (AWC, 2001):

- broomrape;
- floating water chestnut;
- horsetail;
- kochia;
- Miconia; and
- witchweed.

Groves (2002) makes the case that future research and management should be aimed at those species only recently introduced or naturalised, before their negative or positive effects are expressed fully. Groves et al (2003) categorise the 2,700 introduced naturalised plants into groups of major or minor threats to natural ecosystems and agriculture. Some of these are weeds overseas and therefore could have similar effects in Australia and are targets for eradication programs. A total of 34 were recommended for eradication and another 8 with wider distribution also could be targeted.

A case was made (Thackway et al, 2004) that a national inventory of invasive and potentially invasive plant species in Australia would be a valuable policy and planning tool. It would involve a more systematic approach to identification of a comprehensive national list of high risk species, such as selecting targets for pre-emptive action for increased surveillance.

In this regard, national level plant lists that already exist include:

- Candidates for the DEH alert list for environmental weeds (DEH, 2004);
- Priority weeds identified in Groves et al (2003); and
- Northern Australia Quarantine Strategy Target Plant List.

A comprehensive national list of potential and actual eradication targets for priority environmental and agricultural weeds developed, agreed and adopted by the Australian government and all State and Territory governments does not exist. (Glanznig et al 2004a).

The detailed list of 20 species of Australian flora and fauna that are threatened by specific invasive plants (CRC Weeds, 2003b) could also be used in compiling such a list if it were compiled.

*Tasmanian Alert List*

A Weed Alert Network for Tasmania was established in 1999 to increase the chances of finding new introduced or recently established weed species.

Achievements and comments on the Tasmanian initiative include:

- Between 1999 and 2001, 13 new weed alerts were identified of which seven are known to adversely impact biodiversity values and 12 of the 13 are known to affect agricultural production, and two to adversely affect horticultural activities (SoE Tas, 2003)

*Alert Lists for Vertebrate and Invertebrate Pests and Disease*
There does not appear to be a national alert list for vertebrate pests or invertebrate pests that are not specifically pests of agricultural animals. Animal Health Australia maintains a list of animal diseases to be alert for.

At times, State governments or local councils will issue warnings or notices to be alert in relation to specific species, for example fire ants, crazy ants, giant African snail and red-eared slider turtle (Queensland DNR&M website, 2004).

Some high profile pests (and even some environmental pests) that are not yet present in Australia have been targeted in surveillance programs. There include the guava rust fungus that infects numerous Eucalyptus species and poses the most significant threat to Eucalyptus plantations and native plant communities in Australia (Lonsdale, 2003).

There are restrictions on the trade and keeping of high-threat vertebrate species that are already held in captivity as domestic animals or within wildlife parks, petshops and aquaria in order to reduce the risk that they escape or are released and subsequently establish wild pest populations. These species are already past quarantine barriers and usually have not had independent risk assessments on their potential for invasion if released. Reasonably reliable knowledge exits of which exotic vertebrate species already held in Australia and robust science-based risk assessment processes are required to identify these high-threat species (BRS, 2003). The cost and responsibility for conducting risk assessments of pest potential for exotic vertebrates already present in Australia but not yet established in the wild is an issue to be resolved. The VPC has attempted to list all exotic vertebrates (except fish) present in captivity or the wild in Australia. However relatively few of these species have had a risk assessment conducted to determine the threat they pose. According to VPC lists there are currently 218 exotic mammal, 246 bird and 148 reptile and 12 amphibian exotic species present in Australia. Finding the number of fish species is difficult due to detecting species that might be held illegally and significant taxonomic problems in identifying them (BRS, 2003).

The World Conservation Union has nominated the 'World's Worst 100 invaders'. Examples of two of these animals that present a threat to Australia include the giant African snail and the red-eared slider turtle. Information sheets on both of these species have been prepared by the Queensland Government in order to encourage the public to be alert for such species.

The giant African snail (*Achatina fulica*) is one of the world's largest and most damaging land snail pests and has the potential to be a serious environmental and agricultural pest. In large numbers, the pest represents a public nuisance as it leaves behind large trails of slime and excreta. It does not occur in Australia however is occasionally detected on imported shipping containers and materials. There was an outbreak of the snail in Gordonvale, Qld in 1977 which was quickly eradicated. The main risk of introduction to Australia is in plant material, crates, containers, machinery and motor vehicles. In addition the egg stage could be imported in soil. AQIS inspects imports from infected areas. Empty pallets and ground stacked shipping containers are fumigated.

The red-eared slider turtle was recently found in the Pine Rivers Shire in South East Queensland and colonies are present in New South Wales. It poses an extreme risk to the biodiversity of Queensland and Australia. The Queensland DNR&M has established a specialist task force comprising the Local Council, Queensland Parks and Wildlife Service, Queensland DPI&F, Queensland Museum and AQIS. In addition to competing for food and space in waterways and lake systems, larger specimens can inflict a painful bite. The species has few natural predators in Australia. It is illegal to keep the turtle in Queensland and it cannot be imported into Australia. It was originally imported as an aquarium pet in the 1960s and 70s and eventually released into the wild (Queensland DNR&M website, 2004).

Economic analyses and incursion modeling are both tools that can be used to determine the likely impact of a pest or disease incursion.

An example of the potential impact of an invertebrate pest that is not yet present in Australia but which presents a high risk is the screw-worm fly. The economic costs of screw-worm fly if it were to successfully establish in Australia include occasional animal deaths, declines in production, damage to hides and underlying muscle, the cost of insecticides and the cost of additional labor for treatment and management of protocols. Introduction would require frequent livestock inspections for management of unstruck wounds and treatment of wounds already infected by the larvae. An eradication program of a similar species in Libya in 1998 cost approximately $75 million US at a benefit-cost ratio of 50:1. The economic cost of an invasion depends on the point of entry, for Brisbane the cost has been estimated at $281 million per year (Canyon et al, 2002).

In regards to animal diseases that are not yet present in Australia:

- $6.2 million was allocated by the Australian Government in 2004/05 to AQIS to protect birds and wildlife from avian influenza. The additional money was to be used to enhance border protection at airports and seaports and to strengthen protection against such a viral epidemic. Additional staff were employed and a targeted awareness campaign conducted to alert travelers to the risks of bringing in avian influenza through poultry products, feathers and eggs (Kemp, 2004).
- An outbreak of Foot and Mouth Disease in Australia could immediately close down some 90% of the export market for animal products, and cost Australia up to $3 billion p.a. in lost export trade, even if the disease was eradicated immediately (Olsen, 1998). If the outbreak persisted, continuing losses could be between $0.3 and $4 billion a year, depending on whether the trade was affected in just one State or country-wide (Olsen, 1998).

## 5.5 Emergency Response and Eradication

### 5.5.1 Response Processes

Response processes refer to having coordinated eradication plans in place including nationally agreed lists, decision making procedures, and a formula for pre-commitment of resources.

The States have their own incursion management protocols under their own legislation (SA Animal and Plant Pest Control Commission, 2003). At the Australian Government level, DAFF in conjunction with State/Territory and industry stakeholders has developed arrangements to manage pest and disease incursions that have the potential to impact upon Australia's primary industries. The Primary Industries Ministerial Council has responsibilities for plant and animal pests; and the Natural Resource Management Ministerial Council deals with weeds and marine pests (DAFF, 2003). At an operational level the coordination of Australian Government and State Government involvement in incursion management is primarily undertaken through consultative committees. These consultative committees make recommendations to the Standing Committee of the relevant Ministerial Council on further action before determining if eradication is feasible. The Standing Committee may either endorse a recommendation for no action or makes a decision on recommendations regarding eradication and the funding formula. It has not been possible in this review to analyse the response times for decision making and how they may be reduced through higher levels of preparedness.

At the operational level, the Product Integrity, Animal and Plant Health Business Unit is the focal point for the Australian Government's involvement in emergency responses involving pests and diseases with potential implications for Australia's agriculture, fisheries and forestry industries. DAFF has recently established an Emergency Risk Management Unit to coordinate and facilitate DAFF's involvement in such emergency preparedness and response activities, most notably the recent FMD simulation 'Operation Minotaur'.

Also, the National Information Manager's Technical Group has been funded by the Primary Industries Stranding Committee under a cost sharing agreement. The Group is developing surveillance, quarantine, control and recovery software for use in emergencies. The same application interface will be used for animals, plants, pests, weeds and incursion incidents at both the routine and emergency levels, giving consistency and reducing staff training issues in major incidents (John Thorp, pers comm., 2005).

**Animal Health**

Animal Health Australia manages the Emergency Animal Disease Preparedness (EADP) program on behalf of its members. It has been a core program of AHA since 1996 and has the following key components:

- Emergency Animal Disease Training Program
- Livestock Industry Awareness
- AUSVETPLAN Development
- Emergency Animal Disease Watch hotline
- Funding of emergency disease responses
- Biosecurity plans
- National Approach to Small Hive Beetle
- Screw Worm Fly Preparedness Project

The National Emergency Animal Disease (EAD) preparedness and response system in Australia is the sum of activities carried out by the States, Territories and Australian Government, the livestock industries, CSIRO, private veterinarians and laboratories

and other animal health workers in relation to disease surveillance, monitoring, response and programs.

The EAD Response Agreement provides certainty of funding for the initial response to a disease incursion or outbreak through a partnership of the Australian Government, State and Territory governments and major livestock industry organisations. It specifies 63 diseases classified into four categories with the share of costs between governments and industries depending on the beneficiary of control as measured against the impact on human health and socio-economic concerns, the environment and livestock production. Categorisation can be reviewed and new diseases added as circumstances change. The costs of each party are managed by applying an "agreed limit" that ensures intense examination of costs and benefits before committing to further national resources (AHA website, 2004). The livestock contributions are obtained by means appropriate to that industry but generally by a statutory levy, initially set at a zero operative rate that could be activated in the event of an emergency response (Phil Hitch, pers comm., 2005).

The EAD Response Agreement has other important provisions relating to the conduct of a response to an emergency animal disease. It uses a series of existing standards such as the Australian Veterinary Emergency Plan (AUSVETPLAN) and defines standards for training of response personnel, accounting and auditing. AUSVETPLAN is the nationally agreed arrangement for responding in a consistent manner to an outbreak, or suspected outbreak of an exotic animal disease anywhere in Australia. It sets out agreed roles, responsibilities, coordination arrangements, financial arrangements, policies and procedures.

AHA also manages the National Animal Health Performance Standards or benchmarks that are being developed across all sectors of the animal health system. Each industry party prepares and promulgates a plan to improve on-farm biosecurity arrangements. This means encouraging the adoption by all producers of simple measures to reduce the likelihood of a serious disease spreading. In addition government parties have prepared statements outlining their biosecurity policies and programs including feral animal, public health and environmental policies (AHA website, 2004).

The livestock industries are formally included in decision making about the management of a disease outbreak. This is through a high-level committee comprising chief executives of government parties and presidents of livestock industry parties formed to manage response plans and budgets and to monitor expenditure. This committee is called the EAD National Management Group (NMG) and also carries responsibility for decision making on policy and resource allocation issues. Technical representatives of each relevant industry are also appointed to the Consultative Committee on EAD that is the key technical coordinating body providing links between the parties and advising the NMG on the national response to an emergency disease outbreak (AHA website, 2004).

The National Emergency Animal Disease Training Program was developed to provide on-going, proactive education and training to producers, veterinarians and other stakeholders in the Australian livestock industries. The Training Program aims to ensure all personnel who take part in an emergency animal disease response are

competent to perform their role; develop a national team of trained personnel who are competent to perform their duties in any jurisdiction; and each State and Territory to have a competent, accredited control centre team by June 2004. All member agencies have agreed to support AHA's competency based assessment and training program (AHA website, 2004).

Additional funding was provided under the "Building a National Approach to Animal and Plant Health' initiative and funding in the 2001 and 2002 Budgets to strengthen post-border preparedness, enhance epidemiological and diagnostic resources and boost rural veterinary services (DAFF, 2003). In the 2002-03 budget the government provided $10 million over four years for additional DAFF veterinary epidemiology and emergency management staff, and for increased AAHL testing capacity (AHA, 2004).

In 2003 there were no Emergency Animal Disease incidents within Australia that required a national response. However the Consultative Committee on Emergency Animal Diseases met occasionally in response to developments overseas such as avian influenza in the Netherlands and BSE in Canada and USA (AHA, 2004).

Newcastle Disease is a highly contagious viral disease of domestic poultry, cage and aviary birds and wild birds. Outbreaks of virulent Newcastle Disease in localised areas of New South Wales were eradicated between 1998 and 2001. In 2002 there was an isolated outbreak west of Melbourne in Victoria and at Horsley Park in NSW. Avirulent strains of the disease are present in all States and it is thought that the outbreaks of virulent strains evolved from an existing Australian strain. There was no evidence that the outbreaks were caused by a virus recently introduced from overseas. The 2002 outbreaks were eradicated using the process described in AUSVETPLAN. In addition the EAD Response Agreement was enacted for the first time and industry were involved in the decision making process for the response. The EAD NMG asked AHA to coordinate a review of Australia's management of Newcastle Disease and this resulted in active monitoring and surveillance as well as compulsory vaccination in designated risk areas. The review resulted in the development of the National Newcastle Disease Management Plan 2002/03 to 2003/04 which has been successfully implemented. A revised plan is being considered (AHA website, 2004).

The linkage of exotic disease to vertebrate pest management has been addressed through the Wildlife Exotic Disease Preparedness Program, with Wild Animal Control Manuals being produced for AUSVETPLAN (Newsome, 2001). The Wild Animal Management Manual of AUSVETPLAN has been reviewed and is now known as the Wild Animal Response Strategy (AHA, 2004).

An exotic disease preparedness exercise was held in north Queensland to assess the process to control feral animals infected with diseases such as FMD (Queensland Government, 2003).

In 2003 the Australian Wildlife Health Network was involved in disease investigations that included cases of facial tumours in Tasmanian devils, *Leishmania spp*. infection in red kangaroos, and a suspected Pacheco's disease outbreak in parrots.

During 2003 there was a major change to Australia's management of aquatic animal health when the Aquatic Animal Health Committee replaced the interim Fish Health Management Committee. This was accompanied by a five-year review of AQUAPLAN. Exercise Tethys was also held which was a simulation of a major disease outbreak. The review of AQUAPLAN found a need to develop cost-sharing arrangements for managing aquatic animal health in Australia (AHA, 2004).

Active and passive surveillance for aquatic animal diseases identified several disease outbreaks in 2003. All outbreaks were caused by the recurrence of known endemic diseases.

**Plant Health**

Finding the papaya fruit fly in Northern Queensland in 1995 and subsequent commitment of over $60 m over five years to eradicate the fly prompted the development of a new Australian Government framework for emergency management of plant health (Evans et al, 1999).

Nairn (1996) stressed the need for plant pest and disease to have pre-incursion agreements in place and a formula for sharing eradication and compensation as with animals. The then current situation was seen as leading to deficient reporting. Some contingency plans had been developed already for plants eg. fireblight, black sigatoka (Nairn, 1996), but they were the exception rather than the rule.

The situation in 2000 was that if agreement to eradicate was reached, a cost sharing formula was invoked such the costs of eradication are shared between the Australian Government and States on a 50-50 basis. The states share their 50% on the basis of value of production at risk. Only direct operating costs are considered and no compensation for producers is considered. The burden therefore fell on individuals or individual industries (CIE and CSIRO, 2000).

Cost sharing arrangements for emergency plant pests have been agreed in principle and are now awaiting formal approval by government and plant industries. These formal arrangements are expected to come into force in the first half of 2005 (Phil Fitch, pers. comm., 2005).

The importance of having cost sharing arrangements in place is illustrated by Cole (undated) with regard to the potato spindle virus in Western Australia. It was decided the best action was to destroy the crop but as there were no compensation mechanisms in place the decision was delayed and had to be supported by biological data. The crop was eventually destroyed anyway, but in some cases this delay could be costly.

Panetta et al (2002) defined principles to be used when an exotic plant incursion warrants a nationally coordinated response with cost sharing. If a decision to eradicate is made then the species should not be available for sale in Australia, prohibited for trade if it has been for sale, and the species has to be prohibited by AQIS.

Draft nationally consistent guidelines for management response procedures for emergency pest incursions affecting Australia's plant industries have been produced recently by Plant Health Australia (PHA, 2004). PLANTPLAN is based largely on AUSTVETPLAN.

Plant health legislation varies considerably between States and Territories. Also, there are gaps in legislation in some States and Territories whereby few State and Territory governments have specific powers to control or eradicate across all land types, immediately establish quarantine measures, destroy healthy plants or establish buffer zones (PHA, 2004). One of the central elements underpinning PLANTPLAN is a formal cost sharing agreement covering industry/government funding arrangements for the eradication of emergency plant pests. More formal cost sharing arrangements will now replace the present informal arrangements. Pre-incursion categorisation will be effected to enable quick responses; the category will determine the cost sharing arrangements based on beneficiary pays (PHA, 2004).

One of the inputs required under pest categorisation will be that of regional impact. In this regard a preliminary model has been developed by ABARE that assesses the regional economic impact of a hypothetical incursion and includes the commercial, wholesale and retail losses (Elliston et al, 2004).

*When incursion is deemed not feasible to be eradicated*
If an incursion is considered beyond eradication, then there is no system for joint Australian Government/State action of joint funding for any containment program within one State or more. The Weeds CRC believes that it should be possible to continue with a containment program when all parties agree (CRC Weeds, 2003b). Glanznig (2003) also promotes the idea of the case for a national strategy for containment, as now it is just left to the States.

*Gaps*
A number of gaps appear in emergency response and eradication processes. These include:

- In the DAFF submission to the Senate Inquiry (2003) the VPC is not referred to in reference to emergency response and none of the other committees appear to address pests like fire ants.
- The question needs to be asked as to how well environment interests have been integrated into the development of decision making arrangements.
- Regarding who pays, Davis and Grimm (2003) make the case that the whole of the community need to be involved and financially support the management of an incursion of an invasive species. This may mean the interests of agriculture, forestry, the environment, and even human health need to be represented and involved adequately.
- It would appear that there are no preparedness funds held in reserve by governments specifically for eradication of invasive species.
- As of October 2003, cost sharing arrangements were not in place for weeds, vertebrate or aquatic pests, but were in place for animal diseases (DAFF, 2003) and under development for plant pests.
- Glanznig and Kessal (2004) identify that for naturalised non-native plants recommended for national eradication or containment, there is a strong State/Territory bias towards agricultural over environmental invasive plants.

### 5.5.2 Eradication Achievements

**Weeds and Plant Diseases**
Eradication of some plant diseases has been achieved in the past ten years. These are not addressed in the review, although the case study on black sigatoka in Section 6 refers to one eradication. The remainder of this sub-section refers to weed eradications.

Early eradication of invasive plants provides a greater return in both financial terms and in terms of the environment measured by the avoided extinction of native plants and animals (CRC Weeds, 2003b). There are a number of examples of eradication of naturalised weeds. Groves et al (in press as cited by BRS (2003)) identified 29 naturalised plants and 156 cases where they have or are being eradicated within States and 16 species where eradication is being attempted on a national scale (BRS, 2003). Also, many potential weeds have been eradicated before becoming established as a naturalised or self sustaining population, although this is rarely reported in the literature (BRS, 2003).

Siam weed (*Chromolaena odorata*) is one weed where a ten year eradication program has been operating with mixed results in north Queensland (CRC Weeds, 2004a). Expenditure on the program totals $1.3 m to June 2003. The weed was first found in 1994. Further outbreaks were discovered in Townsville, Mossman and Innot Hot Springs. A review in 2003 identified that the program was progressing towards eradication from known sites but was limited by not knowing the full extent of the infestation (Carter and Dodd, 2003).

Eradication of Branch Broomrape is underway in South Australia (Mark Ramsey, pers comm, 2004). Alligator weed (a WONS) was found in Tasmania but was eradicated from that State in 2000. Also Chilean needle grass has been found in Tasmania but believed no longer present (SoE Tas, 2003).

The aquatic weed salvinia was eradicated from Adelaide River in the NT over a 10 year period from 1977. Bitterweed spread over 50 ha in two infestations and by 1997 it was eradicated after 370 person days of work over 39 years. Seroty weed was first detected near Brisbane in 1962 and by 1970 had spread to two sites covering 0.5 ha. It was eradicated after 50 person days over 18 years (BRS, 2003).

Kochia was introduced in WA in 1990 to 52 properties as a plant to tolerate salinity and by 1992 had spread to 270 properties over an area of 3,200 ha. Eradication commenced in 1992 and by 2000 the area infested had been reduced to five ha. By 2003 it was considered eradicated. This was considered to be one of the most successful national eradications (BRS, 2003), despite the knowledge of knowing where the weed was due to its intentional planting. The total cost of eradication was $500,000 (CRC Weeds, 2003d).

Based on examining 9 weed eradication programs within Australia, Groves and Panetta, 2002, cited by AWC (undated) suggest two general principles determining success:

- Weed eradication programs will be feasible if there is less than 100 ha, if the weed occurs at three or fewer locations, the weed is found in easily accessible sites and is readily detectable, and
- If the weed has a period of seed viability in the soil > 5 years and/or continues to be traded by nurseries and others, the longer will be the period required for eradication.

A later contribution by Panetta and Timmins (2004) refines these principles.

Woldendorp and Bomford (2004) present information on 20 weed eradication programs (eight completed, four where control is complete but still monitoring, seven ongoing and one failed). Of those eight that have been successful, seven covered less than 4 ha of infestation; the others were present in larger areas. The one that failed covered 3,400 ha in area. These results support the theory that a small net area of infestation increases the likelihood of a successful eradication.

The cost of eradication is a function of net area of infestation with small net areas reducing the cost of eradication. Using the cost figures derived, the estimated costs for potential eradication of ten sleeper weeds were between $5300 to $550,000 per weed (Woldendorp and Bomford, 2004).

**Animal Pests and Invertebrates**

The risk analysis framework for vertebrate pests (Bomford, 2003) identified the following factors that influence the feasibility of eradication:

- Rate of removal exceeds rate of increase at all population densities
- Immigration is zero
- All animals are at risk from eradication methods
- Animals can be detected at low densities
- Discounted cost benefit analysis favours eradication over control
- Suitable socio-political environment

The same document also noted that no eradication campaign against any widely established exotic vertebrate species has ever been successful on any continent. However there have been some successes on islands (eg. eradication of cats from Macquarie Island). The timing of an eradication attempt in relation to establishment will also influence the probability of eradication being achieved.

It is noted by Bomford (2003) that eradication of newly established exotic vertebrates in Australia is only likely to be achievable if appropriate, adequately-resourced, contingency plans are in place to ensure that escapes are reported, newly established populations are detected and reported, and containment and control programs are mounted rapidly.

An example of a recent eradication attempt in Australia is the ongoing activity with the red imported fire ant (RIFA) or fire ant. The details of this eradication program are provided as a case study in Section 6, however some institutional factors associated with the eradication are discussed here.

The often fragmented and reactive approach to pest management has been less than ideal in attempting to respond to a pest of the potential magnitude of fire ants

(Queensland Government, 2003). Inadequacies experienced by Queensland with the current arrangements include a lack of clarity in the roles and responsibilities at Ministerial Councils and at agency level in response to pests like fire ants, with very broad-scale impacts across social, environmental and production sectors.

Queensland interests also note that the existing Threat Abatement Plan framework under the EPBC Act may have limited capacity to assist in coordinated action for the early eradication of a pest such as the fire ant. It is noted that in theory a TAP could have been used to establish a plan for the eradication effort agreed by funding partners. However, the capacity to coordinate quick action for this type of species is crucial to any attempts at eradication. The statutory timeframes associated with listing and approval of such a plan are unworkable in these circumstances (Queensland Government, 2003).

Currently, new incursions of serious invertebrate pests such as fire ant and crazy ant are not dealt with under the NRM Ministerial Council. This was identified as a significant institutional omission (WWF, 2003b).

Crazy ants were discovered in Cairns in April 2001. Three Queensland government agencies (DNR&M, EPA and DPI&F) provided a cash budget of approximately $120,000 together with in-kind from all parties. This infestation was successfully eradicated. There was a subsequent infestation in Townville in February 2002, as well as an infestation in Brisbane, and these were both also successfully treated, with no further ants found at these sites (Queensland Government, 2003). The Queensland government notes that on-going surveillance is important to detect possible re-introductions as if a population was to spread from a port of entry it will be significantly more expensive to control than incursions to date (Queensland Government, 2003).

For example, crazy ants were introduced to Christmas Island in the 1930s, however they have only become a major threat to biodiversity more recently. They are now threatening as many as 20 animal species on the island, including the red crabs that are critical to the dynamics of the rainforest communities on the island. They can contribute to canopy dieback and are difficult to control as they form supercolonies, have an extremely broad diet, and forage in three dimensions. Contact sprays, dusts and toxic baits have been successfully used to control the ant on the island due to its lack of native ant species. However, due to the length of time the ants have been present on the island, successful eradication is unlikely. Control of the population is the only option remaining (SoE Australia, 2001).

The discovery of foxes in Tasmania in May 2001 led to an initial fox response group being established in June 2001, however at that stage it was only funded month by month with a handful of staff. State and Australian governments were said to wrangle over funding requests and in January 31 2002 they announced dedicated funding for the new Fox-free Tasmania Taskforce. This included funding for permanent and casual field staff positions, as well as working on strengthening quarantine measures. Community involvement at this stage was limited however mainland experience has shown that the community supplies most fox sightings and does much of the monitoring and control. Community involvement is now more apparent with

conservation, hunting and landholder positions being created on the Taskforce Steering Committee (Feral Herald, 2002**)**.

There have been no more actual fox carcasses produced by the Taskforce or the community since the initial pair in 2001, however a number of fox scats have been positively identified and at least one set of footprints as well. Quality sightings continue to come in throughout 2002 and 1080 baiting was occurring over 6,000 ha in three distinct areas. The Taskforce was originally funded for a three year program with $1.2 million from the State Government and $400,000 from the Australian Government.

## 5.6 Containment and Control of Existing Invasive Species

### 5.6.1 Weeds and Plant Pests

*National Weeds Strategy*
In general terms the National Weeds Strategy has been highly successful in focusing on some weeds (WONS) and coordinating across jurisdictions. In fact the strategic approach to invasive control pioneered with weeds has been promoted to be used with other invasive species (CSIRO, 2003). The strategy has had a principal focus on the WONS which again has demonstrated the benefits of coordination at the established species level. Reporting against goals, objectives and strategies for the period 1997-2002 is provided in a 2002 report (National Weeds Strategy Executive Committee, 2002).

Some of the major achievements of the National Weeds strategy as at February 2002 are listed below (DEH, 2003a). The full list is provided in DEH (2003a).

- More effective border control and the development of a weed risk assessment system for plant imports
- Development of alert and sleeper weed lists
- Establishment of a process for prioritising and determining the WONS
- Development of administrative processes for managing WONS and national strategies developed for their management
- Internet site providing information about weed management
- Promoted complementary laws in relation to weeds at Australian Government, State, Territory and local government levels

*Weeds of National Significance (WONS)*
The major activity of the National Weeds Strategy was to develop a list of Weeds of National Significance (WONS). The development of this list (announced in June 1999) by the Australian Government and the States was a mainstream activity of the strategy. The final list of 20 weeds was selected from a list of 71 based on invasiveness, economic environmental and social effects, current distribution and potential for spread, and impact on desirable plants (SoE, Australia, 2001). The WONS include both terrestrial and aquatic weeds. WONS is really a ranking exercise so therefore estimating the potential for future spread is quite important. The process used is described in Thorp and Lynch (2000). Much of the Weeds CRC economic impact study was based on the WONS effort.

The methods used in identifying the WONS and the methods of assessing their distribution have been endorsed by BRS who are refining the methods used so that before and after maps can be produced (John Thorp, pers comm., 2004). However, no updating of these maps on a national basis has been undertaken due to lack of resources. Changes in established weed populations are generally long term and cost-effective monitoring periods for a national assessment are therefore likely to be associated with long intervals between assessments (John Thorp, pers comm., 2004).

The objective of defining the WONS was to ensure that the major weed species in Australia were under coordinated national management. Management strategies have been developed for each of these species, coordination teams developed, and reporting against these strategies has been undertaken. However, implementation of WONS plans by the coordination teams has been slower than expected due to the high level of consultation required (SoE Australia, 2001).

The progress reports for each of the 20 WONS against strategies are currently being finalised (WONS, 2004).

Activities described in most of the reports include awareness raising; production of fact sheets and control and management manuals, guides and best management practices; extension activities; city and shire council activities, some initiatives on detection; activities to minimise seed spread; workshops; surveys and mapping; bio-control initiatives; on ground projects; and case studies of success in particular areas. Some reports include methods of spread and some revised maps and new containment lines. Activities in more than one state are described to various degrees. Some changes in localised institutional arrangements are reported. An example of a coordinated output is that parthenium is now mapped on a 50 km grid system for all of Australia; the national parthenium map currently being produced incorporates NSW and NT data with that of QLD.

Several reports (eg. those for salvinia and lantana) demonstrate the constraints regarding trade and compliance referred to earlier. For example, salvinia is declared noxious in all States but is still found in retail outlets, backyard ponds and aquariums and Sunday markets.

The total resources invested in the plans for individual species are not available (with 3 or 4 exceptions). Funding would include regulatory and extension costs of the States and Territories, funding from LandCare and community groups and NHT funding. This could be seen as a serious gap as the WONS initiative is a major investment in a coordinated activity and benefit-cost analyses may eventually be seen as highly desirable in both a management and accountability sense.

Weaknesses of the WONS approach that have been noted by Agtrans during this review included:

- The initiative did not engage the many people working on weed problems other than the 20 weeds;
- National strategies developed by stakeholders (multi-state) on other weeds were effectively downgraded;

- As the initiative was based on single species, these species dominated scarce resources and reduced resources for strategies directed at potential weeds.

While the WONS program has generally been seen as an excellent initiative, the funding of pond apple (one of the 20 WONS) was raised as an example of inadequate funding: "There were no Commonwealth funds in 2001 or 2002 allocated and the spread of pond apple is continuing unchecked (CRC Weeds, 2003b)." It has been reported that aquatic weeds are creating major problems in Australia's water resources and yet aquatic weed management in Australia has been poorly funded and lacks expertise (CRC Weeds, 2004d). There is also a comment that there has been limited funding from DEH for the WONS initiative (Weed Management Society of SA, 2003).

The WONS program has only 12-18 months funding commitment that effectively sidelines it, given the long-term nature of control (McFadyen, 2003; Glanznig, 2003). Commitment of funds for at least five years is required (McFadyen, 2003) for the WONS program. A similar case was put by Peacock (2003) for pest animal control R&D.

Many of the performance criteria reported against require simplification and reduction in number to be measurable and meaningful. Reporting is against broad objectives rather than against outcomes. The latter would provide some indication over time as to progress, even if only qualitative.

There does not appear to be any information as to the overall trends in success or otherwise for particular WONS since each strategy was implemented (eg. increase or decrease in areas or density, benefits or likely benefits or reduced impact achieved for the investment to date, and no emphasis on quantitative outcomes).

The kind of reporting statement that would be useful would be: "For five weed species, recent action under the national weed strategy has seen significant activity on all of these species, reducing density of these species if not area of land affected" (Queensland Government, 2003).

*R&D and New Technology*

Comments have already been made on the contribution made by the CRC Weeds in providing a focus for weed R&D. The challenge is to identify, develop and implement cost effective new technology for containment and control of invasive species.

CRC Weeds has worked on Bitou Bush, Boneseed, Bridal Creeper, Broom, Blackberry, Horehound and St Johns Wort. In 2001 the CRC achieved another 7 years of funding and developed two programs of relevance to environmental weeds: a landscape management program plus a weed incursion and risk management program that includes sleeper weeds (SoE Australia, 2001).

Biocontrol appears to offer great promise and has already achieved much with biological control agents being dispersed to assist in management of a range of species (SoE SA, 2003).

Some of the achievements reported include:

- Biological control and active containment programs are having a major impact on some weeds including rubber vine and parthenium (SoE Qld, 2003).
- Bio-control has been successful in a range of studies and is beginning to deliver results – bridal creeper, Pattersons curse, rubber vine, blackberry (CRC Weeds, 2003a)
- Biological control agents are being developed to control 37 weed species in NSW. Of these 14 have had a significant impact on the target weed population including Pattersons curse (crown root weevils); alligator weed (flea beetle) and bitou bush (tip moths and seed flies). Bitou bush also has a national research project on biological control plus collaborative R&D on biological control of lantana (SoE NSW, 2003).
- There have been over 60 weed biological control agents released over the past 2 decades (Queensland Government, 2003).

Costs and benefits include:

- Bio-control programs can cost between $1 to $7 million in total and can take ten years; this compares with the annual cost to Queensland of rubber vine of $27 m per year (CRC Weeds, 2003a)
- Bio-control programs can take a long time to pay off but in the end they are a good investment (McFadyen, 2003)
- CIE and CSIRO (2000) found that appropriate benefit cost ratios are 30 to 1, and at least one in four bio-control programs deliver complete or valuable partial control.
- Biological control systems are appropriate for those species already established; they are cost effective, but slow and require investment up front (PMSEIC, 2002).
- The Weeds CRC work on biological control of bitou bush has the potential to deliver $45 m of gains in present value terms over the next 30 years – through savings on control costs, improved biodiversity and improved amenity value. This compares with costs of $2.2 m indicating an internal rate of return of 29% (Blood, 2001).

Constraints raised with biological control include:

- Bio-control can deliver permanent solutions to control but not eradication (CRC Weeds, 2003a)
- Biological control agents are very closely regulated and this provides a disincentive to researchers; a more efficient approach is needed for importing agents for evaluation of their potential as biological control agents (Nairn, 1996).
- The rate of biological control agent release has slowed in the past 14 years despite there being virtually no non-target impacts since appropriate non-target risk assessment procedures were implemented. The exception is the impact on the introduced fiddlewood tree of the approved biocontrol agent *Aconophora compressa* introduced to attack lantana.
- From 1974 to 2000 there was an average of five releases per year for new biological agents against weeds issued each year in Australia, but since 2001, the rate has dropped to only two a year (McFadyen, 2004a)
- A more balanced approach is needed in assessing benefits and risks of biological controls. There is a good track record with introduced insects and pathogens controlling about 80% of the weeds they were introduced to suppress with

virtually no damaging effect on the ground. Hence Australia is spending a lot of money avoiding a very small risk (McFadyen, 2004a). On the other hand, the rarity of non-target impacts could be an indication of the effectiveness of the regulatory controls. Detailed risk assessments are necessary as illustrated by the impact of the cane toad, originally imported as a biological agent to control sugarcane beetles.

- Biological control programs often need to be implemented in conjunction with more conventional methods to effect containment or control.

*Community Involvement and Awareness*

The involvement of the community and their level of awareness are important elements in the efficient and effective control of weeds. There is a wide range of community groups involved in weed projects. For example, in 2005 there were 868 Landcare groups in NSW involved in weed projects, a significant increase from the 557 groups working on weeds in 1999 (Richard Carter, pers comm., 2005). There are a number of State based weed awareness program as well as national weed awareness programs (eg Weed Watch supported by the Weeds CRC and Weedbuster Week that is linked to the State Programs).

Weedbusters is an awareness program that works with communities to achieve sustainable land and water management. It commenced in Queensland in 1994 and in 1997 Weedbuster week was launched nationally and is held in October each year. An analysis of the investment in this program showed that for every dollar invested in education activities, $44 were returned (Queensland Government, 2003). The program has spread to New Zealand and South Africa.

The Weed Warriors program was developed in 2001 by the Weeds CRC. The initial focus was on schools in Victoria but now the program extends nationally. Activities include class room projects, experiments and field activities including biological control and the development of linkages between communities, industry and government. For example, in 2001/02 Weed Warriors targeted bridal creeper where students reared and released leafhoppers and rust fungus. In 2003 the program focused on gorse and rearing and releasing a gorse spider mites (DEH, in press).

A number of programs that raise awareness of invasives are also run by AQIS, NAQS, Northwatch and industry (for example in Western Australia, Grainguard and Hortguard). In some cases capacity of local government has been increased to deliver strategic weed management programs. The development of the national weed management competencies and their inclusion in the Conservation and Land Management Training Package have made an important contribution.

A series of weed management guides for the WONS and for the Alert list for Environmental weeds has been produced by the Weeds CRC. These guides are also useful for raising awareness and for identification and management.

No studies were identified that investigated the level of community awareness of sleeper weeds and the past history and current potential of nursery plants to become weeds in the future. Such studies could be an important source of information in the design of effective awareness programs on this issue.

*Primary Industry Threats versus Environmental Threats in Control*
A recent review of the OCPPO stated that management of plant pests in non-agricultural areas or without agricultural significance was not the responsibility of the OCPPO (OCPPO, 2000). However, it was recognised that the only significant expertise and structures for management of plant pest incursions was in the OCPPO and State Agriculture Departments. As a result the review panel endorsed the effort to engage Environment Australia and other relevant agencies on this issue (OCPPO, 2000).

Legislation does not work as effectively as it may do for established weeds when the target weeds are new or environmental weeds. This is because there is hesitancy to enforce control in bushland or only on a few landholders (Weed Management Society of SA Inc, 2003).

### 5.6.2 Animal Pests and Other Invertebrates

*Australian Government Activities*
In relation to vertebrate pests and pests of animals, most of DAFF's efforts and responsibilities are aimed at exotic invasive species and protection and response (as distinct from established pests). This includes managing the development and implementation of international agreements and undertakings; pre-border and border monitoring, detection and control arrangements; and national policies and programs to manage emergency pest incursions (DAFF, 2003).

DAFF is also involved in the management of these species to the extent that there is a significant and discernable national interest (DAFF, 2003).

While the responsibility for the management of established pests rests fundamentally with State, Territory and local governments as well as landholders and industry, the Australian Government may play a role in funding and setting the strategic framework that other stakeholders implement. DAFF through Product Integrity Animal and Plant Health (PIAPH) has a significant role in facilitating a coordinated and concerted effort to address established pests where there is a clear and discernable national interest.

At present for established and widespread vertebrate pests, eradication in Australia is not feasible. The current objective of feral animal management is to reduce the damage caused by pest species in the most cost-effective manner. This approach involves localised eradication, periodic reduction of feral numbers and sustained reduction of feral numbers, and removal of the most destructive individuals or exclusion of feral animals from an area (DEH website, 2004). Strategic Sustained Management (SSM) is a method that usually means reducing populations to a density below that from which they can rapidly recover, and keeping them there (Quentin Hart, pers comm., 2004).

It is possible that there are species of exotic naturalised fish and birds that are only present in localised populations and for which national eradication is still feasible (Bomford, pers comm., 2005).

Australian Government activities and national gaps include:

- The Vertebrate Pets Committee is currently in the process of preparing a National Pest Animal Strategy.

- A strategic approach to the management of ornamental fish in Australia is currently being drafted.
- The NFACP is administered by BRS and is focused on strategic, sustained best practice management of agricultural pest animals where they are causing actual rather than perceived damage (SoE SA, 2003). The NFACP which supports applied research projects which are developing improved control techniques and strategies to improve the efficacy, economics, humaneness and safety of pest animal control (Hart, 2002).
- DEH manages the Australian Government's activities in relation to environmental pest animals through its Invasive Species Program (BRS, 2003). This includes coordinating the development of National Threat Abatement Plans for invasive species listed under the EPBC Act as key threatening processes.
- With a focus on agricultural impacts of pest animals, BRS has prepared guidelines for the management of rabbits, foxes, feral goats, feral pigs, rodents, carp, wild dogs and feral horses. These guidelines identify deficiencies in legislation, research, extension and management that are hindering effective management of each species (Hart, 2002).
- The Queensland Government (2003) notes in its submission to the Senate Inquiry that to date Australian Government funds delivered under the NFACP have not had a nationally agreed strategic focus or direction (Queensland Government, 2003). However the VPC signed off on the species management guidelines which BRS/NFACP uses to guide project funding which provides some level of national endorsement of the program's activities (Quentin Hart, pers comm., 2005).
- There is no clear input or direction federally on some invasive species such as birds or urban pests which include pigs, foxes and various bird species. These pests suffer from a lack of acceptable control options as options used in rural areas can often not be used in urban areas (Queensland Government, 2003).
- There is no real consistency in regard to permitting and regulating the keeping of imported exotic organisms (Queensland Government, 2003).
- It is in the area of management of established pests where the lack of clear distinction in roles between States and Australian Government leads to duplication, uncoordinated service delivery and ineffective use of funds. A major problem appears to be poor communication on priorities and programs between the two levels of government (Queensland Government, 2003).

*State Activities*

Some State activities in control and containment are listed below. Not all States/Territories are covered.

New South Wales

- The main responses to managing pest animals in NSW include:
    - Placing obligations on public and private landholders to develop management plans under the Rural Lands Protection Act 1998
    - Identifying and developing management plans for threatening pests under the Threatened Species Conservation Act 1995
    - Regulating licensed hunters under the Game and Feral Animal Control Act 2002 (SoE NSW, 2003).

- In 2000-01 the NPWS conducted more than 900 pest animal control programs of which more than 70% were run in collaboration with neighbouring landholders and other stakeholders (SoE NSW, 2003).
- NSW agriculture conducts R&D programs to reduce environmental and agricultural impacts of vertebrate pests (SoE NSW, 2003).

Queensland
- A Queensland Pest Animal Strategy has been developed (SoE Qld, 2003).
- The Land Protection (Pest and Stock Route Management) Act was passed in 2002. This provides for pest plants and animals to be declared in three classes, each of which imposes a different set of obligations on landholders (SoE Qld, 2003). It also prevents the importation of all mammals, amphibians and reptiles not native to Queensland (Queensland Government, 2003).
- Chemical barriers have been used in some parts of Queensland, generally for large vertebrate pests such as dogs, pigs and foxes. These programs involve coordinated poison baiting along geographic barriers such as high country or changes in ecosystems from grasslands to forests (Queensland Government, 2003).
- In Queensland a large group of potential pest animals is contained by permitting their keeping only in regulated facilities such as circuses, zoos, tertiary institutions or government stations (Queensland Government, 2003).

South Australia
- The SA Animal and Plant Control Commission (APCC) is responsible for administering and implementing the Animal and Plant Control Act 1986. The APCC provides for local control and policy development through Animal and Plant Control Boards (SoE SA, 2003).
- Estimates of annual economic benefits to agriculture through APCC Programs (1996) were $72.8 million due to the prevention of the establishment of new exotic animals; $62.0 million due to the management of rabbits; $9.4 million due to the management of dingoes; $1.4 million due to the control of other vertebrate pests (SoE SA, 2003).

Western Australia
- The Western Shield Program, managed by Conservation and Land Management (CALM) in WA aims to bring at least 13 fauna species back from the brink of extinction by controlling foxes and feral cats on almost 5 million ha of land (SoE Australia, 2001). The program uses 1080 and has shown a decrease in fox numbers and a dramatic increase in native animal numbers. Three forest-dwelling mammals have been removed from the State's Threatened Fauna List as a result (SoE Australia, 2001).
- Reintroduction of the numbat to a WA nature reserve was not entirely successful as reducing the foxes had led to an increase in cats (Olsen, 1998).

Tasmania
- Of the 44 environmental pests in Tasmania only 14 are covered by control/eradication programs and only six have been formally declared by legislation as a pest species (SoE Tas, 2003).
- Many of the 14 programs are for individual areas and do not cover the full geographic distribution of the relevant species. For example only 0.18% of the

feral cat and black rat range is covered by a management plan and only 4% of the rabbit range (SoE Tas, 2003).

- Only 3 of Tasmania's 59 islands known to support vertebrate pests have active pest management actions in place (at Feb 2002) including Flinders, Bruny and Macquarie Islands (SoE Tas, 2003).
- Vertebrate pest management on Macquarie Island has been conducted since 1974 and ongoing quarantine strategies exist (SoE Tas, 2003). Cats were recently eradicated, and control of rabbits, rats and mice is ongoing.

*Activities by Pest Species*

The terrestrial vertebrate pests present in Australia have mostly been present in Australia for decades, and therefore control of those species is the only remaining option. Examples of control programs and strategies for the major pest vertebrates are provided below.

| Species | Control programs/activities |
|---|---|
| Foxes | • In 1999 a national threat abatement plan was approved for the red fox under the EPBC Act. The plan identifies species most at risk from fox predation and the localities where the benefits of fox control will be greatest.<br>• In South Australia, priority has been given to managing fox numbers in selected, high conservation areas around the State. For example, Operation Bounceback, the Ark on Eyre Program and the West Coast Integrated Pest Management Strategy. These programs have resulted in a decline in fox numbers over the last 10 years in the Flinders and Gammon Ranges and on parts of the Eyre Peninsula. There has been native species recovery as a result (SoE SA, 2003). Elsewhere in South Australia foxes remain a problem despite some significant baiting (SoE SA, 2003).<br>• Foxes were probably only introduced to Tasmania in the last five years. The Tasmanian government has formed the fox free Tasmania taskforce to prevent the establishment of foxes in Tasmania (SoE Tas, 2003).<br>• The Pest Animal Control CRC is currently developing a fertility control vaccine delivered in a non-toxic bait attractive to foxes. It contains the canine herpesvirus and will only affect foxes (PAC CRC, 2004a).<br>• The Western Shield program in WA protects over 5 million ha using 1080 (PAC CRC, 2004a).<br>• After eight years of fox control in two rock wallaby colonies, populations increased four to five fold. Following fox control on Dolphin Island, the sightings of Rothschild's rock wallabies increased nearly thirtyfold, and following fox control for five years in Dryandra State Forest, numbat numbers increased significantly (Bomford and Hart, 2002).<br>• In NSW fox control has been shown to increase mallee fowl (Bomford and Hart, 2002).<br>• Control of foxes is an important element of endangered species recovery programs (eg. bridled nail tail wallaby program at Idalia |

| | |
|---|---|
| | National Park, turtle program at Mon Repos and Brushtail Rock Wallaby program at Crows Nest) (Queensland Government, 2003). |
| Cats | • Control is labour intensive as cats can be trap shy, do not take baits readily and avoid human contact. Barrier fences are the most effective technique but high costs means it is only useful for small areas of land. Recreational shooters kill feral cats; however the impact of this is not known (McLeod, 2004).<br>• Macquarie Island was officially declared cat free on 25 June 2003, with no cats having been found for more than two years. This was the result of a $1.2 million joint State and Australian Government pest management program funded by the NHT between 1997 and 2001. The situation is still monitored. The grey petrel seabird has successfully returned and the recovery of the endangered blue petrel has continued. Mice and rats are now being targeted through localised baiting programs to ensure that the absence of cats does not lead to population explosions in these species (DEH, 2003b).<br>• A felid (cat) toxin is being developed by DEH in conjunction with Victorian and Western Australian governments. |
| Rabbit | • Release of the rabbit calicivirus is the major control action taken in the last ten years, however traditional methods of control (baits, warren destruction and removal of shelter) are encouraged to enhance the effectiveness of the virus.<br>• RCV can cause mortalities of up to 95% among adults, although regional variation in infection rates can be significant (SoE Australia, 2001).<br>• PAC CRC is developing a fertility control vaccine delivered with the myxoma virus (PAC CRC, 2004b).<br>• Concerns about the humaneness of chloropicrin, a pressure fumigant used in rabbit warrens, led BRS to support work on a new carbon monoxide fumigation technique (Hart, 2002).<br>• The Darling Downs-Moreton Rabbit Board (DDMRB) region in Qld is an ongoing containment zone, defended by both a fence and staff that maintains a zero rabbit tolerance policy. The local governments in the Board area fund its activities to the value of $0.8 million per annum. The returns have not been calculated. The DDMRB region is the only sizeable suitable habitat on mainland Australia where rabbits have never established (Queensland Government, 2003).<br>• In Queensland two biological control agents, and Spanish fleas to improve spread, have been released and landholders/local government staff are providing assistance and training in mechanical control and other methods (Queensland Government, 2003).<br>• Bulloo Downs Station in western Qld, where an estimated 25% of the states rabbits occur, has been subject to adaptive management using Australian Government, State and landholder funds. A study showed that the calicivirus was present but that its action was not |

| | |
|---|---|
| | fast enough to keep up with rabbit production due to the ecology of the Bulloo River floodplains. Warren ripping near permanent water resulted in immediate rabbit impact reduction with subsequent increased flora and fauna. Ripping of the dense warren areas was cheapest due to reduced travel. Costs were $1,300 to $3900 per square kilometre. Funding for this ripping is seen as a successful way of integrating old methods into a better management package (Queensland Government, 2003). |
| Pigs | • Amateur hunting may reduce the feral pig population by 7.5% a year (McLeod, 2004).<br>• Community-based feral pig trapping program in the Wet Tropics. Over 800 traps have been deployed. These are mostly on the interface between the World Heritage Area and neighbouring landholders. Since 1993-94 (until publication) the program trapped over 12,000 pigs; 2,000 during 01-02. The program is funded by a partnership across federal, state and local organisations and community groups and individual landholders (SoE Qld, 2003).<br>• Hunting and commercial harvesting are likely to be affecting less than 20% of the total pig population annually (PAC CRC, 2004c). |
| Dogs/dingoes | • Coordinated campaigns against wild dogs are commonly undertaken (SoE Qld, 2003).<br>• There is a comprehensive wild dog management strategy and on-ground management programs including the wild dog barrier fence, 1080 baiting programs and working with communities in Queensland (Agribox News Headlines, 2004).<br>• BRS has supported a major wild dog management project in SE NSW for the past five years. There has been considerable input from all collaborators and signs of long-term change (Hart, 2002).<br>• A canid (Wild dog/fox) specific toxin is being developed by the PAC CRC. |
| Mouse | • Baiting with strychnine is the major control mechanisms used in plague situations. Other techniques to reduce populations include removal of rubbish, mouse-proofing of grain storage facilities, grazing livestock on stubble, removal of weeds and optimisation of machinery harvesting configuration to minimize spillage during harvest (McLeod, 2004).<br>• Mice plagues still occur as they are influenced by climate. There has been no measure of change in the severity of impact of plagues due to advances in any of the possible control mechanisms (McLeod, 2004).<br>• PAC CRC is developing a fertility control vaccine delivered using a non-toxic bait or virus that is highly specific to mice. The virus being modified is called murine cytomegalovirus (PAC CRC, 2004d). |
| Goat | • An Australian Government funded goat eradication program carried out in key areas of the State during the past five years has achieved localised success (SoE Tas, 2003).<br>• On Townshend Island, Queensland, a small herd of milking goats |

| | |
|---|---|
| | grew to about 2,000 in number and were having a negative impact on native vegetation. In 1993 16 dingoes were introduced and within 25 months only 4 goats remained. These were shot and the dingoes were removed (Olsen, 1998).<br>• The commercial harvest of feral goats has resulted in a reduction in impacts and a higher level of containment (Queensland Government, 2003). |
| Cane toad | • Main controls on the spread of cane toads are quarantine checks between states and public awareness and response (McLeod, 2004).<br>• Control of toads so far has been unsuccessful (Olsen, 1998).<br>• Currently no direct actions are taken on cane toads in Queensland other than general awareness (Queensland Government, 2003).<br>• NT has established a program to limit imports, and the Australian Government and Western Australia have recently announced a preventative program (DEH, pers. comm., 2005).<br>• Research on control methods is being undertaken by CSIRO (Queensland Government, 2003). |
| Wild Horses | • A range of control methods are used including immobilisation using drugs delivered by dart rifle; mustering and trapping; ground shooting and shooting from helicopters (McLeod, 2004).<br>• In Palm Valley in central Australia over 1,000 brumbies were removed. Vegetative changes are now obvious on the floor of the valley and rock wallabies, which previously could only be found up in the surrounding hills, now live on the lower slopes and graze out on the valley floor (Newsome, 2001). |
| Camel | • Ongoing control activities include mustering and shooting (SoE SA, 2003)<br>• Harvest of camels for sale may become a significant component of their management (SoE SA, 2003) |
| Feral deer | • Control is currently ad hoc (SoE SA, 2003) |
| Starling | • The WA government has successfully eradicated starlings. Pockets of starlings were shot and trapped, and a team established to regularly patrol caves and other potential roost sites on the Nullarbor Plain, thereby maintaining an effective barrier to potential immigrants form eastern Australia. This costs the WA Government about $350,000 each year to kill the 1,000 or so starlings annually that attempt to migrate into the south-west. (Olsen 1998) |

*Aquatic Vertebrates*

Exotic fish are managed by State Governments using a number of regulations including legislation, strategic planning, community consultation and on-ground control actions. There is variation in regulations and permitted species between jurisdictions which can lead to confusion.

In Queensland, legislation relevant to exotic fish is the Fisheries Act 1994 and Fisheries Regulation 1995. Eighteen species or families of exotic fish are declared as noxious in Queensland and these fish cannot be possessed, reared, sold or bought

unless a permit has been obtained. Noxious fish are to be killed immediately and disposed of away from the waterway and are not to be used as bait. Non-indigenous fish must be kept in a way to prevent their escape and are not to be released into waterways. Anyone found to be contravening the legislation face large fines of up to $150,000.

"Control of exotic pest fishes – an operation strategy for Queensland freshwaters 2000-2005" was released in 2000 and was developed to complement and support the Murray Darling Basin Commission National Management Strategy for carp control 2000-2005 and the DNR&M Queensland pest animal strategy 2000-2005. The strategy emphasises the control of exotic fishes within the framework of best practice for vertebrate pest control and provides a framework for regional planning and on-ground actions. The strategy has a full time officer and operating budget for implementation (Queensland Government, 2003). Preventing new infestations is largely undertaken by an extensive education campaign including posters, media campaigns, brochures, signs and education modules (Queensland Government, 2003).

A specific control option for managing feral fish that is successful though costly is the installation of screen barriers across outlets and balancing storages of dams. They have a mesh small enough to prevent the transfer of eggs and larvae of the species of concern and cost over $2 million. This approach needs to be combined with education campaigns to stop people using the fish as bait downstream of the barrier (Queensland Government, 2003).

The Vertebrate Pests Committee has recently been expanded to include freshwater fish species, and the Committee is in the process of preparing a National Pest Animal Strategy which will include such species.

Also, the Ornamental Fish Policy Working Group is in the process of developing a national strategic approach on ornamental/exotic fish which partly aims to address inconsistencies in legislation and policy between jurisdictions relating to permitted/noxious species and any effective controls.

*Invertebrate pests*

The small hive beetle (SHB) is an exotic pest that invades honeybee hives. It was first detected in Australia in late October 2002 in the Hawkesbury region near Richmond in NSW and subsequently traced to Stroud and the Cowra/Woodstock area of NSW, Binalong 40 km NW of Yass and Beerwah, 80km north of Brisbane (AHA website, 2004). The National EAD Management Group formed to address the issue determined in December 2002 that eradicating the infestation from Australia is not feasible and that a national strategy should be developed to assist beekeepers manage the exotic pest. The SHB National Management Plan was endorsed by the SHB National Management Group on 16 December 2003. The management plan aims to reduce the impact of SHB on productivity, slow the spread of SHB in Australia and minimise the damage in infested apiaries. Ongoing surveillance and communications are key elements of the plan.

*Monitoring control actions*

The Department of Environment and Heritage commissioned Victoria's Arthur Rylah Institute to undertake a project aimed at understanding the benefits of feral animal

control on mitigating the threats of the feral species to native species and ecological communities. The first stage of the report (Reddiex et al, 2004) was recently completed and details an audit of existing feral animal control activities in Australia. Future stages include identification of gaps in information, recommendations for filling these gaps, development of pest species monitoring protocols and designing a process to determine priority ranking for control of feral animals in order to minimise threats to native species and ecological communities.

The review team surveyed federal, state/territory and local government agencies potentially involved in feral animal control.

The studies recommendations were:

- Study designs that include replicated and randomly allocated treatment and non-treatment areas, and adequate monitoring of changes in the abundance of both pests and resources.
- Contracts for the delivery of feral animal control must stipulate strict conditions about the design of the control program and its associated monitoring programs and reporting. At the least actions should include pre- and post-control monitoring of the abundance of the feral animal and conservation resources being protected, and if at all possible include one or more non-treatment areas.
- Federal and state/territory agencies should design and implement feral animal control operations with the intention of undertaking meta-analysis on the key outcomes of the operations.
- Standard protocols are required for estimating the kill rate of feral animals and native species during control operations, and the absolute or relative abundance of feral animals and conservation resources.
- Organisations/funders need to collate and store data from feral animal control operations and any associated monitoring in a way that is both accessible to managers and amenable to future meta-analysis.

### 5.6.3 National Threat Abatement Plans

Nine species (both plants and animals) have been listed as key processes that threaten the environment. Several disease causing organisms are also listed (DEH, 2003a). After a species is listed, draft plans for managing the threat are developed and approved after consultation.

For example, a draft plan for phytophthora was circulated in July 1999 when it was estimated that over $10 million would be needed to be spent in the five years to implement the plan (SoE Australia, 2001).

Threat Abatement Plans (TAPs) have been developed by the Australian Government for some vertebrate pests that include:

- Competition and land degradation by feral rabbits
- Predation by the European red fox
- Predation by feral cats
- Predation, habitat Degradation, Competition and Disease Transmission by feral pigs
- Competition and land degradation by feral goats

The plans focus on strategic approaches to reducing to an acceptable level the effects of processes that threaten the long-term survival of native species and ecological communities (SoE Australia, 2001).

While providing a focus on the particular invasive species, there have been several criticisms of the usefulness of the plans. For example, Glanznig (2003) states that the plans are not very useful in practice and more direct controls are required. Queensland Government suggest that plans are not fully implemented due to resourcing constraints. The plans provide limited capacity for coordinated action, the process is slow, they do not apply to all land types, and there is not a high level of cooperative planning with the States and community (Queensland Government, 2003).

One observation made in Queensland is that although TAPs are statutory, they have limited applications to Australian Government lands and for all other lands they need State cooperation (Queensland Government, 2003).

### 5.6.4 Investment and Decision Making on Control

In terms of resource allocation it is important to be able to estimate the costs and likelihood of success of different responses to invasive species including early eradication, containment, damage mitigation and inaction (BRS, 2003). Inaction is only acceptable when the costs of action exceed benefits or there is no method to control the pest. Inaction can be a very expensive option for a newly discovered pest (BRS, 2003).

In terms of priority setting across species for control or containment, it is necessary to tradeoff the negative impact of a weed against the benefits that some weeds bestow on the environment (eg. habitat compared with what may have been there otherwise), socially (new ornamentals) or their use in productive activities (pasture grasses, honey production). The indirect impact of control measures also needs to be considered (chemical use, non target impacts).

Another important decision problem therefore is the resolution of "weedy" conflicts of interest for species already in Australia. Virtue et al (2004b) point out that some trees, grasses and other plants are being cultivated in Australia that are weeds or potential weeds and that inconsistent action has been undertaken to date to reconcile these conflicts of interest.

The analysis of a range of weed control projects funded by local government and the State of Queensland produced high benefit-cost ratios ranging from 1 to 28, with all investments profitable and some delivering a very high rate of return (AEC Group, 2002). This analysis showed that early eradication or suppression provided significantly greater benefits than other forms of weed and pest animal management (AEC Group, 2002).

An independent study in 2000 by CIE showed that available control measures for many invasives are highly cost-effective (CRC Weeds, 2004c). CIE (2001) cited in CRC Weeds (2004a) showed that CRC research saved $900 m in present value terms and gave an internal rate of return of 29 to 62%. Major beneficiaries were agricultural producers (CRC Weeds, 2004a). The CRC Weeds is currently undertaking an

evaluation of assessment methods to ensure that they are collecting the data needed to demonstrate the economic return on research (CRC Weeds, 2004a).

In terms of setting national priorities on an objective basis there are issues associated with judging the importance of weeds that impact on primary industries versus those that are environmental weeds or impact on social infrastructure and amenities such as waterways and water storages, or where there are impacts such as human health and safety involved. Two questions are apparent:

- Who should pay when there are multiple sector impacts?
- What process can be used to allocate resources when there are options to invest in competing impact types?

Little information on experience with incentives to assist control with invasive species was identified in the review (eg. bounties, cash rewards for early detection, part of wider ecosystem enhancement incentives, local government incentives for removal of invasive plants, incentives for nurseries not to sell specific plants).

Virtue et al (2004a) describe a national protocol for post-border weed risk management that can be used to set priorities in weed management. The protocol refers to early intervention, eradication, containment decisions and covers risk management needs for commercial uses of plants.

A number of decision making aids have been developed over the past few years to assist with decisions on resource allocation. Some of these stretch back to resource commitment to eradication and prevention of entry. Examples are:

- The choice of an optimal plant and animal disease management strategy that directs whether resources should go into border controls, measures to restrict spread (such as quarantining), and measures to increase the probability of detection (Beare and Hinde, 2001).
- The minimisation of total costs when there are recurrent episodes of pest or disease incursions and including costs of hazard reduction, eradication and control. For example it may pay under some circumstances to decrease the hazard rate and then eradication is not needed so many times (Cao and Klijn, 2004a, b).

## 5.7 Summary

**Institutional arrangements**

*Plants*

1. In 2000 the scope of the Australian Weeds Committee was extended to include all weeds (those of primary industry, forestry and the environment).
2. The development of the National Weeds Strategy between 1992 and 1997 was a major achievement in coordination between the Australian Government and the States and Territories.
3. The Weeds CRC established in 2001 (and its forerunner) have provided a focus for weeds research and a degree of national coordination.
4. The CRC for Tropical Plant Protection established in 2000 (and its forerunner) has produced valuable outcomes in terms of diagnostics and improving resistance to important plant diseases.

5. The Office of the Chief Plant Protection Officer was established in 1997 and has provided a focus for the national coordination of plant protection activities.
6. Plant Health Australia established in 2000 has provided a focus for centralising information and coordination of plant health functions involving and affecting governments and a range of industries.

*Animals*

7. Animal Health Australia was established in 1996 with the aim of improving the national capability, standards and performance of Australia's animal health system, animal disease surveillance, and emergency animal disease preparedness.
8. The Pest Animal Control CRC (established in 1999) has pursued scientific approaches to the management and control of Australia's established pest animal species.
9. The National Feral Animal Control Program was established in 1996 with funding provided through the Natural Heritage Trust for national level support. It has focused on capacity building through extension and training, as well as developing improved approaches to vertebrate pest control.
10. The Vertebrate Pests Committee has expanded to include freshwater fish species and native pest species. It is also currently in the process of developing a National Pest Animal Strategy.
11. The OFPWG was established in 2003 to develop a national strategic approach on ornamental/exotic fish. The draft strategic approach to the management of ornamental fish in Australia will soon be released for consultation.
12. The OCVO was established in 1995 and provides national leadership and coordination of animal (including aquatic animal) health activities.

*General*

13. The establishment of Biosecurity Australia in 2000 has separated the policy and market access functions of government from that the operational activities of AQIS. Biosecurity Australia became a prescribed agency in December 2004.
14. States and Territories have developed various institutions and strategies over the ten years including weed strategies, animal pest strategies, exotic fish strategies and in Queensland an interdepartmental pest management committee.
15. Gaps in institutional arrangements include:
    - There has been no national vertebrate pest strategy or national strategies that deal with exotic freshwater pest fish, however a National Pest Animal Strategy including terrestrial vertebrates and freshwater fish is currently being prepared. Also a national strategy for ornamental fish is currently being developed.
    - There is no institution that focuses on invertebrate pests that cause mainly social or environmental impacts.
    - Institutional arrangements for handling environmental and social pests are generally less well developed than those for agriculture that have evolved over many years.
    - With the delivery of many government resources for on ground activities through regional groups in the future, arrangements for ensuring coordination of invasive investment and activities will be required, for example integrated regional plans and state agency/scientist input.

**Prevention of entry**

1. AQIS has continued to develop programs to increase awareness of the Australian community of the importance of quarantine and some of these programs have been highly successful.
2. Australian initiatives pre-border such as research and other forms of assistance to other countries has contributed to Australian knowledge, experience and preparedness as well as reduced threats to Australia by strengthening quarantine services in neighbouring countries.
3. A large increase in the budget for border protection in 2001 led to an increase in Australia's quarantine intervention and substantially strengthened border control with higher interception and effectiveness levels reported by AQIS.
4. Improved risk assessment processes were introduced for animal pests in the early 1990s and re-evaluated in 2003.
5. AQIS changed to a three tier system for assessing imported plants and seeds in 1997 that included a permitted list, an improved import risk analysis process, and a prohibited list. The change has been viewed by most as a highly effective policy, but some flaws have been identified as detailed below.
6. Some progress has been made in identifying sources of entry of weeds to Australia. The majority of plants that have become weeds were introduced to Australia in the very early days after settlement. Most of those that have been introduced since have been legitimately introduced for other purposes (eg. ornamentals and agriculture) and have become weeds at a later stage. At least 65% of naturalised species over the period 1971 to 1995 emanated from earlier ornamental introductions.
7. Gaps identified include:
    - It is not clear that many of the pre-border activities excluding those of NAQS and AQIS take account of overall priorities that may have been set in Australia regarding invasive species, for example, the activities of ACIAR.
    - Some listings of plants on the permitted list for imports are by genus and not by species or variety, leaving entry open to weed species in particular genera (the schedule 5 loophole); an accelerated review of the permitted list is now underway.
    - Importation can sometimes be allowed for a plant that is prohibited as it may fall within a permitted genus into which it had been previously classified (different name).
    - Both changes to classification and listings of genera of fish can cause confusion of the status of species in relation to importation. In addition, the physical capacity of agents on the border to be able to accurately identify over 400 different species of fish can be a limitation to the border security process
    - There is perceived lack of independence of vertebrate risk assessments as due to constraints on knowledge there is a subjective component to risk assessments that requires input by suitably qualified experts. Applicants often pay for a risk assessment and it is thought by some that arrangements are not yet in place to ensure that an independent authority undertakes the risk assessment for the import of exotic vertebrates.
    - The prevention of entry by invasives through direct seed ordering from overseas via the internet may constitute an area of risk.

**Surveillance**

1. Surveillance has been successful with a number of new pests detected identified and sometimes eradicated over the ten year period.
2. Diagnostic capacity has been important in enabling eradication and containment of plant diseases over the ten year period and in supporting quarantine measures, for example in assessing imports of rooted plant material.
3. AWC has been attempting to better coordinate the different legislation, regulations and structures throughout Australia that contribute to weed plants still being traded. Nationally consistent legislation regarding sale and importation from other states is being developed, albeit slowly, with some States responding more quickly than others. The approach to date of seeking voluntary removal from sale of known garden invasives has increased awareness of the issue but has not been effective overall.
4. Sleeper weeds have been identified and prioritisation for eradication has been undertaken but not agreed to by jurisdictions; priorities are based only on BRS studies at this stage.
5. Alert lists for high priority invasives have been developed for both weeds of primary production and of the environment; however, a comprehensive national list of potential and actual eradication targets for priority environmental and agricultural weeds has not been agreed nationally and used.
6. Some high risk invasive plants that are not yet present in Australia have been identified using criteria of history overseas, pathways for entry and potential impact. Various other high profile pests that are not yet present in Australia have been targeted in surveillance programs.
7. A high level of community awareness has proven to be an important part of monitoring and surveillance. For example, communication and raising awareness regarding fire ants has resulted in the identification of more established nests outside the official surveillance zone.
8. The likelihood of early detection of invasive plant species should be increased through the implementation of a national reporting system, a targeted awareness program and the establishment of a free hotline to encourage reporting by the public.
9. Gaps identified include:
    - Current State legislation (with the exception of Tasmania) does not oblige landowners or diagnostic laboratories to report suspicious new incursions of potential invasives. Also, the cost recovery policy of AQIS may dissuade some reporting.
    - Invasive species that do not directly threaten primary production generally have not been strongly targeted for surveillance at a national level, largely due to a lack of clarity of institutional roles and responsibilities, and undeveloped institutional structures and budget processes. Surveillance is weaker for environmental pests, social insects and fish. Examples include fire ants, cats and cane toads. In some cases methods for surveillance are also undeveloped.
    - A national policy for pest and disease surveillance could be considered that addresses awareness raising in communities at a generic level, as well as funding, targets, surveillance levels, methods, and training for specific invasive species and groups of species.
    - While further investment in diagnostic capacity has been made in the past ten years, particularly through DNA libraries and molecular testing, there have

been examples of delays from not having a nationally agreed and accepted diagnostic procedure in place prior to an incident.

- While it has been recognised that there is a need to restrict trade nationally in weedy species, only two states prohibit the sale of all 20 Weeds of National Significance. Further, many potential weeds are already in Australia but are traded and kept without restrictions in gardens and nurseries. These potential weeds could be made subject to risk assessments so that priorities can be formed for the development of approaches to reduce the threat to the environment and agriculture.
- Apart from nurseries, other sources of potential weeds that exist in Australia are the Genetic Resource Centres, botanic gardens, arboreta and tree seed collections. These facilities contain a significant number of plant accessions that have legally passed through quarantine. Most have not been subject to a weed risk assessment and few jurisdictions insist on a risk assessment before germplasm is released to plant breeders or the wider environment.
- Resources and action to eradicate or contain sleeper weeds have been lacking despite the likely cost-effectiveness of such a strategy.
- The compilation of a national list of invasive and potentially invasive plant species in Australia using a more systematic approach to identify high risk species has been promoted for selecting targets for pre-emptive action and for increased surveillance.
- The alert list for environmental weeds has been criticised as not being useful to regional groups as a number of species are not of concern to government agencies or the community; there was inadequate consultation involved, and the basis for the selection of weeds on the list was not made clear; the list is not recognised nationally.
- There is a need for an equivalent formally recognised "alert list" for weeds that can impact on agriculture and or/the environment. Such a list could address both species that are not yet present in Australia as well as those species that have entered Australia and could become weeds.
- There is no national alert list for vertebrate pests or invertebrate pests that are not specifically pests of agricultural animals, however there are sometimes individual warnings or alerts put out, for example for the giant African snail and red-eared slider turtle.
- While the Vertebrate Pests Committee has attempted to list all exotic vertebrates present in captivity or the wild in Australia, relatively few of these species have had a risk assessment conducted to determine the threat they pose, even though they are already past quarantine barriers. The cost and responsibility for conducting such risk assessments is an issue that has not been resolved. A similar situation may apply to invertebrates that are primarily social or environmental pests.

**Emergency Response and Eradication**

1. Over the past ten years, formal response arrangements have been developed and implemented for managing exotic pest and disease incursions affecting animal and plant health. The Department of Agriculture, Fisheries and Forestry, through the OCVO and OCPPO, has led the development of these arrangements and, in actual emergencies, leads the national response.

2. Arrangements to manage pest and disease incursions that have the potential to impact upon Australia's primary industries have been established, in the case of parasites and diseases affecting animals through AUSVETPLAN and the Emergency Animal Disease Preparedness Program managed by AHA.
3. The animal industries approach to National Emergency Animal Diseases is considered an excellent model on which to base responses to incursions in other industries or sectors (eg. plants, vertebrate and invertebrate pests).
4. Wildlife health is monitored through the Australian Wildlife Health Network which was established in 2002 in order to develop a coordinated national program focused on the health and diseases of free-ranging wild animal populations to better prepare Australia for serious disease outbreaks in its wild and feral animal populations.
5. Nationally consistent guidelines for emergency pest incursions affecting Australia's plant industries (PLANTPLAN), based on AUSVETPLAN have been drafted recently by Plant Health Australia.
6. Eradication of some new plant diseases and weeds has been achieved in the past ten years. Most have been in the early stages of developing into pests. Early eradication of an invasive species has been shown to be far preferable in terms of cost effectiveness as the feasibility and cost of eradication increases as the invasive spreads. There are few examples of any weed or invasive animal pest that has been eradicated once it has become widespread. Exceptions are successes on islands, including cats on Macquarie Island, and the weed Kochia has been eradicated in Western Australia (considered to have been widespread).
7. Principles for assessing the likely success of a weed or animal pest eradication program have been developed. Useful information has been assembled regarding the costs and feasibility of weed eradications that should be useful in considering future eradication options.
8. The National Information Manager's Technical Group is developing surveillance, quarantine, control and recovery software for use in emergencies. The same application interface will be used for animals, plants, pests, weeds and incursion incidents.
9. Historically, detection and management of invasive species has been the responsibility of primary industries and related government agencies due to the large and noticeable economic impact on such industries. Invasive species with a largely environmental or social impact have tended to be given less attention in relation to detection, surveillance, R&D, and control actions. This is partially due to a lack of a funding and skills base for such activities.
10. Gaps identified include:
    - Preparedness plans for incursions generally do not exist for pest and disease incursions that do not have a significant primary industry impact. Environment interests have not been well integrated into the development of decision making on response arrangements for plant health.
    - Preparedness plans also do not exist for responding to new incursions of pest animals (either for species with potential primary industry or environmental impacts).
    - The importance of not having cost sharing agreements in place has been stressed and demonstrated over the past ten years. However, as of October 2003, cost sharing arrangements were not in place for weeds, vertebrate or aquatic pests, but were in place for animal diseases and under development for plant pests.

- The principle of beneficiary pays has not been incorporated effectively into response arrangements with regard to the environment and broader social beneficiaries (eg. human health). Although taxpayers via governments are responsible and ultimately provide resources, the specific channels and institutional structures used for funding and cost sharing are not well developed and can cause delays.
- There are no preparedness funds held in reserve by governments specifically for eradication or containment of newly discovered invasive species.
- The Queensland Government's experience with fire ants demonstrates that there is a lack of clarity in roles and responsibilities when dealing with a pest with very broad-scale impacts across social, environmental and production sectors. This can lead to delays in pursuing an eradication or control program.
- There are gaps in legislation in some states and territories whereby few State and Territory governments have specific powers to control or eradicate across all land types, immediately establish quarantine measures, destroy healthy plants if necessary or establish buffer zones.
- If an incursion of an invasive is considered beyond eradication, then there is no system for joint Australian Government/State action of joint funding for any containment program within one State or more. This constitutes a gap in the arrangements when it may well be in the national interest to contain the species.
- There may be bias in the States and Territories of eradication programs towards weeds of primary production as opposed to environmental weeds. This should be confirmed and reasons for this situation identified.

**Containment and Control**

1. In general terms the National Weeds Strategy has been highly successful in providing a focus for a concerted effort on containing or controlling some weeds (WONS), coordinating across jurisdictions, and identifying sleeper and alert weed lists.
2. The WONS program, together with the National Facilitator, have generally been seen as excellent initiatives and provide examples of coordinated activities between the States.
3. Nine species have been listed as key processes that threaten the environment and threat abatement plans (TAPs) have been developed or are being developed, and are administered by DEH.
4. The ten years has demonstrated that bio-control offers great promise and has already achieved much with biological control agents being dispersed to assist in the management of a range of invasives. Bio-control investment has been shown to be highly cost-effective.
5. While there have been no examples of eradication of vertebrate pests on mainland Australia, there are some success stories in relation to control of vertebrate pests which has resulted in the recovery of native vegetation and endangered fauna.
6. The most successful control of a vertebrate pest species in Australia in the pest ten years is most likely the rabbit, through the release of the Rabbit Calicivirus Disease.
7. The ecological impact of control actions and programs in relation to vertebrate pests is not well documented due to a lack of appropriate monitoring and evaluation associated with such control actions and programs.

8. A number of benefit-cost analyses of a number of invasive species control projects have demonstrated high returns to investment.
9. A number of decision making aids have been developed over the past few years to assist with decisions on resource allocation.
10. The last ten years has seen an increasing focus by government agency and industry groups on the involvement of the community and their level of awareness in the efficient and effective control of invasives.
11. Gaps identified include:
    - The WONS initiative has suffered from inadequate funding in some areas including aquatic weeds and implementation of the initiative in some areas has been slower than anticipated.
    - The WONS reports do not appear to provide much information even on a species basis as to the overall trends in success or otherwise since each strategy was implemented (eg. increase or decrease in areas or density, benefits or likely benefits or reduced impact achieved for the investment to date, and little emphasis on quantitative outcomes).
    - TAPs have been criticised as being slow to develop, as not including adequate consultation, under resourced, and not fully implemented.
    - The regulation of biological control agents can provide a disincentive to researchers. The rate of biological control agent release has slowed in the past 14 years, despite there being virtually no non-target impacts since appropriate non-target risk assessment procedures were implemented. On the other hand, the rarity of non-target impacts could be an indication of the effectiveness of the regulatory controls.
    - In terms of setting national priorities for containment and control on an objective basis there are issues associated with assessing the importance of species that impact on primary industries versus those that impact on the environment or social infrastructure and amenities such as waterways and water storages, or where there are impacts such as human health and safety involved. Key questions are who should pay and what process can be used to identify appropriate responsibilities and cost sharing.
    - The management of invasives in non-agricultural areas or without agricultural significance sometimes falls to government agricultural structures as this is where there is the most significant expertise and structures for organisation and management. This suggests a gap exists as these agencies should not necessarily have the responsibility to manage and fund response and control activities for such incursions. They may however be the best agencies to undertake this work because of their skills and protocols.
    - There is no national coordination of control of vertebrate pests already present in Australia, as the management of fauna is considered a State/Territory responsibility. This is with the exception of where there is significant national interest. However, the Vertebrate Pests Committee is currently in the process of preparing a National Pest Animal Strategy. Also, a national strategic approach to ornamental/exotic fish is currently being drafted.

# 6. Case Studies

The purpose of presenting the following case studies is to illustrate and support some themes and principles that are evident in the earlier part of this review.

## 6.1 The Cost of Interrupted Surveillance: Papaya Fruit Fly

The following papaya fruit fly case study illustrates the importance of continuous monitoring and surveillance for important invasive species and how a lapse in surveillance can work against cost-effectiveness.

An inadequate trapping network in North Queensland was associated with undetected incursions of the papaya fruit (*Bactrocera papayae*) fly near Cairns in 1995. The background to this is described in De Barro (1999) and summarised as:

"In the mid 1970s $30,000 was provided by the Federal Government to each of the Northern Territory, Western Australia and Queensland Departments of Primary Industries to install and operate trap networks for fruit fly as part of the Northern Monitoring Program. In 1988 responsibility for the network shifted from State to Federal Government. This included Cairns, Mareeba, Coen, Laura and the Cooktown region. The Lindsay Review endorsed this approach. In 1991 a review of NAQS recommended the surveillance network be broadened to include Cairns and a Horticultural Policy Council review also recommended the establishment of traps in Cairns. Neither recommendation was acted upon. The cost of surveillance in Queensland from 1975 to 1995 if one assumed a 10% increase for each year would have been approximately $1.9 million".

The outbreak had gone undetected for about 18 months and was quite severe and resulted in a cost of $34 m over four years to eradicate it. It also caused disruption to the marketing of nearly all fruit crops from North Queensland and cost growers up to $100 million (Cole, undated; Delane, 1999).

As a result of this incident, a national trapping grid was established that was later effective in detecting a fruit fly outbreak (*B. philippinensis*) in Darwin. This outbreak was detected within several months of establishment. Eradication proceeded at a much lower cost than for the Cairns outbreak (Roberts, 1999). In contrast to the Cairns outbreak, the fruit fly outbreak in Darwin was eradicated for $5m as it was detected much earlier (Cole, undated; OCPPO, 2002).

This fruit fly incident was one factor that led to the review of Australia's quarantine activities "Australian Quarantine: A Shared Responsibility" in 1996 (Cole, 1999) and subsequent institutional changes such as the establishment of Plant Health Australia.

*Major observations*

- There is a need to maintain an effective detection network for species that are likely to enter Australia and which can have major impacts.

- Surveillance investment can be an excellent investment due to the increasing costs that are usually incurred if an invasive species is not detected early.

## 6.2 Saving Millions: The Eradication of Black Sigatoka

Black sigatoka *(Mycosphaerella fijiensis*) is a highly significant disease of bananas. Since 1981 there have been nine incursions of the disease in north Queensland. Each outbreak has been eradicated. The latest incursion was in 2001 in the Tully Valley region of North Queensland. Much of the following is drawn from Agtrans Research (2004).

The previous eight detections of black sigatoka in Australia were discovered outside the main banana production areas mostly in remote areas of far North Queensland (except the two Daintree detections). Eradication was simple due to the isolation and proximity to other banana plants. In these previous detections, identification was by microscopic examination with identification in the last three detections confirmed by Polymerase Chain Reaction (PCR). The 2001 detection in Tully was far more complex as it was in a major production area and the disease was detected at a number of sites.

As the disease was detected in a commercial banana production zone, the eradication and sampling zones involved large areas under commercial cultivation of bananas, as well as a large number of non-commercial/domestic sites. Because the traditional diagnosis by microscopy was compromised in the early stages (early April) due to rainfall washing away the fungal structures, the number of samples requiring detection by PCR rose from 10% of a previously small number of samples to 30% of hundreds of samples.

Quarantine regulations stipulate that when a disease such as black sigatoka is detected all plants within 500m are to be destroyed and all plant material including fruit within 50km is quarantined. The extent of the disease is ascertained by surveying all banana blocks within the region with the intensity of sampling decreasing away from sites where the disease has been confirmed. In the 2001 incursion, the disease was shown by mid May to be restricted to the Tully area and in July the Tully quarantine area had been defined and all plants within the area were deemed to be infected. Initially no fruit within 500m of an infection could be marketed and fruit within 50km could only be marketed in Victoria, South Australia and Tasmania. Following the delimitation of the infection and negotiations with NSW, fruit from the 50km zone could be marketed in Sydney but not in Brisbane. Following the acceptance of the success of the eradication program all fruit including Tully bananas were by late calendar 2003 being distributed to all markets except northern NSW.

*The Eradication Program*
A decision had to be made quickly on whether it was feasible to attempt an eradication program. There was some opinion at the time that it would not be possible to eradicate the disease. The surveillance program showed that the pathogen had not spread widely and gave confidence to the decision to eradicate. The availability of a PCR test allowed a rapid and accurate turnaround of results (less than 2% of samples had to be retested) and allowed regulatory authorities to confidently make

management decisions. Microscopy testing was not effective in the early stages of the incursion due to the absence of the fungal structures due to the extensive rainfall in early April and early May 2001. The alternative of incubating samples to induce spore production would have delayed diagnoses and required more resources (staff, laboratory space and equipment). The molecular test therefore was a contributing factor to which the decision to eradicate can be attributed.

Following the early detection, all bananas on one property and a block of bananas on two other plantations were ploughed out, but with further detections on other plantations the cost of ploughing out was considered prohibitive and an eradication program based on inoculum annihilation and prevention of new infections throughout the quarantine area was devised. This program which involved an intense de-leafing program to remove all inoculum and a rigorous spraying regime was approved by the Federal and State Governments in June 2001. The program commenced in September 2001. Growers whose plants were ploughed out received some compensation from the industry. Replanting of these ploughed out areas was delayed until all banana trash (potential inoculum source) was buried (September). Production and fruit quality on many properties was reduced as a result of the intense de-leafing regime. The program subsidised all growers in the quarantine area for the cost of the extra de-leafing and sprays required. The program funded the extensive monitoring/inspection and sampling programs required under the eradication strategy.

Much of the Innisfail district was within the 50km quarantine zone and had to be surveyed throughout the program to demonstrate initially that the disease was restricted to the Tully area and later to ensure there had been no spread of the disease.

*Diagnosis*
Diagnosis was very important in detecting and eradicating the incursions as there are other fungal pathogens that have similar morphology and cause similar disease symptoms. For example, yellow sigatoka (*Mycosphaerella musicola*) is already widespread in Australia but under management control. Both microscopy experience and a new PCR test that was developed by the CRCTPP contributed to the handling of a vast number of samples. In July 2000 an increased emphasis had been placed on developing tests for exotic plant diseases which were recognised as posing a serious risk to plant biosecurity. A number of important diseases of banana were recognised as high risk and funding made available to develop and improve molecular diagnostic assays for these pathogens.

*Factors contributing to success*
A number of factors contributed to the successful eradication of *M. fijiensis* in the Tully Valley including the biology of the organism (no alternative hosts and no survival structures), early detection (black sigatoka surveillance program funded by the industry for >10 years), the diagnostics capacity at Mareeba (staff with 20+ years experience, the laboratory resources and the PCR capabilities including the CRCTPP developments) the commitment of the Queensland DPI&F personnel, the understanding and commitment of the banana industry and its growers to the eradication program, and the cooperation and funding from the State and Federal governments.

This success illustrates the importance of surveillance programs, cooperation between industry, State and Australian Governments in moving quickly, the importance of diagnostic tests and the maintenance of capacity and experience in state agencies.

*No eradication*
Due to its high level of aggressiveness, the introduction of *M. fijiensis* into Australia would have had a highly significant negative impact on the Australian banana industry. If the disease had not been eradicated, then the Tully banana growing region would have incurred higher production costs due to the control program that would have been necessary. This would have involved regular de-leafing of banana plants (high labour costs) and spraying more regularly. For example, the existing 20-26 sprays per annum would increase by 50% or more (Peterson, pers comm, Nov 2003). These increased costs may have driven some banana growers out of business. Also, bananas may not have been allowed to be sold out of Tully to all Australian markets, due to the risk of infecting other banana growing areas. As much as 70 to 80% of Australian bananas are grown in North Queensland and the Tully Valley contributes nearly 40% of total Australian production.

If not eradicated there would have been a high probability that the disease would have spread to other banana growing areas in North Queensland, if not to bananas in other parts of Australia, thus imposing higher production costs on other producers.

*Declaring area free of disease*
An "area freedom" monitoring program was instituted from May 2002 to May 2003 to determine the effectiveness of the eradication program. In May 2003, the black sigatoka Technical Working Group declared the program a success as all data indicated that *M. fijiensis* had been eradicated from the Tully area. The "area freedom" program was funded by the banana industry and managed by the Queensland Fruit and Vegetable Growers, with technical input from Queensland DPI&F.

## 6.3 Missing the Opportunity for Early Intervention: *Mimosa Pigra*

Mimosa is an example of a sleeper weed that has become an extremely serious weed in the Northern Territory. It was introduced to Darwin sometime in the 20 years prior to 1891. It was not much of a problem until 1952; however, by 1981 much of the Adelaide River floodplain was infested. It is an environmental weed but also cost $636,000 to agriculture in 2000 (BRS, 2003).

The weed was present in the Darwin area for some time but only caused an occasional nuisance. But when material was relocated to an inland site at the headwaters of the Adelaide River in 1952, its water borne seeds spread it across the Adelaide River floodplain (Groves, undated). Its spread was particularly rapid from the mid 1970s (Miller and Pickering, 2001). The rates of spread of Mimosa have been described quantitatively in Lonsdale (1993).

But even then there was a strong chance of control that was thwarted. According to Ernie Friend (CRC Weeds, 2004d) Mimosa could have been stopped in the late 1960s when an eradication program was initiated and apparently was progressing quite

successfully. However, a Northern Territory Department restructure amalgamated the Agriculture Branch and the Animal Industry Branch to form the Primary Industries Branch. Priorities then changed and the follow up spraying was not carried out. Hence the mimosa expansion was due to a lack of continuity in efforts and poor priority setting since the resources were deployed on what turned out to be a futile exercise killing *Cycas media* plants that were affecting cattle.

*Current Status*
Currently mimosa is one of northern Australia's major weeds of seasonally flooded wetland areas and ranges over areas from near the Fitzmaurice River in the west to Arnhem Land. Mimosa displaces native vegetation and animals from large areas of land and seriously affects conservation, tourism and traditional use of wetlands by Aboriginal people (Miller and Pickering, 2001).

There are known infestations in Kakadu. Control in Kakadu commenced 22 years ago by fencing off and chemically treating several large infestations. New seedlings are still emerging from old plots, but the number of new infestations found every year remains fairly constant. It has been decided that it is probably not feasible to eradicate it but that it can be controlled (CRC Weeds, 2003a). Control in Kakadu National Park costs approximately $0.5 m per year. As a result Kakadu remains the most significant mimosa-free wetland region in the Northern Territory (DEH, in press). The current total costs of control for mimosa in the Northern Territory including Kakadu is approximately $4.2m per annum (Steve Wingrave, pers comm., 2005). This funding is contributed by the NT Government, the Australian Government, industry and the community including the Indigenous Land Corporation.

Mimosa is currently declared a weed in al States and Territories except for the ACT.

*Biological Control of Mimosa*
To date 11 species of insects and two disease-causing fungi have been released as bio-control agents for mimosa in the NT. Of the agents tested, tip and stem borers have been the most effective as they do not require flowers or seeds for survival, and therefore feed on the plant in the dry season. Insects released 14 years ago are only now beginning to cause a noticeable effect on the weed, but the impact on the invasive should increase (DEH, in press).

As with many other bio-control agents they need to be viewed as part of an integrated control approach that is used in combination with the use of other control methods such as herbicides, mechanical methods, grazing and fire (DEH, in press).

The biological control program is largely funded by NHT.

*Queensland outbreak*
The first mimosa outbreak was detected in Queensland in February 2001 in the region of the Peter Faust dam near Proserpine. It had potential impacts on cane lands and internationally listed Japanese and Chinese migratory birds Agreement sites (Queensland Government, 2003). The expected costs for eradication in Queensland were $3 m and the time taken about seven years but it was noted that funds may be required for up to 20 years due to the long-lived seed bank (Queensland Government, 2003)

It has not yet been determined how mimosa arrived at this site and whether it came from the Northern Territory. Being a long way from the Northern Territory border, the location illustrates the point that there is a need for statewide awareness and surveillance activities for major weeds in order for them to be contained effectively (Queensland Government, 2003).

*Method of Spread*
There is a lack of detailed knowledge of the method of spread of Mimosa. It is suspected but not proven that waterfowl have played a significant part in the spread of Mimosa seed from the original infestation on wetlands in the Darwin region to wetlands on the Fitzmaurice River in the west and to wetlands in Arnhem land in the east (Roger Smith, pers comm., 2005).

*Coordination*
Although mimosa is a WONS, the monitoring program at the Queensland site and surveillance at other at-risk sites in Queensland did not receive funding from the Mimosa National Weeds program funds in 2002, despite the Whitsunday region defining it as a high priority for funding under NHT2 (Queensland Government, 2003).

*Major observations*
The major observations emanating from this case study are:

- Mimosa illustrates well the sleeper concept in weeds where an introduced and then naturalised plant posed little problem for a long period of time. Being translocated to a favourable environment meant that it could spread rapidly at some later time.
- The case study supports the value of early intervention; if intervention is not early enough, eradication is extremely unlikely and containment made more difficult.
- Tracing and recording methods of spread would be helpful in containing possible outbreaks in other regions.
- Continuing commitment to an eradication program is essential for success.

## 6.4 The Importance of Diagnostics in Containing a Non-Eradicable Pathogen: Foc Tropical Race 4

'Tropical' race 4 of Fusarium was first identified in Darwin in 1997. This pathogen had not been found in Australia prior to this incursion. It is a devastating disease as once present in the soil it can not be eradicated and will prevent production of banana types that are susceptible. Another strain (race 1) affects Ladyfinger bananas and much former banana growing land in the eastern states can no longer produce Ladyfinger bananas due to its spread. Tropical race 4 could be even more devastating as it affects the Cavendish variety that is not susceptible to race 1 and which is the predominant type of banana grown in Australia. This case study is based on material present in Agtrans Research (2004).

*Identification*
The DNA associated with the first outbreak was compared with that of all other strains of *Fusarium oxysporum* f.sp. *cubense* (*Foc)* that occur in different parts of the world. This was made possible by the extensive collections of *Foc* (the most extensive in the world) held at Queensland DPI&F. As there is variation in behaviour (virulence, host range etc) between strains of *Foc*, confidence in quarantine measures and future research would have been limited if the occurring strain of *Foc* was not known (Daly, pers comm, 2003).

Officials acted quickly thereafter to prevent further spread of the disease outside the Darwin area. Quarantine restrictions and disease management strategies were put in place to restrict the spread of the disease.

*Response*
As race 1 and subtropical race 4 were already present in Australia, the response to the knowledge that it was 'tropical' race 4 meant that the other States and Australian Government became more closely involved and provided close scrutiny of the response of the NT Government. A stringent set of quarantine and management provisions was set in place including:

- destruction of banana plants including those within a buffer zone
- fencing off of known infected areas
- building walls around affected areas to reduce water runoff
- quarantining any soil removal from the properties
- restricting movement of banana material

These measures were to stop or slow the spread of the disease within the farm, to other farms in the region and to stop the spread to other banana growing regions within Australia.

The disease has now been detected in eight commercial banana plantations in the Darwin area where there were originally nine commercial plantations. Three of these plantations have now ceased production. The area remains under active quarantine provisions to limit the risk of spread within the Northern Territory and to other areas in Australia. The latest detection as of late 2003 was on a previously clean property in April 2003 (Andrew Daly, pers comm., 2003). There is a lack of detailed knowledge of how the soil-borne pathogen has spread locally in the Darwin region despite the control mechanisms in place. For example, waterfowl and pigs have been implicated but no specific mechanisms have been confirmed. Information on the method of spread locally would be useful to assist with containing any further outbreaks in other areas of Australia.

It is assumed that these measures reduced the probability of the disease spreading to other states in Australia, and slowed the rate of spread to other farms in the Northern Territory. If the CRCTPP had not had the DNA database it may have taken some time to identify the pathogen and the response may not have been so rapid. Knowing the identity of the pathogen enabled appropriate quarantine measures to be put into practice quickly and proper grower education about the disease to be effected. The major factors responsible for slowing the spread of 'tropical' race 4 in the NT banana industry and to preventing it spreading to other banana growing regions in Australia were:

- early detection and identification through excellent diagnostics,
- quarantine measures applied to the outbreaks, and
- grower/awareness and education.

## 6.5 Preparedness, Protocols and People in Containing a 'Social' Invertebrate Pest: The Red Imported Fire Ant

The South American red imported fire ant (RIFA) was first found in Brisbane on 22 February 2001. It was declared a pest under the Plant Protection Act 1989 and is now a notifiable pest (SoE Qld, 2003). In September 2001, a Fire Ant Control Centre was established and a nationally funded eradication program started. In October 2001 the first on-ground control works in the eradication campaign started and in March 2002, regulations were introduced to restrict the movement of material that posed a high risk of spreading fire ants (SoE Qld, 2003).

In April 2004 an extra $37.5 million from all Australian governments was secured to extend the campaign to eradicate fire ants to a new treatment area, and for an additional year. This brings the total budget to $175.4 over six years. The Natural Resource Management Ministerial Council now has oversight of the program, and it is managed by the Queensland Department of Primary Industries and Fisheries.

A benefit-cost analysis was undertaken by the Australian Bureau of Agricultural and Resource Economics in 2001 into the proposed eradication program. The analysis found that the cost to the community if the fire ant was not controlled would be $8.9 billion over a 30 year period and that the benefit-cost ratio of the program would be 25:1 based on a $124m program over five years. The major costs calculated were from loss of property values, cost of household repairs and treatment, and the cost to agriculture.

If fire ants were allowed to spread throughout Australia unimpeded they would occupy any land with mean annual rainfall exceeding 510 mm excepting areas that experience extremes of cold. Predictive modeling of the expected rate of spread shows that at least 600,000 square kms and as much as 4 million square kms would be infested by 2035 (Canyon et al, 2002). As a result of direct attack, and reduction in food supply, the fire ant would affect many Australian mammals, especially those that are insectivorous. This would also lead to a change in foraging and sleeping behaviours of such mammals. Fire ants predate on the hatchlings of a wide range of ground-nesting bird species and all egg laying reptiles are also susceptible to attack while in the nesting cavity as are amphibians due to where they burrow and lay eggs. The biggest concerns for human impacts are the safety of small children and the loss of the ability to use yards as places of relaxation, gardening or maintain pets. Fire ants can cause anaphylaxis in susceptible people.

As mentioned in Section 5.4, it has been estimated that fire ants were present in Queensland for up to ten years before they were detected and this delay in detection resulted in the spread of the fire ant beyond its original point of introduction to a wider area of South East Queensland. The subsequent increase in the cost and size of the eradication program provides a good example of the benefits of early detection systems and the need for surveillance in high risk areas such as ports. An example of

the importance of early detection in such cases comes from New Zealand, which has established a National Invasive Ant Surveillance Program at a cost of $NZ400,000 that systematically surveys high risk potential invasion sites, such as ports and airports. The program resulted in the detection of an infestation of RIFA in Napier in 2004, which was estimated to have been there for about 1 year (Simon O'Connor, pers comm.).

As mentioned in Section 5.5, the often fragmented and reactive approach to pest management has been less than ideal in attempting to respond to a pest of the potential magnitude of fire ants (Queensland Government, 2003). Inadequacies experienced by Queensland with the current arrangements include a lack of clarity in the roles and responsibilities at Ministerial Councils and at agency level in response to pests like fire ants, with very broad-scale impacts across social, environmental and production sectors. For example, due to their experience and existing structures, government primary industry departments such as the Queensland Department of Primary Industries and Fisheries are the lead agencies contributing to and managing the fire ant eradication program. This is despite fire ants impacting on the environment, tourism, urban infrastructure and human recreation and health, with the impact on primary industries being comparatively minor with only 11% of the expected impact (Davis and Grimm, 2003).

Failure to secure national funding for the eradication program would have placed the Queensland Government under pressure to implement an ongoing 'facilitative management' program for fire ant to assist industry and the community manage this pest. The cost to government of such a program is estimated at $2m annually, but would depend on the level of 'subsidisation of control activities undertaken by industry and the community (Queensland Government, 2003).

The current total treatment area (22 November 2004) is 28, 030 hectares, with twelve rounds of treatment completed since the start of the program, and a 13$^{th}$ round currently in progress. This is the fourth season of treatment, and many suburbs in the restricted area are no longer receiving treatment. However suburbs in areas where active nests have been found in the last two years will continue to receive treatment this season (Queensland DPI&F website, 2004). It is anticipated that 157 tonnes of bait will be used for treatment in the 2004/05 season, compared with 459 tonnes that were used in the 2003/04 season. The total surveillance area is 60,236 hectares, and there are 2,787 businesses on Approved Risk Management Plans. As at October 2003, 98% of known infestations treated over two years were fire ant free.

The involvement of the community in detecting new fire ant infestations has been a significant part of the eradication program. For example, in July 2003, during 'Find the Fire Ant Week', two separate infestations of fire ants were discovered by local residents 800 metres apart. These were mature nests and were outside the treatment and surveillance zones.

Another example of community involvement was provided in November 2003 when a schools awareness program conducted by the Queensland DPI&F led to the discovery of a live fire ant infestation. The Fire Ant Control Centre has been distributing fire ant awareness kits to students on the peripheries of the declared fire ant treatment area. The kits contained plastic containers for the return of ant samples and students

were asked to take the kits home and have their parents examine their yards for signs of fire ant activity. One of the returned samples led to the discovery of a single fire ant nest in Brisbane's eastern suburbs.

Fire Ant Community Watch Groups made up of volunteers check public areas, such as parks and bushland, outside the current treatment and surveillance zones as well as educate the general community at public events in the identification and reporting of fire ants. There are eight groups which expect to check about 600 public areas over three years.

In conclusion, the incursion of fire ants into south east Queensland and the subsequent eradication program have demonstrated the following:

- The importance of a pre-existing preparedness or cost-sharing arrangements for pests that do not clearly impact on only one industry, but rather on the environment and community as a whole. The lack of such arrangements can lead to delays in any eradication or containment program being undertaken due to uncertainty of funding or management.
- The use of agencies with good skills in control / eradication programs.
- The importance of early detection, and appropriate detection programs around high risk ports of entry.
- The importance of awareness, education and community involvement in surveillance and detection.

## 6.6 Success Through a Regional Approach: Two Integrated Conservation Management Programs

This case study provides two examples of integrated conservation management programs that seek to restore habitat and re-establish threatened species through the control of feral pests. Both programs include activities on both public land such as national parks, as well as neighbouring private properties, to provide an integrated regional approach.

*Bounceback – Flinders Ranges*
The Flinders Ranges Bounceback Program was initiated by National Parks and Wildlife, South Australia to protect the native species that have persisted in the region and make it possible to reintroduce some species that have become locally extinct. The program is ongoing.

In the mid to late 1800s much of the Flinders region was used for pastoral production with high stocking rates which led to changes in plant communities, local extinctions of animal species, and negative impacts on soil condition. When the Flinders and Gammon Ranges National Parks were declared they were destocked, however there has subsequently been little recovery of plants, animals or soil condition. European foxes, rabbits, feral cats, feral goats, donkeys and introduced plants such as onion weed, horehound and salvation Jane have continued to persist in the region.

The broad strategies behind Bounceback include:

- Monitoring and evaluation programs.

- Threat abatement programs.
- A regional approach.
- An integrated/systems approach to conservation.
- District involvement and community partnerships.

More specifically, activities in the region's national parks include removal of foxes and feral goats, destruction of rabbit warrens, regeneration of native plant species, protection of habitats, fauna re-introductions, re-invasion (buffer zone) management, and monitoring programs.

In areas surrounding the parks, the focus is on control of wheel cactus and feral goats and rabbits, removal of foxes and protection of endangered species. The program brings together people managing national parks, private sanctuaries, pastoral properties and Indigenous Protected Areas in an integrated approach.

Within the national parks, achievements include a major reduction in the number of feral goats and rabbits, a increase in the number of yellow-footed rock wallabies, a trial reintroduction of the brush-tailed bettong to the Flinders Ranges National Park, and land reclamation using saltbush.

Among the program's off-park results are reduction of feral goat numbers on several properties and the elimination of foxes adjacent to the park.

*Western Shield, WA*
The Western Shield Program was launched in 1996 and is managed by CALM in Western Australia. Its aim is to bring at least 13 fauna species back from the brink of extinction by controlling foxes and feral cats on almost 5 million ha of land (SoE Australia, 2001).

The program uses the poison 1080 which is naturally occurring and found in native plants called gastrolobiums or 'poison peas'. Native animals in Western Australia have evolved with these plants and therefore have a high tolerance to the poison, however introduced animals do not. Aerial and hand baiting occurs on almost 3.5 million hectares of Department-managed land and baiting operations take place four times a year throughout the State from as far North as Karratha to Esperance in the South. Smaller nature reserves are baited more frequently.

Many private landowners and Land Conservation District Committees have laid fox-baits on their own land neighbouring conservation reserves and State forest. Also, sponsorship of specific geographical areas occurs with major sponsors funding baiting over specific geographical areas.

Since 1996 CALM has carried out more than 60 translocations of 16 animal species including the chuditch, dibbler, numbat, bilby, quenda, western barred bandicoot, woylie, mala, tammar wallaby, western ringtail possum, Shark Bay mouse, Thevenard Island mouse, noisy scrub-bird, western bristlebird, malleefowl and western swamp tortoise.

The program has shown a decrease in fox numbers and a dramatic increase in native animal numbers. Baiting has been so successful that between 20 and 40 translocated

native animals result in the successful establishment of new populations. Three forest-dwelling mammals have been removed form the State's Threatened Fauna List as a result (tammar wallaby, quenda and woylie) (SoE Australia, 2001).

*Conclusion*
The success of these two conservation programs demonstrates the importance of an integrated approach to a conservation program that includes not only activities on publicly-owned land, but also working with the community and corporations on privately owned land to ensure a regional approach.

The programs also demonstrate the importance of an integrated and ongoing approach to such pest control and conservation programs, that considers whole-of-ecosystem issues by pursuing control of several species at once, and also pursuing revegetation and fauna re-introduction strategies.

## 6.7 Achievements Through Supporting Involvement of the Community: Serrated Tussock

Serrated tussock (*Nassella trichotoma*) is a major invasive plant of native pastures that significantly lowers the carrying capacity of sheep and cattle in southern Australia. It imposes an annual cost of $40 m in NSW and about $5.1 million (for 1997) in Victoria with a coverage of 130,000 ha. Victorian costs could escalate to $15 m in 10 years (BRS, 2003). Control measures used include mechanical, pasture management, burning, cultivation and chemicals (flupropanate) (CSIRO, 2003).

In 1994 a community driven public meeting in Victoria was convened and resulted in the formation of the Victorian Serrated Tussock Taskforce, later to become the Victorian Serrated Tussock Working Party (Victorian Department of Primary Industries, 2003).

The control program established by the Working Party has been highly successful with a substantial reduction in the density and distribution of serrated tussock (Victorian Department of Primary Industries and Department of Sustainability and Environment, 2004). For example post-June 1999, 40% of previously infested properties reinspected were found to be serrated tussock free. Landcare groups and other community groups have taken responsibility for serrated tussock control and management. Impacts are evident on both private and public lands.

The gross economic benefits generated by the program over the period 1995 to 2002 have been estimated at between $6.3 to 11.1 m (Victorian Department of Primary Industries, 2003) with even greater benefits predicted for the future.

The focus of the program was on raising awareness of landholders and gaining acceptance for the wider and joint ownership to the serrated tussock problem and what to do about it. This was achieved by:

- Recognising the role of monitoring and data management in such a program;
- Improving knowledge and technologies available for control;
- Introducing appropriate incentives and assistance to enable landholders to comply with responsibilities; and

- Increasing the role of local government and community groups in the coordination of on-ground control activities.

Of perhaps of greatest importance to the success of the program was the gaining confidence and support of the Department in the program so that they would fully support the legislative requirements. This compliance component that ensured all private and public land managers were involved in the program was regarded as the most important factor for program success in a survey of over 800 landholders. While peer and community pressure were important motivators, the enforcement program resulted in confidence for all to take action. The enforcement process has been the catalyst on steep rocky non-arable ground in particular.

The case study illustrates the power of a high level of community awareness and involvement that is backed by enforcement processes that involve all land managers.

## 6.8 Cost-Effective Control and National Coordination: Biological Control of Rubber Vine

Rubber vine mainly affects Queensland but also has the potential to affect the Northern Territory. Rubber vine (*Cryptostegia grandiflora*), a native of Madagascar, was originally introduced to Australia as a garden plant. It has been recorded across 20% of Queensland and has the potential to infest 60 m ha in northern Australia.

This case study of the control of rubber vine is used to illustrate the economic success of bio-control investment, and the importance of integrated control methods and coordination.

*Control measures*
A major program on rubber vine was initiated by the Queensland Government in the mid 1990s in order to reduce its extent and density. Both chemical and mechanical methods were funded and the use of fire was developed as a major control method for the vine in non-riparian situations. The rubber vine program received over $2.7 m in State Government funds between 1995 and 1999 and covered 40% of the area infested within Queensland. This effort resulted in a containment line with all rubber vine found outside this area being subject to eradication.

Biological control initiatives included both a moth and a rust pathogen that were imported and tested. The rust resulted in the complete halt to the expansion of this weed in Queensland (Queensland Government, 2003). Leaf loss caused by the rust has also improved the economics of other management actions with programs such as burning and stick raking more cost-effective and efficient (Queensland Government, 2003).

The development of the rust fungus was assisted greatly by CAB International who collected the fungus in Madagascar and carried out extensive trials in the United Kingdom before supplying it to Australia. This is an example of the benefits of international agricultural research cooperation. Australia, through ACIAR, is a strong investor in CAB International (Bob Clements, pers. comm., 2005).

As rubber vine is one of the Weeds of National Significance a national rubber vine strategic plan was developed. Two projects in particular are featured in the 2003/2004 review of progress against the strategic plan. The first is the implementation of a Queensland /Northern Territory Buffer Zone to ensure control and to maintain a rubber vine free status within the Northern Territory. Current mapping work has identified rubber vine as within 45 kilometres of the Northern Territory. The second was the continued implementation of a number of strategic eradication control projects within areas of Queensland to maintain the containment line (Austin, 2004).

*Costs and benefits of control*
In 1995 rubber vine costs were $27 m comprising control costs of $9 m and beef production losses of $18 m (Mackay, 1996 as cited in WWF, 2003a). In contrast to these impacts the integrated fire and bio-control program cost $0.7 m (ARMCANZ, 2001 as cited in WWF, 2003a).

A recent benefit-cost study has shown that the release of the imported rust is currently returning $80 for each $1 expended on the program (Franco-Dixon, 2003 as quoted by Queensland Government, 2003).

*Major observations*
The major observations arising from this case study are:

- The positive economics of investment in bio-control;
- The benefits and synergies produced by bio-control and its interaction with other methods of control; and
- The benefits from national coordination when a weed established in one State may threaten another State or Territory.

## 6.9 Cost-Effective Control and National Coordination: Biological Control of Rabbits

The European Rabbit was introduced to Australia in 1859 and now occurs in abundance throughout Australia, mainly south of the Tropic of Capricorn on well-drained soils but generally not in dense forest or at the highest altitude.

Competition by rabbits results in the carrying of less livestock, lower wool production per animal, reduced lambing percentages, lessened wool quality and higher stock mortality during periods of feed scarcity (McLeod, 2004). The Australian impact of rabbits was estimated at $600 million before Rabbit Calicivirus (RCV) (Queensland Government, 2003). Before RCV was released average densities of rabbits annually consumed 10 tonnes of dry pasture per sq km (Bomford and Hart, 2002). Rabbits also cause extensive losses to forestry and tree plantations, preventing regeneration and damaging tree plantings. This increases the cost of tree planting programs because of the need to erect tree guards. Damage from browsing rabbits can approximate one year's loss of growth, equivalent to $800/ha at clear felling and rabbit control costs in private forests can run as high as $80/ha during the period when trees are vulnerable to rabbit damage (Bomford and Hart, 2002).

In the early 1950s the myxoma virus was introduced and rabbit abundance fell dramatically, however even though the virus still plays a role in limiting the abundance of rabbits, the virulence of the virus and the resistance of rabbits to it has changed over time.

In 1989 CSIRO began investigation of the use of Rabbit Calicivirus Disease (RCD) as a biological control agent of rabbits, and in August 1991 it was imported into the Australian Animal Health Laboratory. This importation followed consultation by AQIS with State and Territory agencies, livestock industry councils and community groups (Neave, 1999).

In March 1995 formal assessment under the Biological Control Act 1984 commenced with the nomination of the rabbit as target organism and RCV as the agent organism. Field trials on Wardang Island, South Australia also started in March 1995. The virus escaped from Wardang Island onto the Australian mainland in October 1995 before the assessment was completed. Public submissions were called for by the Biological Control Authority in November 1995 and from April to August 1996 additional tests on non-target species and human health were undertaken as part of the assessment (Neave, 1999).

In October 1996 Australian Government, State and Territory Ministers declared the rabbit as a target organism and RCV as an agent organism under the biological Control Act and deliberate releases started.

The early assessment of the disease was managed by a Proponent Committee comprising members from the funding consortium supporting the research which included the Meat Research Corporation, International Wool Secretariat, New Zealand Ministry of Agriculture, Australian Nature Conservation Agency, CSIRO and State and Territory funding through ARMCANZ and ANZECC (Neave, 1999).

Following this, the 1996-98 RCD Program was developed in conjunction with State and Territory vertebrate pest control and conservation agencies. There was a high level of collaboration between and within Australian Government, State and Territory agencies. The RCD Monitoring and Surveillance Program was funded for two years through ARMCANZ and ANZECC. The Program was managed by the RCD Science Sub-Committee on behalf of the RCD Management Group, and coordinated by a Project Officer in the BRS. There was also a RCD Epidemiology Research Program conducted by CSIRO and funded by MRC, IWS, EA, ARMCANZ and ANZECC (Neave, 1999).

The RCD Management Group comprised members representing ARMCANZ, ANZECC, BRS, CSIRO, EA and MRC. The Management Group reported to ARMCANZ, ANZECC and the Vertebrate Pests Committee. The RCD Science Sub-committee comprised representatives from CSIRO, EA and BRS and State and Territory vertebrate pest and conservation agencies (Neave, 1999).

The budget for the RCD Monitoring and Surveillance Program was $3.8 million over two years, with 50% of the funds coming from the NHT. Since the cessation of the RCD Monitoring and Surveillance Program in 1999, there has been no national coordination of monitoring of the effectiveness of RCD and only limited piecemeal data collection by some states (Bomford, pers comm., 2005).

In 2004, the economic impact of rabbits was calculated at $113.1 million per annum. This is made up of $35.4 million sheep production loss, $34.39 cattle production loss, $18.3 million cropping industry loss, $20 million control cost and $5 million research cost (McLeod, 2004).

The RCV induced decline in rabbit numbers has been estimated to result in a benefit of at least $165 million a year to wool and sheep producers in Australia (Bomford and Hart, 2002) and significant environmental benefits. It is estimated that the spread of RCV has reduced rabbit numbers by an average of 75%. In arid areas the reduction has been as high as 95%, while in higher rainfall areas the impact has been lower and more variable (SoE SA, 2003).

In conclusion, the success of the release of RCV as a biological control agent for the European rabbit demonstrates the large-scale benefits that are possible from this approach to pest management. The success of RCV as a control agent is partially due to the integrated approach to funding and management of the R&D by industry and governments at the national level in order to address a significant national problem.

## 6.10 Summary of Implications of Case Studies

The case studies have been chosen to illustrate specific themes. A summary of the implications evident for the management of invasive species include:

- The importance of an effective and ongoing surveillance network.
- Surveillance can be an excellent investment due to the increasing costs that are usually incurred if an invasive species is not detected early
- The importance of awareness, education and community involvement in surveillance, detection and eradication.
- The importance of early detection, identification and quarantining.
- Cooperation between industry, State and Australian governments allowing them to act quickly.
- The importance of diagnostic tests and the maintenance of capacity and experience in state agencies.
- The value of early intervention; if intervention is not early enough, eradication is extremely unlikely and containment made more difficult.
- Continuing commitment to an eradication program is essential for success.
- The importance of the enforcement of compliance in gaining confidence of communities in being involved in invasive programs.
- The importance of an integrated and ongoing approach to pest control that considers whole-of-ecosystem issues.
- The importance of a pre-existing preparedness or cost-sharing arrangement for pests that do not clearly impact on only one industry, but rather on the environment and community as a whole.
- The use of agencies with good skills in control / eradication programs.
- The positive economics of investment in bio-control and its positive interaction with other methods of control.
- The benefits from national coordination when an invasive species established in one State may threaten another State or Territory.

## 7. Principal Findings

The following findings are those considered by the authors to be the most important emanating from this review. A more comprehensive set of findings are provided in the summaries at the end of sections 3, 4, 5, and 6, and in the Executive Summary.

Australian efforts to manage invasive species over the past ten years have been considerable and effective. Much of this progress is presented in this review. A continuous improvement culture has been evident, enhanced coordination developed, and some outstanding technical and economic successes achieved.

Globalisation and reduced trade barriers will increase pressure from invasives even more in the future. Even small gaps that currently exist in current strategies could have significant consequences in the future. Hence this review attempts also to identify the gaps that may be addressed in future in order to maintain the effective management record that has been displayed in the past few years.

**Impact of Invasive Species**

1. Invasive species are costing Australia many billions of dollars annually mainly in costs of control and value of production foregone. Estimates of the different costs are incomplete and those that have been made need refinement and further justification if they are to be used to prioritise and stimulate further action on invasive species. The estimates made largely exclude the values of environmental or social costs of invasive species.
2. There is no commonly accepted method of valuing environmental impacts in dollar terms for purposes of priority setting among alternative activities and for integration with activities that lessen industry impacts. Willingness to pay methods of valuation have improved recently but are still used only sparingly by planners and policy makers. An additional issue is the adequacy of knowledge of the contribution of the invasive to any impact on native species or the wider ecosystem.
3. There are few studies that have identified in specific or quantitative terms the health, safety and quality of life/choice impacts of invasive species. A review could be undertaken of the seriousness of these impacts, particularly those involving human health and safety.
4. The benefits from invasive species need to be accounted for in more detail in the measurement of their costs so that a net cost to Australia can be estimated.

**Distribution and Abundance**

1. There is a trend towards an increasing rate of plant naturalisation based on the past 25 years of data. It is therefore likely that the number of new weeds will also increase in the future. Some weeds are spreading and some weeds are being contained, but there is no generalised information available on the broad picture of the changing impact of weeds over time. The impression is that the total number and area of weeds is increasing.
2. Most if not all States and Territories assemble data on the distribution of the important weeds that exist in their state. However, there is no nationally comparable approach between states for monitoring the distribution of existing weeds. The maps of the current and potential distribution of weeds carried out for

the Weeds of National Significance program is the principal information set available at a national level on the distribution of weeds. The potential for a nationally coordinated audit of weeds has been identified that would include weed distribution and abundanace.

3. The information on distribution of vertebrate pests is relatively good at a national and State level. For some vertebrate pests changes in distribution over long time periods are also available. There is some information on the abundance of established animal pests, but it is patchy and inconsistent; data interpretation is hampered by changes in seasonal conditions, and trends are not easy to identify. Abundance information is important for determining success or otherwise of control programs and for monitoring frontiers.
4. For invertebrate pests of animals and for animal diseases, distribution data is quite good. For insect pests of plants or diseases of plants there has been no significant trend in the number of new species introduced, at least from 1971-1995. For other invertebrate pests no trends were reported in the literature surveyed.

**Institutional Arrangements**

1. The Australian Government and State governments together with industry have increasingly recognised the importance of greater coordination in managing invasive species over the past ten years. Coordinating mechanisms have been developed between industry and government and between and within State and Australian Governments in some areas. While some agricultural-environment integration has developed, most of the institutional strengthening has been within the agricultural arena rather than the environmental arena.
   Specifically, the most significant changes have been:
   - The broadening of the role of the Australian Weeds Committee to include environmental weeds.
   - Establishment of the National Weeds Strategy and the Weeds of National Significance Program to provide a focus for coordination between the Australian Government and the States and Territories.
   - The development of State/Territory pest strategies.
   - The advent of the Weeds CRC and Pest Animal Control CRC has given a stronger focus to invasives and improved coordination of R&D.
   - The advent of Animal Health Australia and the development of the Emergency Animal Disease Preparedness Program and AUSVETPLAN which has been used as a model for the plant industries.
   - The advent of Plant Health Australia and the increased planning and coordination between plant industries and governments.
   - The establishment of the Office of the Chief Plant Protection Officer and its coordination role within the Australian Government.
2. Some of the gaps in institutional arrangements that are still apparent include:
   - There has been no national vertebrate pest strategy or national strategies that deal with exotic freshwater pest fish, however a National Pest Animal Strategy including terrestrial vertebrates and freshwater fish is currently being prepared. Also, a national strategic approach to ornamental/exotic fish is currently being drafted.
   - There is no institution that focuses on invertebrate pests that generate mainly social or environmental impacts.

- The institutional arrangements for handling invasive species that impact on the environment and have social impacts are less well developed than those for agriculture that have evolved over many years.

3. In order to lessen the likelihood of non-agricultural pests being neglected, a National Invasives Strategy may be appropriate to ensure those invasives that do not easily fit within one of the existing 'silos' are firstly able to be detected, and secondly that any program to eradicate, contain or control such species is funded and managed by the appropriate agencies and/or funding base. It would be useful to have a national strategy for invasive pests that involves different government sectors whereby learning from the experiences of other sectors is demonstrated.

**Prevention of Entry**

1. AQIS has continued to develop programs to increase the awareness of the Australian community of the importance of quarantine and some of these programs have been highly successful.
2. A large increase in the budget for border protection in 2001 led to an increase in Australia's quarantine effort and substantially strengthened border control with higher interception and effectiveness levels reported by AQIS.
3. Australian initiatives pre-border such as research and other forms of assistance to other countries has contributed to Australian knowledge, experience and preparedness as well as reduced threats to Australia by strengthening quarantine services in neighbouring countries. However, it is not clear whether many of the pre-border activities (eg the activities of ACIAR) excluding those of NAQS and AQIS take account of overall priorities that may have been set in Australia regarding invasive species.
4. Significant improvements have been made in import risk assessments as well as with the weed risk assessment system. Weaknesses still remain in the latter, however, in that potential weedy species can still be imported as whole genera are listed on the approved list and some prohibited species can be imported though use of older botanical names.

**Surveillance**

1. Surveillance for invasive species has been successful with a number of new pests detected, identified and sometimes eradicated over the ten year period. However, while increased funding for selected high risk pests has been forthcoming, surveillance is stronger for species that impact on primary production compared with those that impact mainly on the environment or socially (eg. social insects, fish). This is largely due to a lack of clarity of institutional roles and responsibilities, and undeveloped institutional structures and budget processes.
2. AWC has been attempting to better coordinate the different legislation, regulations and structures throughout Australia that contribute to weedy plants still being traded. However, garden plants that are categorised as weeds still remain for sale in many states despite attempts at voluntary removal from sale and legislative changes within some States.
3. Sleeper weeds have been identified and prioritisation for eradication has been undertaken; but not agreed to nationally. Alert lists for high priority invasives have been developed. The alert list for environmental weeds has been criticised as not being useful to regional groups as a number of species are not of concern to government agencies or the community; there was inadequate consultation involved, and the basis for the selection of weeds on the list was not made clear.

4. There is a need for an equivalent formally recognised "alert list" for weeds that can impact on agriculture and or/the environment. Such a list could address both species that are not yet present in Australia as well as those species that have entered Australia and could become weeds.
5. There is no national alert list for vertebrate or invertebrate pests that are not specifically pests of agricultural animals, however there are sometimes individual warnings or alerts put out.
6. A high level of community awareness has proven to be an important part of monitoring and surveillance. However, current State legislation (with the exception of Tasmania) does not obligate landowners or diagnostic laboratories to report suspicious new incursions of invasives.
7. While the Vertebrate Pests Committee has attempted to list all exotic terrestrial vertebrates present in captivity or the wild in Australia, relatively few of these species have had a risk assessment conducted to determine the threat they pose, even though they are already past quarantine barriers. The cost and responsibility for conducting such risk assessments is an issue that has not been resolved. This applies also to invertebrates where no attempt has been made to list those with possible impacts on the environment.
8. A national policy for pest and disease surveillance could be considered that addresses awareness raising in communities at a generic level, as well as funding, targets, surveillance levels, methods, and training for specific invasive species and groups of species.

**Emergency Response and Eradication**

1. Nationally consistent guidelines for emergency pest incursions affecting Australia's plant industries (PLANTPLAN), based on AUSVETPLAN have been drafted recently by Plant Health Australia. However, environment interests have not been integrated into the development of decision making on response arrangements for plant health. Also, the principle of beneficiary pays has not been incorporated effectively into response arrangements with regard to the environment and broader social beneficiaries (eg human health). There are gaps in legislation in that few State and Territory governments have specific powers to control or eradicate across all land types, immediately establish quarantine measures, destroy healthy plants or establish buffer zones. Also, if an incursion of an invasive is considered beyond eradication, then there is no system for joint Australian Government/State action of joint funding for any containment program within one state or more. This constitutes a gap in the arrangements when it may well be in the national interest to contain the species.
2. The importance of not having cost sharing agreements in place has been stressed and demonstrated over the past ten years. However, as of October 2003, cost sharing arrangements were not in place for weeds, vertebrate or aquatic pests, but were in place for animal diseases, and under development for plant pests. Preparedness plans for incursions do not exist for pest and disease incursions that do not have a significant primary industry impact. There are no preparedness funds held in reserve by governments specifically for eradication or containment of newly discovered invasive species.
3. Eradication of some new plant diseases and weeds has been effected in the past ten years. Most have been in the early stages of developing into pests. Early eradication of an invasive species has been shown to be far preferable in terms of cost effectiveness as the feasibility and cost of eradication increases as the

invasive spreads. There are few examples of any weed or invasive animal pest that has been eradicated on the Australian mainland once it has become widespread.

4. Historically, detection and management of invasive species has been the responsibility of primary industries and related government agencies due to the large and noticeable economic impact on such industries. Invasive species with a largely environmental or social impact have tended to be given less attention in relation to detection, surveillance, R&D, and control actions. This is partially due to a lack of a funding base for such activities.

**Containment and Control**

1. In general terms the National Weeds Strategy has been highly successful in providing a focus for a concerted effort on containing or controlling some weeds (WONS), coordinating across jurisdictions, and identifying sleeper and alert weed lists. The WONS program, together with the National Weeds Facilitator, have generally been regarded as excellent initiatives and provide examples of coordinated activities between the States.
2. The ten years has demonstrated that bio-control offers great promise, is highly cost-effective and has already achieved much with biological control agents being dispersed and contributing to the management of a range of invasive. However, the regulation of biological control agents can provide a disincentive to researchers.
3. The last ten years has seen an increasing focus by government agencies and industry groups on the involvement of the community and their level of awareness in the efficient and effective surveillance, detection, containment and control of invasives.
4. In terms of setting national priorities for containment and control on an objective basis there are issues in decision making associated with assessing the importance of species that impact on primary industries versus those that impact on the environment or social infrastructure and amenities such as waterways and water storages, or where there are impacts such as human health and safety involved. Key questions are who should pay and what process can be used to identify appropriate responsibilities and cost sharing. The management of invasives in non-agricultural areas or without agricultural significance sometimes falls to government agricultural structures as this is where there is the most significant expertise and structures for organisation and management. This suggests a gap exists as these agencies, although having appropriate skills and protocols, should not necessarily have the responsibility to manage and fund response and control activities for such incursions.

**Resourcing**

1. Two comments are justified regarding resourcing. First, the total amount of resources invested by the public sector appears less than what might be justified given the impact of invasives in relation to other natural resource areas and the high benefit-cost ratios associated with most invasive investments. Second, there appears inadequate knowledge of what resources are invested in invasive species programs as a whole.

# References


ABARE (2003) "Commodity Statistics", Canberra.

Adamowicz W (2004) "What's it worth? An examination of historical trends and future directions in environmental valuation", Australian Journal of Agricultural and Resource Economics, Vol 48, Issue 3, September 2004.

Adamson D Bilsoton A and Lynch K (2000) "The potential economic benefits of the Siam Weed Eradication Campaign", RDE Connections, NRSM and the University of Queensland.

Adamson D and Lynch K (2000) "An economic assessment of SWEEP, RDE Connections", NRSM. The University of Queensland.

AEC Group (2002) "Economic Impact of State and Local Government Expenditure on Weed and Pest Animal Management in Qld" October 2002 (LGA QLD)

AEC Group (2003) "Economic Assessment of Environmental Weeds in Queensland" Department of Natural Resource and Mines, Oct 2003.

AFFA (2003) "Plant Health Structures in Australia: An Information Paper Outlining the Australian Plant Health System, Plant Health Bodies and Exotic Pest and Disease Incursion Management", AFFA.

Agribox News Headlines (2004) "Queensland Report on Wild Dogs Economic Impact Released", http://www.agribox.com.au 22 October 2004.

Agtrans Research (1999) "Evaluation of the HRDC/AAPGA Investment in R&D for the Apple and Pear Industry with Emphasis on IPM", Report to Horticultural Research and Development Corporation, Sydney

Agtrans Research (2004) "Assessment of Representative Investments by the CRC for Tropical Plant Protection over the period 1992 to 2006", Final Report to the CRC TPP, March 2004.

Animal Health Australia (AHA) (2004) "Animal Health in Australia 2003", Canberra, Australia

AHA website (2004) http://www.aahc.com.au

Ardley J (1999) "Pesticide Considerations: An Environmental Concern" in Agricultural Science Vol 12, No.2 pp21-24

Austin P (2004) "Review of Progress Against the Rubber Vine Strategic Plan", AWC

AWC (2001) "Uniform State/Territory Controls over the Trade and Distribution of Highly Invasive Plants", as endorsed by SCRM17 Item 1.2.7 in Wellington on 7 March 2001.

AWC (2004a) “Australian Weeds Committee”, http://www.weeds.org.au/awc.htm

AWC (2004b) “Weeds of National Significance website” http://www.weeds.org.au/natsig.htm

Beare S and Hinde R (2001) “Cost Effective Management of Animal and Plant Disease Incursions”, 45th Annual Conference of the Australian Agricultural and Resource Economics Society, Adelaide.

Bennett J, van Beuren M and Whitten S (2004) “Estimating society’s willingness to pay to maintain viable rural communities”, Australian Journal of Agricultural and Resource Economics, Vol 48, Issue 3, September 2004.

Blood K (2001) “Environmental Weeds: Progress is being made” 3 May 2001 Kate Blood, Weed Education Officer, CRC Weed Management Systems

Bomford M (2003) “Risk Assessment for the Import and Keeping of Exotic Vertebrates in Australia”, Bureau of Rural Sciences, Canberra.

Bomford, M and Hart Q (2002) “Non-Indigenous Vertebrates in Australia” in “Biological Invasions: Economic and Environmental Cost of Alien Plant, Animal and Microbe Species”, D Pimental (ed) CRC press, London

Brennan J and Murray G (1998) “Economic Importance of Wheat Diseases in Australia”, NSW Agriculture, Wagga.

BRS (2003) “Submission to Senate Inquiry on Invasive Species”.

Cahill D (1993) “Review of Phytophthora Diseases in Australia”, Project ANU16A, A Report for the Rural Industries Research and Development Corporation, Canberra.

Canyon,D, Speare R, Naumann I, and Winkel K (2002) “Environmental And Economic Costs of Invertebrate Invasions in Australia” in “Biological Invasions: Economic and Environmental Cost of Alien Plant, Animal and Microbe Species”, D Pimental (ed) CRC press, London

Cao L and Klijn N (2004a) “Optimal Hazard Reduction for Recurrent Episodes of Pest or Disease Incursion and Eradication”, 48th Annual Conference of Australian Agricultural and Resource Economics Society.

Cao L and Klijn N (2004b) “Economic Analysis of Risk and Management of Pest or Disease Incursions” Risk Analysis Conference, Greece, 2004.

Carter R and Dodd J (2003) “Review of the National Siam Weed Eradication Program”, Report to Australian Weeds Committee.

Choquenot D McIlroy J & Korn T (1996) “Managing Vertebrate Pests – Feral Pigs” Bureau of Rural Sciences, Canberra.

CIE and CSIRO (2000) "Funding and Compensation for emergency eradication of exotic plant pests and diseases: An issues paper" Prepared for PHA as a basis for discussion with interested organisations and individuals.

Chakraborty S, Murray , G and White N (2002) "Impact of Climate Change on Important Plant Diseases in Australia: A Report for the Rural Industries Research and Development Corporation", RIDC Canberra

Cole M (1999) "The Australian Surveillance Network : Present status and future", paper in Proceedings of a Workshop edited by McRae C F and Dempsey S M on "Plant Health in the New Trading Environment: Managing Exotic Insects, Weeds and Pathogens", Canberra 23-24 February 1999.

Cole M (undated) "Management of Invasive Plant Pests in Australia", Office of the Chief Plant Protection Officer, AFFA

Cole M (2003) "Forest Invasive Species Strategies in Australia", July 2003, Office of the Chief Plant Protection Officer, AFFA.

Combellack H (1987) "Weed Control Pursuits in Australia" Chemistry and Industry pp273-380

Cooke C (1995) "Commercialisation Strategy for Anthracnose Biocontrol" Final Report Presented to HRDC.

CRC for Australian Weed Management (2003a) "Killing Us Softly: Australia's Green Stalkers: A call to action on invasive plants, and a way forward", A 2020 Vision Statement, Weeds CRC.

CRC for Australian Weed Management (2003b) "Submission to Senate ECILTA Committee on the Regulation, Control and Management of Invasive Species".

CRC for Australian Weed Management (2003c) "Weedwatch No. 3"

CRC for Australian Weed Management (2003d) "Weedwatch No. 4"

CRC for Australian Weed Management (2004a) "Annual Report".

CRC for Australian Weeds Management (2004b), "Media Material"

CRC for Australian Weeds Management (2004c) "Facts and Figures"

CRC for Australian Weeds Management (2004d) "Weedwatch No. 5"

CRC for Australian Weeds Management (2004e) "Weedwatch No. 6"

CRC for Australian Weeds Management (2004f) "Weedwatch No. 7"

CSIRO (2003) "Submission to Invasive Species Inquiry"

CSIRO (2004) "Yellow crazy ant eradication begins in Arnhem Land" CSIRO Media Release 16 July 2004.

CSIRO Livestock Industries (2004) "Taking Stock" Issue 8 October 2004

Cunningham D, Woldendorp G, Burgess M, and Barry S (2003) "Prioritising Sleeper Weeds for Eradication: Selection of species based on potential impacts on agriculture and feasibility of eradication", Bureau of Rural Sciences, Canberra

DAFF (undated) "Review of Australia's Quarantine Function", DAFF Submission to the Joint Committee of Public Accounts and Audit, Canberra

DAFF (2003) "Submission to Senate Inquiry into Invasive Species".

DAFF (2004) "Animal Biosecurity: Update on Import Risk Analyses and Market Access List", Animal Biosecurity Policy Memorandum 2004/11.

DAFF Website (2004) "Quarantine and Export Service" http://www.daff.gov.au

Davis P and Grimm M (2003) "Submission to Senate Inquiry on Reducing the Effect of Invasive Species".

De Barro (1999) "A penny spent is a pound saved: Pre-emptive approaches to managing quarantine threats to primary industries", paper in Proceedings of a Workshop edited by McRae C F and Dempsey S M on "Plant Health in the New Trading Environment: Managing Exotic Insects, Weeds and Pathogens", Canberra 23-24 February 1999.

DEH (2001) "Threat Abatement Plan for Dieback Caused by the Root-rot Fungus *Phytophthora cinnamomi*", October 2001.

DEH (2003a) "Submission to Senate Inquiry on Reducing the Effect of Invasive Species".

DEH (2003b) "Macquarie Island Declared Cat Free" press release, Department of Environment and Heritage.

DEH (2004) "Weeds on the National Environmental Alert List", www.deh.gov.au/biodiversity/invasive/weeds/alert-list.html

DEH (in press) "Managing Invasive Species: Success Stories", Canberra

DEH website (2004) "About Feral Animals in Australia" http://deh.gov.au/biodiversity/invasive/ferals/index.html

Delane R (1999) "Coordinating Plant Health Management in Australia: Towards Formation of the Australian Plant Health Council", paper in Proceedings of a Workshop edited by McRae C F and Dempsey S M on "Plant Health in the New

Trading Environment: Managing Exotic Insects, Weeds and Pathogens", Canberra 23-24 February 1999.

DNR&M (2004) Queensland Pest Assessment Mapping (Annual pest Assessment or APA) www.dnre.qld.gov.au/pests/pest_assessment/

Elliston L, Yainshet A and Hinde R (2004) "Karnal Bunt: The Regional Economic Effects of a Potential Incursion", ABARE Report to Plant Health Australia.

Environmental Weed Strategy for Western Australia (1999) Department of Conservation and Land Management.

Evans G, McRae C and Dempsey S (1999) "Towards A National Approach to Plant Protection in Australia", Paper in Proceedings of a Workshop edited by McRae C F and Dempsey S M on "Plant Health in the New Trading Environment: Managing Exotic Insects, Weeds and Pathogens", Canberra 23-24 February 1999.

Evans R (2000) "Environmental Water Requirements of Groundwater Dependent Ecosystems", Project Number WC01191, Environment Australia

Feral Herald #2 (2002) "Foxes in Tasmania – An Update" December 2002

Feral.org.au website (2005) "Common starling (Sturnus vulgaris)" http://feral.org.au/species/starling.asp

Glanznig A (2003) Senate Committee Hearings in Canberra on Invasive Species, 26 Nov 2003, Canberra

Glanznig A, McLachlan K and Kessal O (2004) "Garden Plants that are Invasive Plants of National Importance: An overview of their legal status, commercial availability and risk status", WWF Australia.

Glanznig A and Kessal O (2004a) "Invasive Plants of National Importance and their Legal Status by State and Territory", WWF Australia.

Glanznig A, McLachlan K and Kessal O (2004b) "Commercial Availability of 'Garden Thug' Plants", WWF, Australia

Grice A, Field A, and McFadyen R (2004) Quantifying the Effect of Weeds on Biodiversity: Beyond Blind Freddy's Test", Proceedings of Australian Weeds Conference 2004.

Groves R (1998) (Convenor) "Recent Incursions of Weeds to Australia 1971 to 1995", CRC for Weed Management Systems, Appendix compiled by J R Hosking. CRC Technical Series No 3, January 1998

Groves R (2002) "The impacts of alien plants in Australia", in "Biological Invasions: Economic and Environmental Cost of Alien Plant, Animal and Microbe Species", D Pimental (ed) CRC press, London

Groves R (undated) “Meeting the Challenges Posed by Sleeper Weeds”

Groves R and Panetta D (2002) “Some General Principles for Weed Eradication”, Paper in Proceedings of the 13th Australian Weeds Conference, pp 307-310, Plant Protection Society of Western Australia, Perth, WA.

Groves R, Hosking J, Batianoff G, Cooke D, Cowie I, Johnson R, Keighery G, Lepschi B, Mitchell A, Moerkerk R, Randall A, Rozefelds A, Walsh N and Waterhouse B (2003) Weed Categories for Natural and Agricultural Ecosystem Management”, BRS, Canberra.

Hart, Q (2002) “Managing Pest Animals in Australia” Science for Decision Makers November 2002, Bureau of Rural Sciences, Canberra.

IBC (2005) “The Northern Territory Profile” International Business Council Chamber of Commerce Northern Territory, http://www.ibc.org.au/nt

Invasive Species Council (2003 ) Home Page http://www.invasivespecies.org.au .

Kemp D (2004) “A Sustainability Strategy for the Australian Continent: Environmental Budget Statement 2004-05” Statement by the Honourable Dr David Kemp, MP, Minister for the Environment and Heritage 11 May 2004, Canberra.

Jakabsson K M and Dragun A K (2001) “The Worth of a Possum: Valuing Species with the Contingent Valuation Method”, Environmental and Resource Economics 19:211-227

Kailola P J (2000) “Development of an Alert List for Non-Native Freshwater Fishes” Unpublished final report to Environment Australia, Canberra.

Lintermans, M (2004) “Human-assisted dispersal of alien freshwater fish in Australia” in New Zealand Journal of Marine and Freshwater Research, Vol 38:481-501.

Lockwood, M. and Carberry D., 1998, State Preference Surveys of Remnant Native Vegetation Conservation. Johnstone Centre Report No. 104, Charles Sturt University, Albury.

Lonsdale M (1993) “Rates of Spread of an Invading Species: *Mimosa pigra* in Northern Australia, Journal of Ecology, 81, 513-521

Lonsdale M (1994) “Inviting Trouble: Introduced Pasture Species in Northern Australia, Australian Journal of Ecology, 19, 345-354

Lonsdale M (2003) Senate Committee Hearings in Canberra on Invasive Species, 26 Nov 2003, Canberra

Lonsdale M (2002) “The Highest Form of Generalship? A Review of Australia’s Weed Strategies”, Proceedings of 13th Australian Weeds Conference, Plant Protection Society of Western Australia, Perth, WA.

Lubulwa G and McMeniman (1997) "An economic evaluation of realised and potential impacts of ACIAR's biological control projects (1983-1996)", Working Papers IAP-WP26, ACIAR, Canberra.

Maxwell S, Burbidge A and Morris K (1996) "Action Plan for Marsupials and Monotremes" IUCN Species Survival Commission
http://www.deh.gov.au/biodiversity/threatened/action/marsupials

McFadyen (2003) Senate Committee Hearings in Canberra on Invasive Species, 26 Nov 2003, Canberra

McFadyen R (2004a) "Weeds out of Biocontrol" 14th Annual Weeds Conference

McFadyen R. (2004b) Weekly Times Article, December 2004.

McLaren D, Whattam M, Blood K, Stajsic V and Hore R (1999) "Mexican feather grass (*Nassella tenuissima*): a potential disaster for Australia", 12th Australian Weeds Conference, West Point Convention Centre, Hobart, pp 658-662

McLeod R (1996) "Annual Cost of Weeds, Pest and Diseases to the Australian Sugar Industry", Unpublished Consultants Report, Sugar Research and Development Corporation, Brisbane

McLeod R (2004) "Counting the Cost: Impact of Invasive Animals in Australia 2004" Cooperative Research Centre for Pest Animal Control, Canberra.

McRae C F and Dempsey S M (eds) (1999) "Plant Health in the New Trading Environment: Managing Exotic Insects, Weeds and Pathogens", Proceedings of a Workshop Held in Canberra 23-24 February 1999.

Miller I and Pickering S (2001) "Mimosa or Giant Sensitive Plant", Agnote 466 no F2, Northern Territory

Nairn (1996) "Australian Quarantine: A Shared Responsibility", Commonwealth of Australia

National Weeds Strategy Executive Committee (2002), "Report 1997-2002"
www.weeds.org.au/docs/nws5yrrpt.pdf

Neave H M (1999) "Rabbit Calicivirus Disease Program Report 1: Overview of Effects on Australian Wild Rabbit Populations and Implications for Agriculture and Biodiversity". A Report of research conducted by participants of the Rabbit Calicivirus Disease Monitoring and Surveillance Program and Epidemiology Research Program. Prepared for the RCD Management Group, Bureau of Rural Sciences, Canberra.

Newsome A (2001) "Data needs and methods to investigate impacts of animal and insect pests on Australian landscapes and primary production". Audit themes and projects, http://nlwra.gov.au

NRM (2004) “Pest Assessment Mapping”, Queensland Department of Natural Resources and Mines www.nrm.qld.gov.au/pests/pest _assessment/

NSW Biodiversity Research Network (2002) “Australian Wildlife Health Network” in Newsletter No.2 August 2002 http://www.nationalparks.nsw.gov.au/npws.nsf

NSW Department of Primary Industries Website (2005) http://www.agric.nsw.gov.au/reader/releases/bird-damage-form.htm

OCPPO (2002) “Detection, Monitoring and Management of Invasive Pest Plants in Australia”, Country Report Prepared for APEC Symposium on Invasive Plant Pests by the Office of the Chief Plant Protection Officer.

Office of the Chief Plant Protection Officer (OCPPO) (2000), Product Integrity Animal and Plant Health Functional Review.

Old K (1999) “The strengths, weaknesses and opportunities of threat identification”, Paper in Proceedings of a Workshop edited by McRae C F and Dempsey S M on “Plant Health in the New Trading Environment: Managing Exotic Insects, Weeds and Pathogens”, Canberra 23-24 February 1999.

Olsen P (1998) “Australia’s Pest Animals: New Solutions to Old Problems” Bureau of Resource Sciences, Canberra.

Panetta D, Pheloung P, Hosking J, Weiss J, Virtue J and Randall R (2002) Principles to be utilised in determining when an exotic plant incursion warrants a nationally coordinated response with cost sharing “, A discussion paper endorsed by the Australian Weeds Committee.

Panetta D and Timmins S (2004) “Evaluating the Feasibility of Eradication for Terrestrial Weed Incursions”, Plant Protection Quarterly 19: 5-11.

Paton D (1996) “Overview of Feral and Managed Honeybees in Australia” Australian Nature Conservation Agency, Environment Australia, Canberra.

Peacock (2003) Senate Committee Hearings in Canberra on Invasive Species, 26 Nov 2003, Canberra

Pest Animal Control CRC (2004a) “The Fox: Australia’s number one predator” http://www.pestanimal.crc.org.au

Pest Animal Control CRC (2004b) “The Rabbit: Australia’s number one pest” http://www.pestanimal.crc.org.au

Pest Animal Control CRC (2004c) “The Feral Pig in Australia” http://www.pestanimal.crc.org.au

Pest Animal Control CRC (2004d) “The Mouse: A major threat to grain producers” http://www.pestanimal.crc.org.au

Pest Animal Control CRC (2004e) "The Carp: damage to aquatic plants and fauna" http://www.pestanimal.crc.org.au

Pest Animal Control CRC website (2005) http://www.pestanimal.crc.org.au

Pimental D, Lach L, Zuniga R. and Morrison D (2000) "Environmental and economic costs of non-indigenous species in the United States" Bioscience, 50(1):53.

Plant Health Australia (2002a) "Outcomes of Expert Reference Groups: Progress towards a cost sharing agreement for Australia's Plant Industries" Plant Health Australia.

Plant Health Australia (2002b) Media release.

Plant Health Australia (2004) "PLANTPLAN: Australian Emergency Plant Pest Response Plan", Plant Health Australia, Canberra, ACT

Possingham H, Ryan S Baxter J and Morton S (2002) "Setting Biodiversity Priorities" Paper produced by Working group on "Sustaining our Natural Systems and Biodiversity ", PMSEIC.

Prime Minister's Science, Engineering and Innovation Council (2002) "Sustaining our Natural Systems and Biodiversity", Canberra.

Queensland Government (2003) "Submission to Senate Invasive Species Inquiry".

Queensland Government (2004) "NR&M remains vigilant for crazy ants" Queensland Department of Natural Resources & Mines media release 12 October 2004.

Queensland Government (2005) "Crazy Ants won't stop trade at Caboolture estate" Queensland Department of Natural Resources & Mines media release 25 January 2005.

Queensland DPI&F website (2004) "Animal and Plant Health - Fire ants" http://www.dpi.qld.gov.au/fireants

Queensland DNR&M website (2004) "Pest and weed management – red-eared slider turtle" http://www.nrm.qld.gov.au/pests/red_eared_slider_turtle.html

Reddiex B, Forsyth D M, McDonald-Madden E, Einoder L, Griffioen A, Chick R R, & Robley A J (2004) "Review of Existing Feral Goat, Feral Cat, European Rabbit, Feral Pig, Red Fox and Wild Dog Control in Australia" Draft Report for the Australian Government Department of the Environment and Heritage. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Melbourne.

Roberts W (1999) "Responding to incursions of exotic pests and diseases: the national approach ", paper in Proceedings of a Workshop edited by McRae C F and

Dempsey S M on "Plant Health in the New Trading Environment: Managing Exotic Insects, Weeds and Pathogens", Canberra 23-24 February 1999.

Rolfe J C, Bennett J W, Blamey R K (2000) "An Economic Evaluation of Broadscale Tree Clearing in the Desert Uplands Region of Queensland", Research Report No. 12, Choice Modelling Research Reports.

Saalfeld W K (1997) "Aerial Survey of Buffalo, Horses and Red-tail Black Cockatoo in the Western Top End, Northern Territory 1997". Technical Report, Parks and Wildlife Commission of the Northern Territory, Palmerston.

Saalfeld W K (1998) "Aerial Survey of Large Vertebrates in Arnhem Land 1998" Technical Report, Parks and Wildlife Commission of the Northern Territory, Palmerston

Sinden J, Jones R, Hester S, Odom D, Kalisch C, James R, and Cactro O (2004) "The Economic Impact of Weeds in Australia", CRC for Australian Weed Management, Technical Series No 8, Adelaide

South Australian Animal and Plant Control Commission (2003) "Submission to Senate Enquiry".

Spafford Jacob H, Randall R, and Lloyd S (2004) Front Door Wide Open to Weeds: An examination of the weed species permitted for import without risk assessment" Report prepared for WWF Australia, Weeds CRC.

State of Environment Australia (2001), Biodiversity Theme Report. www.deh.gov.au/soe/2001/biodiversity/biodiversity04-2a.html

State of Environment Report NSW (2003) Chapter 6 on Biodiversity. www.environment.nsw.gov.au/soe/soe2003/chp_6

State of the Environment Queensland (2003), Chapter 7 Biodiversity

State of the Environment Report 2003, South Australia, Chapter 5 Biodiversity

State of the Environment Tasmania (2003) www.rpdc.tas.gov.au/soer/bio/

State of the Environment Report 1998, Western Australia

State Weed Plan Steering Group (2001) "A Weed Plan for Western Australia" Department of Agriculture

Thackway R, Yapp G, Cunningham D and McNaught I (2003)"Towards a national set of core attributes for mapping Weeds of National Significance (WONS), Discussion Paper, Sept 2003.

Thackway R, Parsons M, Cunningham D, McNaught I, and Woldendorp G (2004) "Draft National Weeds Assessment Work Plan", BRS, 12 Oct 2004

Thorp J and Lynch R (2000) "The Determination of Weeds of National Significance" Commonwealth of Australia and National Weeds Strategy Executive Committee, Launceston. Available at www.weeds.org.au/docs/WONS/

Van Beuren M and Bennett J (2004) "Towards the development of a transferable set of value estimates for environmental attributes", Australian Journal of Agricultural and Resource Economics, Vol 48, Issue 1, March 2004.

Victorian Catchment Management Council (2002) "The Health of Our Catchments: A Victorian Report Card", Melbourne.

Victorian Department of Primary Industries (2003) "Serrated Tussock Program: Case Study", Victorian Serrated Tussock Working Party.

Victorian Department of Primary Industries and Department of Sustainability and Environment (2004) "Intensifying the Attack on Serrated Tussock", Draft.

Vidler S J (2004) "Using your cute and furries: the role of threatened species in weed awareness", Proceedings Australian Weeds Conference 2004.

Virtue J, Cunningham D, Hanson C, Hosking J, Miller I, Panetta F, Phelong P, Randall R, Timmins S, Walton C, Weiss J and Williams P (2004a) "A National Protocol for Post Border Weed Assessment" Draft for Comment, CRC Weeds.

Virtue J, Bennett S and Randall R (2004b) "Plant introductions in Australia : How can we resolve 'weedy' conflicts of interest", Proceedings of 14th Australian Weeds Conference, Weed Society of NSW, Wagga Wagga, Australia.

Vogelzang B (2000) "Northern Australia Quarantine Strategy (NAQS) Scientific Program", Paper in Proceedings of a Workshop edited by McRae C F and Dempsey S M on "Plant Health in the New Trading Environment: Managing Exotic Insects, Weeds and Pathogens", Canberra 23-24 February 1999.

Waterhouse D, Dillon B, and Vincent D (1998) "Economic Benefits to PNG and Australia from the biological control of banana skipper", Impact Assessment Series IAS12, ACIAR, Canberra.

WA Department of Agriculture (2005) "European House Borer Website" http://ehb.wa.gov.au

Weed Management Society of South Australia Inc. (2003) Submission to Senate Invasive Species Inquiry.

Willcocks C (2004) Senate Committee Hearings in Canberra on Invasive Species, 18 June 2004, Canberra

Woldendorp G and Bomford M (2004) "Weed Eradication", Bureau of Rural Sciences

WONS (2004) Draft Progress Reports

WWF Australia (2003b) Submission to Senate Inquiry, October 2003

WWF Australia (2003a) "Weeds and Pests: Eradicating the Invasive Threat", Position Paper,