Horizon scan for incoming weeds into Queensland, Australia

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Summary Invasive alien species (IAS), of which weeds are a subset, are often threats to natural and managed ecosystem services, including agriculture. The distribution and impacts of IAS are expected to exacerbate in response to increasing human connections (globalisation, commerce) and climate change. Unfortunately, once firmly established across large areas, populations of invasive species tend to become highly resilient and preventative measures become generally unaffordable or unrealistic. Hence, there is a need to identify emerging threats that are still in an early phase of invasion. These emerging threats can be candidates for preventative action; either complete eradication or early containment. Using the grey literature and the Web, including "The weed flora of Australia and its weed status" and "CABI's invasive species compendium", we carried out horizon scanning for ~230 weed species that have been identified as potential IAS in an early stage of invasion in Queensland (QLD), Australia. The majority of these potential IAS are of South and tropical North America in origin, and their present invaded ranges are wide (North/South America, Oceania, Asia, and Africa). Potential impacts are deemed generally negative (especially on environment/ecology, biodiversity, livestock, and economy/livelihood) to neutral, but positive impacts (on livestock, cultural amenity, and economy) were also identified. Introduction mode and pathways of entry are likely to be deliberate via nursery/horticultural trade (40 %), agroforestry for soil stabilization/habitat restoration (26 %) and mail-order/Internet (17.3 %). Once in their invaded ranges, further spread (dispersal) can be expected via mammals (especially by birds and rodents), soil disturbance/waste disposal and aquatic systems. Using the dataset on impact and spread of the focal IAS in invaded ranges around the globe and adjusting for countries/regions whose climates match closely to that of QLD, we derived a state-wide horizon weed priority list of high, medium and low impact scores for policy, research and management.

Keywords: Climate-matching, Horizon-scanning, Invasion-pathway, Pest-risk-assessment, Prioritisation, Weeds

INTRODUCTION

The spread and impact of invasive alien species remain unabated in most habitats around the globe because of increasing human connections and habitat modifications (Beaury *et al.* 2021, Osunkoya *et al.* 2021). Hence for maintenance of the integrity of natural and/or managed ecosystems, biosecurity risks need regular assessments and prioritization for both established and potentially incoming IAS. Using horizon-scanning methodology (Cuhls 2019), we assessed the potential impact of entry and/or spread of new weeds in the State of Queensland (QLD). Horizon or environmental scanning warns us about impending change. The term 'horizon-scanning' evokes images of lookouts on old ships or modern-day radar scanning the horizon. The horizon scanner is to the future what the lookout is to the sea. Most change does not occur suddenly, out of the blue, even if it initially appears that way. Horizon scanning attempts to break the habit of ignoring the early signs of change. It forces people to look at the novelty happening around them and report those signs that could have a significant impact on the enterprise (i.e., on ecosystem services and goods), not just those changes that are sure to have an impact.

For the assessment, we initially relied on a horizon weed list of ~230 species compiled and regularly updated by Biosecurity Queensland (BQ) staff of the Department of Agriculture & Fisheries (DAF) (Csurhes 2021). Our aims were:

1. Explore some of the issues that are deemed current and applicable in IAS management as stated in Neve *et al.* 2020 (climate change, invasiveness (spread), pathways, relative role of species traits (biology), human interaction (sociology/economy), and habitat ranges (geography)).
2. Identify likely threats by the horizon weeds in QLD, and rank them for proactive management, including eradication where feasible.

MATERIALS AND METHODS

At the inception of the project, a tentative list of tasks were drawn up, as below:

1. Use BQ compiled list of horizon weeds (~230 species) as a starting point;

2. Review the pest management plans of all 72 local government areas in the state for emerging species;
3. Cross-check the list with introduced species in Australia listed in Randall (2007);
4. Present the list to stakeholders (impacted farmers, natural resource managers and biosecurity officers) via either online or physical meetings;
5. Review the grey and scientific literature (online) for the global distributions of listed weeds, noting each weeds: (a) native vs invaded ranges, (b) impact on agriculture, nature conservation, health, social-wellbeing and economy, and (c) pathways, including dispersal modes;
6. Predict the potential distribution of listed species in QLD;
7. Combine data on realised/potential distribution of the weeds worldwide and in QLD, and their (perceived) impacts to generate a prioritized list and actions required;
8. Examine the feasibility of eradication.

Tasks 1, 3, 5, 6 have been completed, to some extent, and will be the focus of this paper. For task one we extracted the species list from Csurhes (2021). For task three we used Randall (2007) to confirm taxonomic status, life forms, and weed status. For task five we used online sources including, The Global Biodiversity Information Service (GBIF), Global Register of Invasive and Introduced species (GRIIS), Plants of the World Online (POWO), and CABI Invasive species compendium (ISC). We found CABI the most comprehensive in terms of data needed, and hence our reports are based mainly on extracts from this database. From the CABI-ISC database, we were able to extract information on native and invaded countries for each species, their documented impact, and invasion pathways. For task six we used species and habitat modelling software of the Centre of Excellence for Biosecurity Analyses (MESS and EX-DET rather than the popular CLIMEX) to project/match the climate of the state of QLD to those of invaded countries around the globe (see https://apps.cebra.unimelb.edu.au/climate_matcher/) .

We combined indices of spread (based on native and invaded ranges globally), documented impact, pathways, and QLD habitat/climate suitability (similarity) to native ranges (i.e. country) of the weeds to derive a state-wide horizon weed priority list of high, medium and low impact scores.

RESULTS

Of the ~ 230 species of concern in QLD, 197 of 232 (85 %) also appear on Randall's (2007) list. Of these 197 species, we were able to compile comprehensive information on global spread, impact, habitat ranges (using country as surrogates), and invasion pathways for 132 species (132/197 = 67 %).

As seen in Figure 1, the majority of potential IAS of QLD are from South and tropical North America, and to some extent Indian and Chinese subcontinents. Currently, their invaded ranges are broad (North/South America, South and East Asia, Oceania, and Africa) (Figure 2).

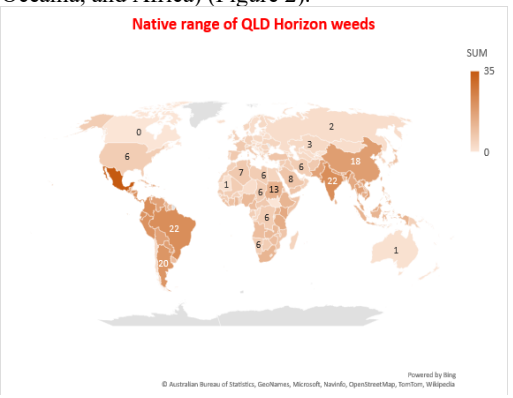


Figure 1. Native ranges (countries) of horizon weeds of QLD. Number on maps refers to number of weeds out of 132 originating from that particular country.

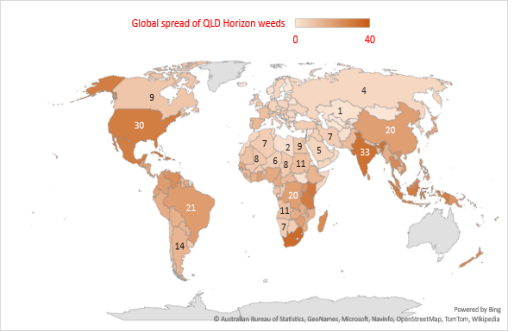


Figure 2. invaded ranges (countries) of horizon weeds of QLD. Number on maps refers to number of weeds out of 132 spreading into that country.

Introduction mode and pathways of entry of QLD horizon weeds are likely to be deliberate via nursery/horticultural trade (40 %), agroforestry for soil stabilization/ habitat restoration (26 %) and mail-order/ internet (17.3 %) (Figure 3). Once in their

invaded ranges, further spread (dispersal) can be expected via mammals (especially by birds and rodents) (18.5 %), soil disturbance/ waste disposal (20.2 %) and aquatic systems (18.5 %) (Figure 4).

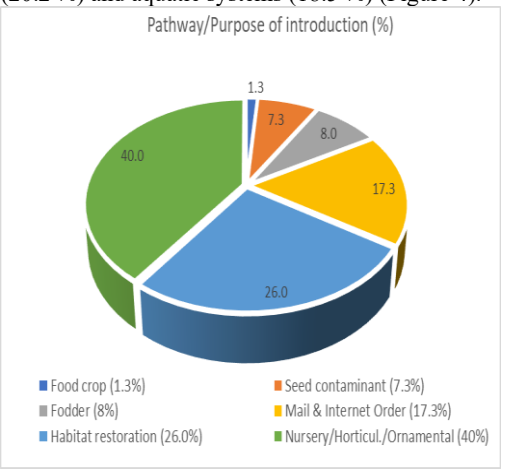


Figure 3. Identified pathways of entry for horizon weeds of QLD.

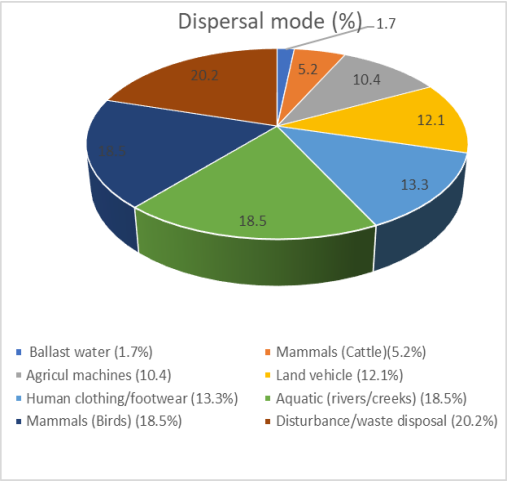
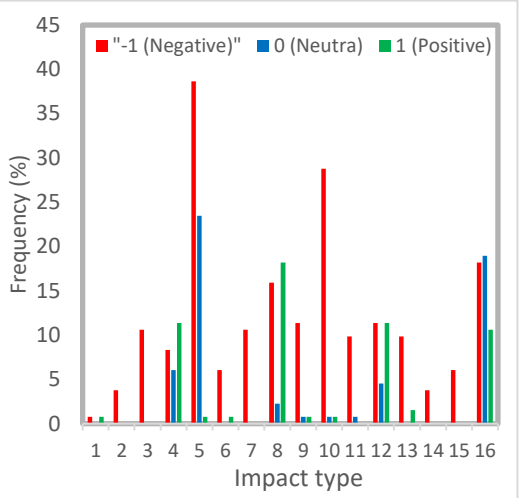


Figure 4. Dispersal vectors for horizon weeds in QLD.

Potential impacts are deemed generally negative (especially on environment/ ecology, biodiversity, livestock, and economy/ livelihood) to neutral, but positive impacts (on livestock, cultural amenity, and economy) were also identified (Figure 5).

Using a simple summation on spread, impact and pathways indices, the top horizon weeds worthy of immediate attention span all life forms, although trees and shrubs dominate (Table 1).



Impact type			
1=Animal/plant collection		7=Forestry	
2=Animal/plant product		8=Livestock	
3=Crop		9=Nature Fauna (Biodiversity)	
4=Cultural Amenity		10=Nature Flora (Biodiversity)	
5=Environment/ecology		11=Rare/Protected Species	
6=Fisheries		12=Human health	
	13=Tourism		
	14=Trade/international relations		
	15=Transport/Travel		
	16=Economy/Livelihood		

Figure 5. Documented impact of QLD horizon weeds on nature and socio-economic factors in their invaded ranges around the globe.

Table 1. Top 25 horizon weeds of QLD worthy of management action.

Species	No. of countries invaded aside from Aust	Life form
Gliricidia sepium	116	Tree
Coffea arabica	115	Shrub
Coix lacryma-jobi	108	Grass
Pithecellobium dulce	97	Tree
Jatropha curcas	96	Shrub/Small tree
Arundo donax	95	Grass
Pennisetum purpureum	76	Grass
Syzygium jambos	69	Tree
Spathodea campanulata	67	Tree
Mimosa pigra	66	Shrub
Robinia pseudoacacia	55	Shrub/Small tree
Ipomoea alba	53	Vine
Pennisetum polystachion	52	Grass
Thunbergia fragrans	49	Vine
Dichrostachys cinerea	48	Shrub
Haematoxylum campechianum	48	Tree
Thunbergia grandiflora	47	Vine
Leonotis nepetifolia	45	Shrub
Elephantopus mollis	44	Herb
Cereus uruguayanus	42	Succulent
Chromolaena odorata	42	Shrub
Gmelina arborea	42	Tree
Ulex europaeus	39	Shrub
Clerodendrum chinense	38	Shrub
Caesalpinia decapetala	37	Vine

DISCUSSION

Much like well-established weed populations in Queensland (Osunkoya *et al.* 2019), most horizon weeds come from the Americas, suggesting that entry of goods (e.g., horticultural products, food crops, machineries etc) from this continent, along with those from the Indian subcontinent require greater scrutiny if we are to avoid further problems of IAS. South Africa, and selected countries in East Africa (Kenya, Uganda, Madagascar) and certain provinces in southern China are also worth noting as common sources of weed incursions into QLD. It is noted that the climates in these regions/countries are similar to those experienced over large parts of QLD.

The horizon weeds are likely to have varying impacts, though the negative influences are often reported, especially on biodiversity and ecology. However, from the analyses there are cases of reported positive impacts (cultural amenity, livestock, human health and livelihood). The positive impacts of alien species are probably underestimated, as there is often a perception bias against alien species (Goodenough 2010, Shackleton *et al.* 2019). Hence management must balance the two impacts in terms of cost-benefit analyses to address the trade-offs in IAS management so that successful implementation of management practices is facilitated.

It is important to note that dominant invasion pathways include the commercial trade in garden ornamentals, forestry/ habitat restoration and mail-order trade. While import restrictions on plants have improved greatly over the past 10-20 years, it is clear that the nursery trade has served as a primary invasion pathway in the past and still needs close monitoring and regulation. In addition, post-border dispersal via water ways, agricultural machines, land vehicles and soil disturbance/ movement appear to be common vectors of spread. Hence, these vectors are worthy of closer surveillance, where feasible, to limit the spread of horizon weeds in QLD. Regional regulation, coupled with improved public awareness for consumers, are also desirable to minimise the spread and impact of invasive plants on the horizon weeds list.

Conclusion

No doubt, some of the indices used for assessment need refinement, particularly climate-matching which, for now, is based on 19 variables of rainfall and temperature. We have also modelled habitat matching/ suitability in QLD as a single entity when there are strong regional differences. Hence the modelling work could be improved if key components of these numerous driver variables were narrowed down. Also, the overall index has been based on simple summation of individual indices, which may not necessarily hold, as some indices might be more important than others. As such, varying weightings may be desirable to facilitate a more robust assessment.

ACKNOWLEDGMENTS

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REFERENCES

Beaury, E.M., Patrick, M. and Bradley, B.A (2021). Invaders for sale: the ongoing spread of invasive species by the plant trade industry. *Front Ecol Environ* 19(10), 550-556

Csurhes, S. 2021. Risk assessment and prioritization of 229 emerging weed threats detected in Queensland. Technical report. Biosecurity Queensland. 54 pages.

Cuhls, K.E. 2019. Horizon Scanning in Foresight – Why Horizon Scanning is only a part of the game. *Futures & Foresight Science* 2(e23).

Goodenough, A.E. 2010. Are the ecological impacts of alien species misrepresented? A review of the "native good, alien bad" philosophy. *Community Ecology* 11, 13–21

Neve, P., Barney, J.N., Buckley, Y. et al 2018. Reviewing research priorities in weed ecology, evolution and management: a horizon scan. *Weed Res* 58, 250–258.

Randall, R.P. 2007. The introduced flora of Australia and its weed status. CRC for Australian Weed Management, University of Adelaide, Glen Osmond, South Australia.

Shackleton R.T., Shackleton C.M., & Kull C.A. 2019. The role of invasive alien species in shaping local livelihoods and human well-being: A review. *J. Environ Manage* 229, 145-157.

Osunkoya, O.O., Lock C.B., Dhileepan K. & Buru J.C. 2021. Lag times and invasion dynamics of established and emerging weeds: insights from herbarium rec ords of Queensland, Australia. *Biol. Invasions* 23, 3383–408.

Osunkoya O.O., Froese J.G., Nicol S., Perrett C., Moore K., Callander J., & Campbell S. 2019. A risk-based inventory of invasive plant species of Queensland, Australia: Regional, ecological and floristic insights. *Austral Ecol* 44, 1123–1138.