Interjurisdictional analysis: invasive species management

NSW Natural Resources Commission

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Template 2.8.1

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Abbreviations

Abbreviation	Description
ACT	Australian Capital Territory
CSIRO	Commonwealth Scientific and Industrial Research Organisation
ELA	Eco Logical Australia Pty Ltd.
ISM	Invasive species management
LLS	Local Land Services
NRC	Natural Resources Commission
NRM	Natural resources management
NSW	New South Wales
RAD	Resist Accept Direct framework
SEQ	South-east Queensland
US	United States of America

Cane toad, Northern Territory
(Photo: Matt, Creative Commons Attribution 2.0)

Summary

Invasive species are a significant social, economic and environmental burden for Australia, negatively impacting on Australia's agriculture, biodiversity, natural and built environments, public health and productivity. Invasive species management (ISM) is therefore a significant and challenging enterprise undertaken by a wide range of agencies and across multiple sectors. Eco Logical Australia Pty Ltd (ELA) completed this interjurisdictional analysis of ISM for the New South Wales (NSW) Natural Resources Commission (NRC) to identify contemporary strategies and highlight innovative practices across Australia and globally. This analysis focused on describing key trends and highlighting innovation across key thematic areas broadly addressed by ISM agencies in Australia (e.g., weeds, feral animals, pest species, disease). Examples were only considered that have been trialled or implemented by the jurisdictions considered and did not include more experimental or theoretical strategies presented in the scientific literature (e.g., CRISPR gene editing), unless such experiments or proposals represented an investment on behalf of the selected jurisdictions.

The key questions addressed by this analysis were:

- What are the most promising and innovative emerging ISM strategies that have been implemented in the jurisdictions considered?
- What features characterise best practice contemporary ISM?
- How do current ISM strategies identified in the jurisdictions considered differ from those presently applied in NSW (e.g., are they alternatives to existing strategies? Or value adds? etc.)?
- What are the key considerations (e.g., biophysical/cultural/economic requirements, trade-offs, etc.) that need to be addressed in choosing and implementing new ISM strategies identified from this analysis in the NSW context?

Findings suggest that ISM trends across the jurisdictions explored are relatively comparable with broadly similar approaches being adopted in most cases, especially amongst Australian States and Territories, including NSW. On-ground ISM interventions are represented by a fairly narrow suite of well-established actions with recent shifts evident in the uptake of technology (e.g., remote camera technology) and underpinning principles (e.g., safe havens, remove and protect). ISM innovation is more apparent with respect to the institutional scaffolding supporting the implementation of on-ground interventions, particularly in relation to the scale of programs and services.

Major highlights in ISM trends identified by this interjurisdictional scan include:

- strong visions and ambitious targets to drive ISM action.
- an emphasis on early eradication
- investment in safe havens for native species
- uptake of new sensor technologies for invasive species monitoring
- facilitation of citizen science invasive species monitoring and associated knowledge hubs
- adaptive management programs with clearly aligned and scientifically informed monitoring
- programs to strengthen engagement, partnerships and regional coordination

Key characteristics of best practice in contemporary ISM identified from this analysis concern: strong collaboration, coordination and codesign; consideration of multiple scales and human elements; integration of data and techniques; and clear adaptive management approaches incorporating embedded monitoring and evaluation as well as an applied science, 'learning by doing' approach. Strong legislation, policy and regulation remain critical to supporting management objectives.

Major considerations for NSW in designing and implementing new ISM strategies recommended include a need for:

- State-level plans need to: better guide regional plans, include animal and plant diseases that fall outside of agricultural and food safety; better align with relevant objectives, targets and actions in threatened species action plans and link to key threatening processes.
- Greater consideration to the implications of climate change.
- Greater consideration to facilitating specific engagement of First Nations peoples in ISM.
- More nuanced and accurate insights based on an improved understanding of the beliefs, values and motivations of multiple segments of the population to encourage action and ownership.
- Thinking big and long-term – how do we effectively steer our landscapes through transition and transformation?
- Capitalising on existing knowledge, gaining new knowledge and refining, adapting and developing the tools and methodologies we need for ISM.
- Give more emphasis to 'applied' science – research into the practical use of alternative approaches and new technologies, bringing them to market and learning by doing.

SECTION 1

Introduction

The NSW Natural Resources Commission (NRC) commissioned Eco Logical Australia Pty Ltd (ELA) to undertake an interjurisdictional analysis of invasive species management (ISM) to identify contemporary strategies and highlight innovative practices across Australia and globally.

Here, we define invasive species as "*a species whose establishment and spread threatens ecosystems, habitats or species with economic or environmental harm*" per the definition in the NSW Invasive Species Plan 2023-2028 (Department of Regional NSW 2023).

We note that the *NSW Biosecurity Act 2016* has a broader definition of biosecurity.

OBJECTIVES AND SCOPE

This analysis focused on Australian States (excluding NSW) and Territories along with a small selection of international jurisdictions (e.g., New Zealand) which are recognised as innovators in managing invasive species. For each of these jurisdictions, the aim of this analysis was to:

- describe broad trends in contemporary ISM
- identify innovative practices in ISM
- identify notable changes in ISM practices (e.g., cessation of past approaches)
- consider the relevance of documented ISM approaches to the NSW context

Overall, the emphasis of this analysis was on describing key trends and highlighting innovation rather than providing a comprehensive systematic review of current ISM approaches in selected jurisdictions, although broad trends were determined. Additionally, this analysis only considered examples of ISM that have been trialled or implemented by the jurisdictions considered and did not include more experimental or theoretical strategies presented in the scientific literature (e.g., CRISPR gene editing), unless such experiments or proposals represented an investment on behalf of the selected jurisdictions. Additionally, we focused mainly on ISM in terrestrial and freshwater realms and excluded programs focusing specifically on coastal, estuarine or marine resources.

1.2. Approach

To complete this review, we undertook the following tasks:

- Development of an ISM analytical framework (Figure 1)
- Scans of published and grey literature relevant to ISM in Australian States and Territories and selected international jurisdictions (using our analytical framework to guide searches)
- Creation of an attributed database of ISM in selected jurisdictions (Appendix 1)
- Synthesis of identified documents to address the following questions:
    - What are the most promising and innovative emerging ISM strategies that have been implemented in the jurisdictions considered?
    - What features characterise best practice contemporary ISM?
    - How do current ISM strategies identified in the jurisdictions considered differ from those presently applied in NSW? (e.g., are they alternatives to existing strategies? Or value adds? etc.)

- What are the key considerations (e.g., biophysical/cultural/economic requirements, trade-offs, etc.) that need to be addressed in choosing and implementing new ISM strategies identified from this analysis in the NSW context?

Examples of relatively recent (~ < 10 years) ISM initiatives are highlighted within this report if they represent:

- novel and innovative practice that significantly progresses general approaches in this realm; or
- particularly large-scale and/or long-term investments on behalf of the jurisdictions involved.

1.3. Structure of this document

The following chapter (Section 2) provides an overview of the major trends identified during this analysis with respect to each ISM activity domain (Figure 1) with key examples, selected in relation to the above criteria. The final chapter (Section 3) provides particular highlights identified during this analysis and discusses their potential application in the NSW context.

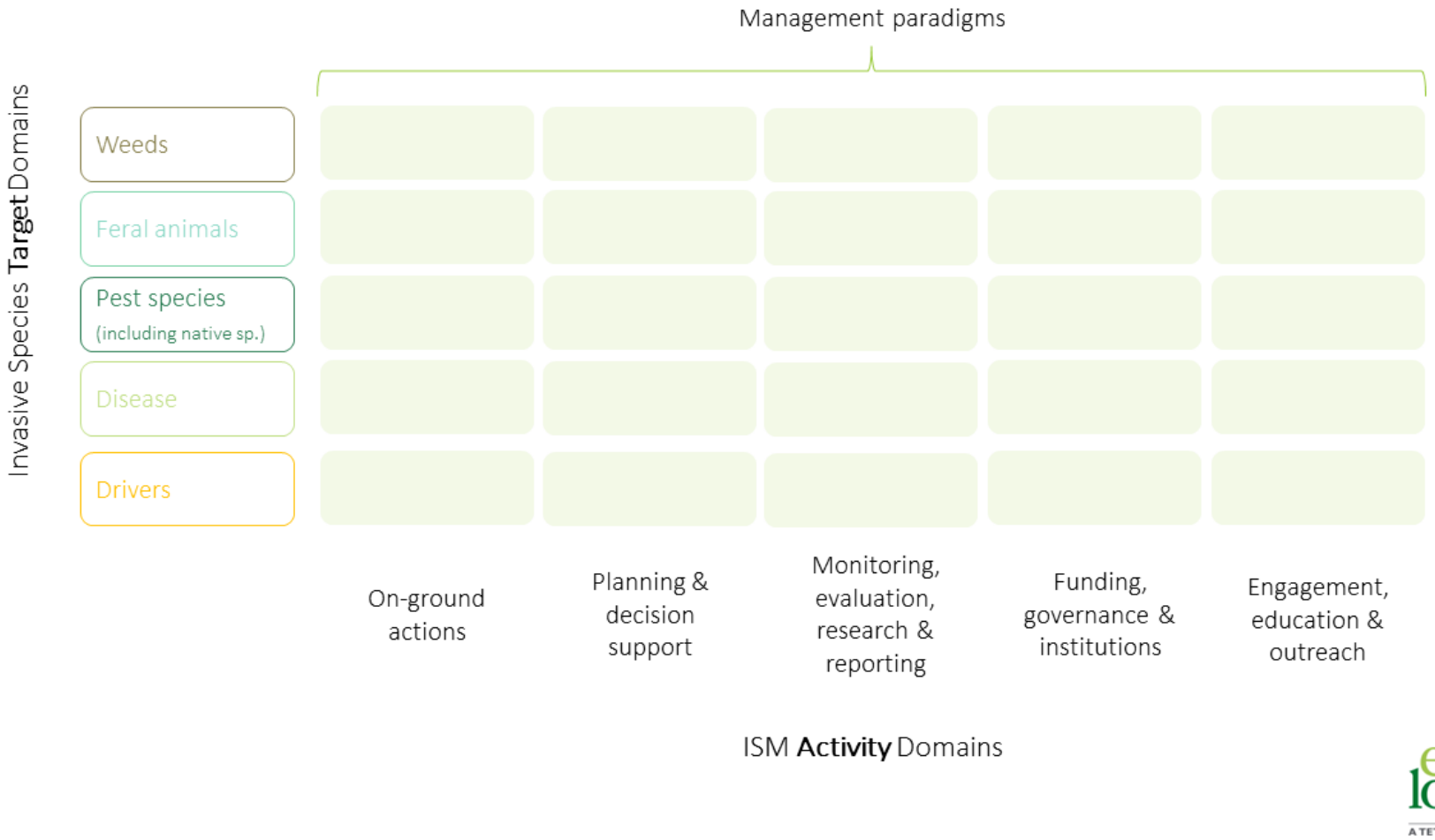

Figure 1 Analytical framework for reviewing Invasive Species Management strategies in relation to invasive species 'target' domains and ISM 'activity' domains.

SECTION 2

Trends & highlights

2. Trends and highlights in invasive species management

This section provides an overview of trends and highlights in contemporary ISM practices implemented by selected jurisdictions nationally and internationally in relation to major ISM activity domains (see Figure 1). The main question addressed in this section is:

- What are the most promising and innovative emerging ISM strategies that have been implemented in the jurisdictions considered?

A database of ISM programs and projects identified during this interjurisdictional scan is provided in Appendix A.

2.1. Invasive species management paradigms

In the last decade, Australian jurisdictions have aligned their focus in ISM with what is generally accepted as the key three elements (the Biosecurity Continuum) for managing biosecurity (Intergovernmental Agreement on Biosecurity (IGAB) (COAG 2012)):

i. Prevention of incursions in the first place
ii. Preparedness for, and emergency response to, incursions and outbreaks
iii. Ongoing management of biosecurity risks once established, including eradication where possible or, if not, containing the spread of new and emerging species, and managing the impact of widespread invasive species, generally at the asset-based protection level.

EARLY ERADICATION

An emphasis on early eradication of weed invasions is evident in numerous jurisdictions. These programs involve detection and listing of early invaders, risk assessments and actions to achieve complete removal of individuals and propagules. Notable examples include:

- Victoria's Department of Environment and Climate Action's Weeds at the early stages of invasion (WESI) project which advocates for early eradication on public lands, providing detailed guidelines for land managers to address early invaders.
- Tasmania invests significantly in preventing the incursion of new threats such as ferrets, classified as an Extreme Threat to Tasmania. Prevention actions include strict control of pets and prohibition of further imports. Small populations which have previously established in Tasmania have been eradicated.
- US Fish and Wildlife Services' Preventing the introduction and spread of invasive species through strategic landscape-level approaches

AMBITIOUS TARGETS

Numerous jurisdictions have adopted ambitious goals and targets which underpin their invasive species management programs, e.g.:

- New Zealand's Zero Invasive Predators 2050 target
- Western Australia's Western Shield project goal to return biodiversity to pre-European levels

- Various island pest species management programs seeking complete eradication of particular species
- ACT's Zero tolerance policy on feral horses in National Parks (e.g., Namadgi NP Feral Horse Management Plan 2020)

2.2. On-ground actions

For the most part, the on-ground actions to prevent or control invasive species supported by the jurisdictions considered comprise a range of tried and tested methods, encompassing physical, chemical, biological and cultural techniques. Integrated weed/pest management strategies which combine a range of these techniques to target different species and/or life history stages have been adopted by most of the programs identified (Appendix A).

SAFE HAVENS

Multiple projects undertaken by the jurisdictions examined represent large-scale investments in the creation of safe havens for native species through the removal and exclusion of invasive species from an area, e.g., an island, a fenced sanctuary or a peninsula. Recent research demonstrates the recovery and delisting of several threatened species as a result of this technique (Woinarksi *et al* 2023). Examples include:

- successful eradication of rodents and rabbits on Macquarie Island undertaken by the Department of Tourism, Arts and the Environment
- several feral animal (cat, pig) eradication programs on Kangaroo Island undertaken by the Kangaroo Island Landscape Board
- Glenelg Ark Victoria – large, landscape-scale fox control project
- Habitat Restoration Project on South Georgia Island (British Overseas Territory) – rodent eradication from entire island using baiting programs.

In New Zealand, a Remove and Protect Model for invasive species management has been adopted in which the barrier may be virtual (e.g., a line of traps or baits) rather than a physical structure, (e.g., a hard fence). This approach provides the ability to remove predators from large areas that are not islands or fenced sanctuaries. This model accepts there will be ongoing incursions that need to be detected and removed. An example of this approach has also been adopted in Australia as part of Western Australia's Western Shield Project (Department of Biodiversity, Conservation and Attractions) which annually baits 3.8 million hectares of land to control feral cats and foxes for the protection of native species.

GENETIC TECHNIQUES

Despite promising results evident in the scientific literature (e.g., Harvey-Samuel *et al* 2017), very few examples of genetic techniques for the control of invasive species have been adopted by the jurisdictions considered. Where such methods have been supported by the selected jurisdictions, they are mainly at the research and trial stage, e.g.: stocking alpine lakes with super-male brook trout (trojan brook trout) by the Idaho Department of Fish and Game (USA). In some cases, such programs have determined that other treatments may be more effective and so have been abandoned, e.g., genetic control of sea lamprey in the Great Lakes (Great Lakes Fishery Commission).

Other noteworthy projects involving innovative on-ground approaches identified included:

- Conditioned taste aversion for cane toad predators – being trialled by the Western Australian Department of Biodiversity, Conservation and Attractions in the Kimberley region.
- The United States Department of Agriculture National Clean Plant Network which provides high quality asexually propagated plant material free of targeted pathogens and pests

2.3. Planning and decision support

With limited resources, most Australian jurisdictions have adopted prioritisation frameworks to underpin legislation and investment in invasive species management, recognising that the greatest return on investment is often achieved by targeting prevention and early intervention rather than focusing on asset-based protection which takes place once pest animals are established and widespread (see 2.1 above).

RISK RATINGS

Weed risk assessments have been undertaken by most Australian jurisdictions, often prior to the declaration of weed species status with numerous approaches based on national risk assessment scoring system. Recent examples include:

- Victoria's Weeds at the early stages of invasion (WESI) project has included a more detailed environmental weed risk database managed by the Department of Energy, Environment and Climate Change. See also Advisory list of environmental weeds in Victoria 2022 (White *et al* 2022)
- Western Australia's Department of Primary Industries and Regional Development has recently released "Environmental weed risk assessment protocol for growing non-indigenous plants in the Western Australian rangelands"

ASSET-BASED PRIORITISATION

Once widespread, the eradication of pest animals and plants over wide areas of different land tenure is rarely practicable. Priorities for the control of these species must be determined and resources focused in areas where the benefits of control will be greatest. This requires identifying the priority assets that are most at risk (Department of Regional NSW 2023). Assets may be environmental, primary production or community (human health, infrastructure or cultural). Within programs, prioritisation of targeted actions may be informed by real-time monitoring of, for example, feral predators in close vicinity of threatened species. A key example is:

- Queensland Department of Environment and Science's Nest to Ocean turtle protection program, which funds projects above and beyond business as usual pest management that employ active monitoring and action to protect turtle nests from feral pigs and other predators. Project with a landscape-scale approach and innovative exclusion techniques as well as stakeholder engagement are particularly encouraged.

2.4. Monitoring, evaluation, research and reporting

Monitoring, evaluation, research and reporting represents a major area of innovation and progress in ISM amongst the jurisdictions considered with significant recent investment evident in consolidating and sharing information as well as monitoring.

NEW MONITORING TECHNOLOGIES

A range of relatively new technologies for monitoring invasive species, as well as assets targeted for protection, have been utilised by the jurisdictions considered, especially in relation to programs across large and/or remote or inaccessible locations, mostly including various sensor technologies, e.g.:

- Use of drones to monitor feral pigs on remote beaches under Queensland's Nest to Ocean turtle protection program
- Use of remote and thermal cameras on Kangaroo Island, installed in 2021, to assist with aerial culling in harder to reach areas
- Use in Western Australia's Rangelands of unmanned aerial vehicles (UAVs) with cameras to locate invasive cacti along with use of artificial intelligence methods to automatically differentiate invasive cacti from other plants
- Broad-scale tracking in Western Australia of feral pigs using infra-red detection of collared feral pigs to inform predictive modelling, along with thermal sensors in aerial surveillance

CITIZEN SCIENCE

Both opportunistic and formal citizen science monitoring programs have been implemented by the jurisdictions considered to promote public involvement in collecting and reporting invasive species occurrences, e.g.:

- Queensland's Weed Spotter's Network and associated App, supported by Biosecurity Queensland and the Queensland Herbarium
- ACT's Nature Map citizen science portal, enabling citizens to report invasive species sightings, monitored by biosecurity officers
- The Asian Giant Hornet trapping program, data portal and public dashboard (Washington State Department of Agriculture, USA)

ADAPTIVE MANAGEMENT

Several monitoring programs identified specifically seek to evaluate the effectiveness of land management practices on the invasive species responses to inform adaptive management, including risks and actions post recent bushfires, e.g.:

- The ACT's Conservation effectiveness monitoring program (CEMP)
- South Australia Department of Primary Industries and Regions' Building better agriculture and land management program, building land manager capacity for weed surveillance and management post 2019-2020 bushfires
- Queensland Department of Agriculture and Fisheries' free electric ant yard check service
- Antigua and Barbuda's Islands without Aliens program in which ongoing monitoring is targeting the prevention of re-incursion events

KNOWLEDGE HUBS

Extensive knowledge hubs are now available for many jurisdictions, providing information on invasive species biology/ecology, distributions, status and management to inform risk assessments and management plans. The most sophisticated of these provide interactive dashboards including maps of weed distributions and management areas, e.g.:

- ACT's Invasive plants dashboard, provides maps of weed distribution and control areas
- Queensland's Restricted and emerging invasive plants in QLD dashboard, provides maps of historic and current weed distributions
- Tasmania's Weed Action Fund Mapping Application, provides weed maps to inform property-level, and multiple property-level, planning

2.5. Funding, governance and institutions

Many of the jurisdictions examined have undertaken significant streamlining of legislation, policy and approval processes pertaining to ISM, either relatively recently (e.g., South Australia, Queensland) or currently (e.g., Victoria). In some cases, such as Victoria, this process of reform has entailed significant stakeholder and community consultation and co-design. New institutions have consequently emerged including funding schemes which support progress and innovation in ISM.

VISIONING

Extensive stakeholder and community consultation and co-design has been undertaken to inform the revision and streamlining of ISM legislation in some jurisdictions, including the development of shared visions for ISM, e.g.:

- Victoria convened a large (>100 participants) online workshop focusing on 'Shaping Victoria's Biosecurity Future' and developed a biosecurity statement for Victoria (Agriculture Victoria)
- New Zealand has a Biosecurity 2025 Direction Statement and accompanying implementation plan developed by over 80 biosecurity system leaders and 60 organisations (Ministry for Primary Industries)

FUNDING PROGRAMS

Dedicated funding schemes to support ISM have been established by numerous jurisdictions investigated including:

- Tasmania's Weed Action Fund (Department of Natural Resources and Environment)
- Western Australia's Biosecurity Research and Development Fund (Department of Industries and Regional Development)

Other jurisdictions have also set up broader natural resources management (NRM) funds which include support for ISM projects, e.g.:

- Landscape Priorities Fund South Australia, established by the Landscape South Australia Act 2019, with ISM projects including:
    - Weed warriors of our waterways: eradicating priority pests for a healthy river, Murraylands and Riverland Landscape Board ($808,978) – will leverage 10 years of invasive weed control in the river channel in River Murray
    - Eyes on Eyre – restoring the health of Eyre Peninsula's coastal environment, Eyre Peninsula Landscape Board ($710,000) – broad NRM project including pest control

- Victoria's BushBank program, Department of Energy, Environment and Climate Action – supports habitat restoration on private and public land including weeding

PARTNERSHIPS

In Australia, considerable investment in ISM has been allocated to programs designed to establish and strengthen partnerships between State and Territory governments and local governments and regional NRM agencies and facilitate improved regional coordination of efforts, e.g.:

- Queensland Department of Agriculture and Fisheries' Enhancing local government biosecurity in Far North Queensland, aims to build long-term collaborative partnerships with local governments
- Queensland Department of Agriculture and Fisheries' Feral Pest Initiative, providing funding to support regional invasive species initiatives including regionally agreed upon cluster fencing
- South Australia's Kangaroo Partnerships project, providing funding, coordination and facilitating partnerships through on-ground trials and other initiative, including projects seeking to increase kangaroo value through quality, product diversity and branding
- Victoria's Department of Environment and Climate Action's Peri-urban weed management partnerships, supporting local land managers to target weeds in Melbourne's peri-urban areas

2.6. Engagement, education and outreach

Investment to facilitate engagement by land managers, land holders, community groups and members and other stakeholders is significant across all of the jurisdictions considered. Most ISM programs identified incorporate significant education and outreach with some offering individualised, bespoke support to land managers to engage in ISM, e.g.:

- South Australia's Pathways to compliance – farmed deer (Hills and Fleurieu Landscape Board; $216,079), supports small farmers with a novel pathway to farmed deer compliance by providing farmers willing to exit the industry a no-cost option to humanely manage unsaleable animals, with subsequent destocking helping to reduce risks posed by feral deer.
- South Australia's Department of Primary Industries and Regions' Coordinated landholder-led control of unpalatable invasive grasses, providing landholder support, training and networks for weed management
- South Australia's voluntary tree replacement program, a pilot in Waikerie red fruit fly outbreak area in the Riverland to enable landholders to replace backyard trees with non-fruiting trees and provide education regarding tree maintenance.

FIRST NATIONS ISM

Numerous jurisdictions have established dedicated programs to support planning, implementation and capacity building in ISM amongst First Nations people and organisations including:

- South Australia's Department of Primary Industries and Regions' Building the capacity of Aboriginal land managers to control Weeds of National Significance, providing training, scientific advice, and assistance with prioritisation and risk assessments

SECTION 3

Synthesis & key messages

3. Synthesis and key messages

This section provides a synthesis of the findings of this ISM interjurisdictional analysis and considerations with respect to the NSW ISM context. The questions addressed in this section are:

- What features characterise best practice contemporary ISM?
- How do current ISM strategies identified in the jurisdictions considered differ from those presently applied in NSW? (e.g., are they alternatives to existing strategies? Or value adds? etc.)
- What are the key considerations (e.g., biophysical/cultural/economic requirements, trade-offs, etc.) that need to be addressed in choosing and implementing new ISM strategies identified from this analysis in the NSW context?

3.1. Features characterising best practice ISM

Based on the findings of this interjurisdictional analysis, along with our expert knowledge and experience, we suggest that contemporary best practice ISM is characterised by:

- Collaboratively developed visions to address specified management issue
- Design for, or with, consideration of multiple possible futures and identification of design parameters
- Strong coordination, collaboration and communication across agencies, sectors and geographic locations
- Consideration of multiple spatial scales, from local to landscape, and connectivity
- Consideration of cultural, social and economic factors in addition to biophysical
- Robust legislative, policy and regulatory pillars to support management objectives
- Systems and processes to enable collation, preservation and sharing of information
- Clear prioritisation processes, spatial and non-spatial, to enable identification of the most critical threats and vulnerable assets
- Integration of a range of control techniques (integrated weed/pest management) focusing on different species, life history stages, and/or drivers
- A willingness to test deeply engrained management assumptions and apply robust scientific design to management interventions to facilitate learning by doing
- Maintenance of an adequate intensity and scale of management following initial implementation
- An adaptive management approach incorporating well aligned and embedded monitoring and evaluation of outcomes and changing technology, knowledge and circumstances

- Continued investment in capability, capacity and incremental and step change technologies particularly in detection, rapid response and management to increase efficiency and effectiveness

- Minimisation of adverse impacts to people, industry and non-target species, with safety and animal welfare remaining key considerations

Overall, ISM should be both risk and evidence based, adopting a precautionary approach where information is lacking. Current best practice ISM is also a shared responsibility and is applied across the continuum of prevention, preparedness, response and ongoing management.

3.2. Overview of current NSW context

NSW has significant ongoing and emerging ISM challenges however ISM in NSW holistically is generally quite modern in its approach. Key documents have recently been updated and refreshed, including the

- NSW-Biosecurity-and-Food-Safety-Strategy-2022-2030
- NSW Invasive Species Plan 2023–2028

A Statutory Review of the Biosecurity Act 2015 is currently underway with submissions on the *Discussion Paper: Statutory review of Biosecurity Act 2015* recently closed. A report on the outcome of the review is due to be tabled in each House of Parliament by 30 June 2023.

Key elements of modern ISM best practice (as outlined above) are well embedded within the NSW framework and aligned with Commonwealth guidance documents.

3.3. Highlights

Overall, trends in ISM across the jurisdictions considered in this analysis are reasonably comparable, with broadly similar approaches being adopted in most cases, especially amongst Australian States and Territories, including NSW. On-ground ISM interventions remain limited to a fairly narrow suite of well-established actions with recent shifts evident in the uptake of technology (e.g., remote camera technology) and underpinning principles (e.g., safe havens, remove and protect). Rather, ISM innovation is more apparent with respect to the institutional scaffolding supporting the implementation of on-ground interventions, particularly in relation to the scale of programs and services. Major highlights include:

➢ STRONG VISIONS AND AMBITIOUS TARGETS

Multiple jurisdictions considered have undertaken extensive consultation, co-design and communication activities to develop collaborative visions for invasive species management/ biosecurity, some of which also comprise ambitious overarching targets. For example:

- New Zealand's Zero Invasive Predators 2050 target
- Western Australia's Western Shield project aims to return biodiversity to pre-European levels
- ACT's Zero tolerance policy on feral horses in National Parks (e.g., Namadgi NP Feral Horse Management Plan 2020)

While NSW has developed a state-wide Biosecurity Strategy, as well as a "No Space for Weeeeeds" message, there is scope to extend the strategy and vision to accommodate the inevitability of some

climate change impacts, e.g. continental-scale range shifts. There is existing information on individual species' range shifts to support an integrated assessment and inform a strategic approach.

➢ EMPHASIS ON EARLY ERADICATION

An emphasis on introduction prevention and early eradication of invading species is evident amongst numerous jurisdictions, typically involving a prioritisation process for identifying the greatest threats.

- Victoria's Department of Environment and Climate Action's Weeds at the early stages of invasion (WESI) project
- Tasmania's classification of classification of potential invaders as Extreme Threats to Tasmania, with associated action plans.

NSW applies the invasion curve approach embedded in the weed risk assessment framework. While NSW has developed lists of regional priority weeds and invasion pathways, as well as drawing on national environmental alert lists, there is scope for an up-to-date horizon scan to determine a 'watch list' of priority threats to the State, especially given the implications of climate change, to ensure potential invasion risks are managed at their early stages. This could be akin to The National Priority List of Exotic Environmental Pests, Weeds and Diseases - DAFF (agriculture.gov.au).

➢ SAFE HAVENS

Large-scale investments in developing safe havens for native species have been committed by numerous jurisdictions, as well as in the private sector, with projects typically attempting to remove all invasive species and continue to exclude these from either islands, peninsulas of fenced sanctuaries. In some cases, a virtual barrier (e.g., lines of baits or traps) may also be used to delineate and protect a safe haven. Key examples include:

- successful eradication of rodents and rabbits on Macquarie Island undertaken by the Department of Tourism, Arts and the Environment
- feral animal (cat, pig) eradication programs on Kangaroo Island undertaken by the Kangaroo Island Landscape Board

There are likely to be a range of opportunities to create additional 'safe havens' in NSW, however, given their potentially controversial nature, there is also scope to develop an innovative decision/risk assessment framework and to determine under what conditions safe havens are likely to be beneficial as well as to develop effective monitoring and evaluation programs. This could inform a State-wide prioritisation process to identify potential safe havens.

➢ NEW MONITORING TECHNOLOGIES

Real-time monitoring of species invasions and potential threats to high value assets (e.g., threatened species) are increasingly enabled by a range of relatively recent technology including remote cameras and unmanned aerial vehicles (UAVs) or drones, often with thermal sensors, infra-red detection collars, e-DNA and artificial intelligence to aid detection and predictive modelling. Key examples include:

- Queensland's Nest to Ocean turtle protection program
- Western Australia's Rangelands unmanned aerial vehicles (UAVs) monitoring of invasive cacti

- Broad-scale tracking of feral pigs using infra-red detection of collared feral pigs to inform predictive modelling in Western Australia.

While such technology is already being deployed in NSW, there are likely to be opportunities at a State-level to promote and enhance more tailored development and uptake of such technologies to improve the outcomes and cost-effectiveness of such approaches.

➢ CITIZEN SCIENCE AND KNOWLEDGE HUBS

Numerous citizen science monitoring programs have been implemented across the jurisdictions explored, many of which capitalise on emerging data management and visualisation technologies. Key examples include:

- Queensland's Weed Spotter's Network and associated App
- Queensland's Restricted and emerging invasive plants in QLD dashboard, provides maps of historic and current weed distributions
- ACT's Nature Map citizen science portal
- ACT's Invasive plants dashboard, provides maps of weed distribution and control areas
- Tasmania's Weed Action Fund Mapping Application, provides weed maps to inform property-level, and multiple property-level, planning

Numerous regional citizen science monitoring programs have been rolled out in NSW of relevance to ISM as well as provision of information tools, e.g. e.g., WeedWise App. There is considerable scope, however, to develop a State-wide data collection and monitoring program to enable knowledge sharing at scale. Additionally, knowledge hubs underpinning ISM in NSW, e.g., NSW Weed maps, could benefit from improved usability and visualisation.

➢ ADAPTIVE MANAGEMENT

Invasive species monitoring in several jurisdictions has been designed to directly inform adaptive management and a 'learning by doing' approach. Key examples are:

- The ACT's Conservation effectiveness monitoring program (CEMP)
- South Australia Department of Primary Industries and Regions' Building better agriculture and land management program, building land manager capacity for weed surveillance and management post 2019-2020 bushfires

There is significant opportunity to improve the cost-effectiveness of ISM through similar, more scientifically informed management strategies in NSW, that include experimental controls (i.e., monitoring of untreated areas) and test a range of techniques in a controlled manner. In particular, long-held assumptions regarding treatment techniques, as well as their suitability under certain conditions, require investigation, e.g., weeding of pioneer plants following bushfires; removal of woody weeds from riparian zones (Capon and Palmer 2018).

➢ PARTNERSHIPS AND ENGAGEMENT

Significant investment amongst numerous jurisdictions examined has been directed towards programs and projects which facilitate and strengthen landholder and First Nations peoples' engagement in, as well as partnerships and regional coordination of ISM. Highlights include:

- Queensland Department of Agriculture and Fisheries' Enhancing local government biosecurity in Far North Queensland and Feral Pest Initiative
- South Australia's Kangaroo Partnerships project and Pathways to compliance – farmed deer
- South Australia's Department of Primary Industries and Regions' Coordinated landholder-led control of unpalatable invasive grasses and Building the capacity of Aboriginal land managers to control Weeds of National Significance

There is considerable potential to drive stronger partnerships and engagement of industry, government and landholders in ISM in NSW, especially through some of the initiatives highlighted above (e.g., citizen science and knowledge hubs, adaptive management programs etc.). In particular, there is scope for greater involvement of First Nations organisations in ISM, including projects to better understand cultural aspects of invasive species and common management approaches (e.g., fencing).

3.4. Key considerations for NSW

Based on our understanding of the NSW ISM context, we identify the following considerations as priorities to be taken into account in developing new ISM strategies for the State:

- The *NSW Invasive Species Plan 2023–2028* is very high level and lacks detail to implement effectively. It is essential that the detail and key changes guided by this State-level plan down to the Regional Pest / Weed Plan level.
- The *NSW Invasive Species Plan 2023–2028* does not include animal and plant diseases, particularly those that impact native species and may fall outside of Agricultural and food safety.
- The *NSW Invasive Species Plan 2023–2028* needs to be aligned with the relevant objectives, targets and actions in the *Commonwealth 2022-2032 Threatened Species Action Plan*, particularly to listed priority species and places and ISM threats in NSW.
- NSW's ISM approach needs to include consideration of safe havens and islands, including consideration of a Remove and Protect approach.
- NSW's ISM approach needs to link to Key Threatening Processes in NSW.
- Greater consideration to the effects of climate change on invasive species in NSW is required.
- Greater consideration to facilitating specific engagement of First Nations peoples in ISM in NSW is necessary.
- Collective impact should be promoted - a concerted effort across organisations and other groups that have national impact, which together will accomplish much more than operating on their own. Working together for collective impact means our efforts can go further, faster.

- Move towards more nuanced and accurate insights based on an improved understanding of the beliefs, values and motivations of multiple segments of the population to encourage action and ownership.
- Think big – how do we move away from sustained IS control to eradication (even locally)? Or, do we need to manage for novel ecosystems in some circumstances?
- Seek to capitalise on existing knowledge, as well as gaining new knowledge and refining, adapting and developing the tools and methodologies we need for ISM.
- Give more emphasis to 'applied' science – research into the practical use of new technologies and bringing them to market and learning by doing.

Salvinia molesta (Photo: Marshman~commonswiki, Creative Commons)

SECTION 4

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4. References

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APPENDIX A

Attributed database of ISM programs and projects from selected

Country	Jurisdiction	Program/project	ISM Target Domain(s)	Agency	Link
Antigua and Barbuda	National	Islands without Aliens: Building Regional Civil Capacity to Eradicate Alien Invasive Species	Weeds; feral animals	Fauna and Flora International (FFI)	Critical Ecosystem Partnership Fund Caribbean Success Story (arcgis.com)
Australia	ACT	Invasive Plants Control Plan 2020-25	Weeds	Environment, Planning and Sustainable Development Directorate - Environment	https://actgov.maps.arcgis.com/apps/MapJournal/index.html?appid=cd59d70662c94c75a0492635f7925384#
Australia	ACT	Conservation effectiveness monitoring program (CEMP)	Weeds	Environment, Planning and Sustainable Development Directorate - Environment	
Australia	ACT	Namadgi National Park Feral Horse Management Plan 2020	Feral animals	Environment, Planning and Sustainable Development Directorate - Environment	https://www.environment.act.gov.au/parks-conservation/plants-and-animals/Biosecurity/pest-animals/feral_horse_management
Australia	ACT	Canberra Nature Map	All	ACT Government	https://canberra.naturemapr.org/
Australia	ACT	Invasive Plants Dashboard	Weeds	Environment, Planning and Sustainable Development Directorate - Environment	https://actgov.maps.arcgis.com/apps/dashboards/5449adb632884d68aeb585e3e73dde99
Australia	Macquarie Island	Plan for the Eradication of Rabbits and Rodents on Subantarctic Macquarie Island	Feral animals	Department of Tourism, Arts and the Environment	Plan for the Eradication of Rabbits and Rodents on Subantarctic Macquarie Island (dcceew.gov.au)
Australia	National	Pest animals and weed management survey	Weeds; feral animals	Department of Agriculture, Fisheries and Forestry (funding)	Pest animals and weed management survey - DAFF (agriculture.gov.au)
Australia	NT	Weed Management Strategy on NT Vacant Crown Land	Weeds	Department of Infrastructure, Planning and Logistics	https://dipl.nt.gov.au/strategies/weed-management-strategy-nt-vacant-crown-land
Australia	QLD	Technical highlights - Invasive plant and animal research 2021-2022	Weeds; feral animals	Queensland Government	Technical Highlights (publications.qld.gov.au)

Country	Jurisdiction	Program/project	ISM Target Domain(s)	Agency	Link
Australia	QLD	Enhancing Local Government Biosecurity in Far North Queensland, includes grants	All	Department of Agriculture and Fisheries	https://www.daf.qld.gov.au/business-priorities/biosecurity/invasive-plants-animals/pest-management-planning/enhancing-local-government-biosecurity-capacity-in-far-north-queensland
Australia	QLD	QLD Feral Pest Initiative	All	Department of Agriculture and Fisheries	https://www.daf.qld.gov.au/business-priorities/biosecurity/invasive-plants-animals/animals/qld-feral-pest-initiative#:~:text=About%20the%20Queensland%20Feral%20Pest%20Initiative%20Since%202015%2C,animals%20and%20capacity%20building%20projects%20through%20the%20QFPI.
Australia	QLD	QLD dog offensive group (QDOG)	Feral animals	Department of Agriculture and Fisheries	Queensland dog offensive group (QDOG) | Department of Agriculture and Fisheries, Queensland (daf.qld.gov.au)
Australia	QLD	Electric ant yard check service	Pest species	Department of Agriculture and Fisheries	https://www.daf.qld.gov.au/business-priorities/biosecurity/invasive-plants-animals/ants/yard-check
Australia	QLD	Restricted and emerging invasive plants in Queensland dashboard	Weeds	Queensland Government	https://qgsp.maps.arcgis.com/apps/MapSeries/index.html?appid=f836f313f7e2477480ec69a851378872
Australia	QLD	Nest to Ocean turtle protection program	Feral animals	Department of Environment and Science	Nest to Ocean Turtle Protection Program | Parks and forests | Department of Environment and Science, Queensland (des.qld.gov.au)
Australia	QLD	Weed spotters network	Weeds	Biosecurity Queensland and Queensland Herbarium	Weed Spotters Network Queensland | Environment, land and water | Queensland Government (www.qld.gov.au)
Australia	QLD	Indigenous Land and Sea Ranger program	Weeds; feral animals	Department of Environmental Science	https://www.qld.gov.au/environment/plants-animals/conservation/community/land-sea-rangers/about-rangers
Australia	SA	Kangaroo Island Feral Cat Eradication Program	Feral animals	Landscape South Australia Kangaroo Island	Landscape South Australia - Kangaroo Island | KI Feral Cat…
Australia	SA	Kangaroo Island Feral Pig Eradication Program	Feral animals	Landscape South Australia Kangaroo Island	KI_FERAL_PIG_ACTION_PLAN_2021.pdf (pir.sa.gov.au)

Country	Jurisdiction	Program/project	ISM Target Domain(s)	Agency	Link
Australia	SA	Weed warriors of our waterways: eradicating priority pests for a healthy river	Weeds	Murraylands and Riverland Landscape Board	
Australia	SA	Pathways to compliance – farmed deer	Feral animals	Hills and Fleurieu Landscape Board	
Australia	SA	Kangaroo Partnerships Project	Pest species	DEW	Landscape South Australia - SA Arid Lands | Kangaroo Partnership… https://cdn.environment.sa.gov.au/landscape/images/Kangaroo-Partnership-Project-Fact-Sheet-v2.pdf
Australia	SA	Controlling declared weeds in South Australia tool	Weeds	Department of Primary Industries and Regions	https://pir.sa.gov.au/biosecurity/weeds
Australia	SA	Coordinated landholder-led control of unpalatable invasive grasses	Weeds	Department of Primary Industries and Regions	https://pir.sa.gov.au/biosecurity/weeds/weed_management_programs
Australia	SA	Building back better agriculture and land management	Weeds	Department of Primary Industries and Regions	https://pir.sa.gov.au/biosecurity/weeds/weed_management_programs
Australia	SA	Building the capacity of Aboriginal land managers to control Weeds of National Significance	Weeds	Department of Primary Industries and Regions	https://pir.sa.gov.au/biosecurity/weeds/weed_management_programs
Australia	SA	Minimising losses from weeds in broadacre crops and permanent pasture	Weeds	Department of Primary Industries and Regions	https://pir.sa.gov.au/biosecurity/weeds/weed_management_programs
Australia	SA	Eastern Plains Boxthorn Control Trial and Demonstration	Weeds	Department of Primary Industries and Regions	https://pir.sa.gov.au/__data/assets/pdf_file/0003/370803/African_Boxthorn_Control_Trial_Report.pdf
Australia	SA	Declared animal policies	Feral animals; pest species	Department of Primary Industries and Regions	https://www.pir.sa.gov.au/biosecurity/introduced-pest-feral-animals/pest_animal_policies_and_regulations

Country	Jurisdiction	Program/project	ISM Target Domain(s)	Agency	Link
Australia	SA	Voluntary tree replacement pilot program	Pest species	Department of Primary Industries and Regions	https://fruitfly.sa.gov.au/news_and_resources/voluntary_tree_replacement
Australia	SA	Land invasive species report card	Weeds; Feral animals	South Australian government	RC2020_RC_Land_InvasiveSpecies.pdf (environment.sa.gov.au)
Australia	TAS	Tasmanian Cat Management Plan 2017-2022	Feral animals	Department of Primary Industries, Parks, Water and Environment	Papers\TASMANIAN CAT MANAGEMENT PLAN FINAL.pdf
Australia	TAS	Tasmanian highly invasive grasses project	Weeds	Department of Natural Resources and Environment	https://nre.tas.gov.au/invasive-species/weeds/tasmanian-highly-invasive-grasses-project
Australia	TAS	Weed Action Fund (WAF)	Weeds	Department of Natural Resources and Environment	Tasmanian Weeds Action Fund (WAF) | Department of Natural Resources and Environment Tasmania (nre.tas.gov.au)
Australia	TAS	WAF Mapping Application	Weeds	Department of Natural Resources and Environment	https://dpipwe-au.maps.arcgis.com/apps/webappviewer/index.html?id=72b317354a77489b95c8da412fa62a17
Australia	TAS	Pictorial Atlas of plant diseases diagnosed in Tasmania	Disease	Department of Natural Resources and Environment	https://nre.tas.gov.au/Documents/Pictorial Atlas of Plant Diseases in Tasmania- Final for WEB.pdf
Australia	VIC	Reforming Victoria's biosecurity legislation	All	Victorian Government	https://agriculture.vic.gov.au/biosecurity/protecting-victoria/strengthening-victorias-biosecurity-system-program/reforming-victorias-biosecurity-legislation
Australia	VIC	Victoria's fruit fly strategy 2021-2025	Pest species	Agriculture Victoria	https://agriculture.vic.gov.au/biosecurity/protecting-victoria/victorias-fruit-fly-strategy-2021-to-2025
Australia	VIC	A Biosecurity statement for Victoria	All	Agriculture Victoria	https://agriculture.vic.gov.au/biosecurity/protecting-victoria/strengthening-victorias-biosecurity-system-program/biosecurity-statement-for-victoria
Australia	VIC	Shaping Victoria's Biosecurity Future workshop	All	Agriculture Victoria	https://agriculture.vic.gov.au/biosecurity/protecting-victoria/strengthening-victorias-biosecurity-system-program/industry-community-and-government-perspectives

Country	Jurisdiction	Program/project	ISM Target Domain(s)	Agency	Link
Australia	VIC	Peri-urban weed management partnerships	Weeds	Department of Environment and Climate Action	https://www.environment.vic.gov.au/invasive-plants-and-animals/invasive-species-on-public-land/peri-urban-weed-management-partnerships
Australia	VIC	Weeds and pests on public land program	Weeds; feral animals; pest species	Department of Environment and Climate Action	https://www.environment.vic.gov.au/invasive-plants-and-animals/invasive-species-on-public-land/weeds-and-pests-on-public-land-program
Australia	VIC	Weeds at the early stages of invasion (WESI) project	Weeds	Department of Environment and Climate Action	Early invader weeds (environment.vic.gov.au)
Australia	VIC	Glenelg Ark	Feral animals	Department of Environment and Climate Action	https://www.environment.vic.gov.au/invasive-plants-and-animals/invasive-species-on-public-land/weeds-and-pests-on-public-land-program
Australia	Victoria	WESI Project Victoria environmental weed risk database	Weeds	Department of Energy, Environment and Climate Change	https://www.environment.vic.gov.au/invasive-plants-and-animals/weed-risk-ratings
Australia	WA	Piloting new techniques to control and eradicate Mediterranean fruit fly in Carnarvon - part of the Boosting Biosecurity Defences program	Feral animals	Department of Primary Industries and Regional Development	Piloting new techniques to control and eradicate Mediterranean fruit fly in Carnarvon | Agriculture and Food
Australia	WA	Western Australian Wild Dog Action Plan 2016-2021	Feral animals	Department of Agriculture and Food	Papers\WA-Wild-Dog-Action-Plan 2016-2021 PDF.pdf
Australia	WA	Using innovative technologies to identify and map invasive cacti in the southern Rangelands of Western Australia - Biosecurity Research and Development Fund	Weeds	Department of Primary Industries and Regional Development	Biosecurity RD fund - GNRBA Cactus project - DPIRD Summary - Feb 2018.pdf (agric.wa.gov.au)
Australia	WA	Reducing feral pig disease risks through the use of aerially deployed infrared sensors and	Feral animals	Department of Primary Industries and Regional Development	Biosecurity RD Fund - Feral pig project - DPIRD Summary - Feb 2018_0.pdf (agric.wa.gov.au)

Country	Jurisdiction	Program/project	ISM Target Domain(s)	Agency	Link
		habitat modelling - Biosecurity Research and Development Fund			
Australia	WA	Finding common ground to protect Ningaloo Coast World Heritage Area	Water & wetlands	Rangelands NRM	» Finding common ground to protect Ningaloo Coast World Heritage AreaRangelands NRM WA (rangelandswa.com.au)
Australia	WA	Conditioned taste aversion for cane toad predators	Pest species	Department of Biodiversity, Conservation and Attractions	https://www.dpaw.wa.gov.au/management/pests-diseases/cane-toads
Australia	WA	Western Shield	Feral animals	Department of Biodiversity, Conservation and Attractions	Western Shield | Department of Biodiversity, Conservation and Attractions (dbca.wa.gov.au)
Australia	WA	Good neighbour guideline	Weeds; Feral animals	Department of Biodiversity, Conservation and Attractions	Good Neighbour Guideline | Department of Biodiversity, Conservation and Attractions (dbca.wa.gov.au)
Australia	WA	Biosecurity Research and Development Fund	All	Department of Industries and Regional Development	Biosecurity Research and Development Fund | Agriculture and Food
Australia	WA	Using innovative technologies to identify and map invasive cacti in the southern rangeland	Weeds	Department of Primary Industries and Regional Development	Using innovative technologies to identify and map invasive cacti in the southern rangelands of Western Australia | Agriculture and Food
Australia	Western Australia	Environmental weed risk assessment protocol for growing non-indigenous plants in the Western Australian rangelands	Weeds	Department of Primary Industries and Regional Development	Environmental weed risk assessments | Agriculture and Food
Australia	Western Australia	Weed management at Tharra	Weeds	Department of Water and Environmental Regulation	https://www.wa.gov.au/service/environment/environment-information-services/weed-management-project-tharra-woodstock-abydos-aboriginal-reserve
British Overseas Terriotry	South Georgia and the South Sandwich Islands	Restoring South Georgia for its endemic and native species - The Habitat Restoration Project	Weeds; feral animals	South Georgia Heritage Trust	Habitat Restoration Project - South Georgia Heritage Trust (sght.org)
New Zealand	National	Zero Invasive Predators 2050	Feral animals		ZIP Annual Report 2019-20 by Zero Invasive Predators - Issuu

Country	Jurisdiction	Program/project	ISM Target Domain(s)	Agency	Link
New Zealand	National	Biosecurity 2025	All	Ministry for Primary Industries	https://www.mpi.govt.nz/biosecurity/about-biosecurity-in-new-zealand/biosecurity-2025/
New Zealand	New Zealand	Biodiversity 20205 Direction Statement	All	Ministry for Primary Industries	Biosecurity 2025 Direction Statement | NZ Government (mpi.govt.nz)
USA	Idaho	Stocking alpine lakes with super-male brook trout (Trojan brook trout)	Feral animals	Idaho Department of Fish and Game	https://idfg.idaho.gov/blog/2021/08/can-super-male-brook-trout-improve-angling-alpine-lakes
USA	National	The National Clean Plant Network	Pest species; Disease	US Department of Agriculture	https://www.aphis.usda.gov/aphis/ourfocus/planthealth/ppa-ppdmdpp/sa_ncpn
USA	USA; Canada	Preventing the introduction and spread of invasive species through strategic landscape-level approaches	Weeds; feral animals; pest species	US Fish and Wildlife Service	https://www.invasivespeciesinfo.gov/subject/grants-and-funding
USA	USA; Canada	Plant pest and disease management and disaster prevention program	Weeds; feral animals; pest species	US Department of Agriculture	https://www.aphis.usda.gov/aphis/newsroom/stakeholder-info/sa_by_date/sa-2023/ppa7721-national
USA	Washington	Asian Gian Hornet Public Dashboard	Pest species	Washington State Department of Agriculture	https://westgov.org/news/article/invasive-species-data-citizen-science-data-critical-to-fighting-the-asian-giant-hornet
USA; Canada	USA; Canada	Genetic control of sea lamprey	Feral animals	Great Lakes Fishery Commission	http://www.glfc.org/genetic-control-of-sea-lamprey-theme.php#:~:text=The%20Sea%20Lamprey%20Genetic%20Control%20theme%20encompasses%20research,program%20to%20fully%20assess%20feasibility%2C%20efficacy%2C%20and%20risk.

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