Prevention is best: Protecting Australia from future environmental weed threats

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Summary The national priority list of exotic environmental pests, weeds and diseases was released in November 2020. An implementation plan to identify and prioritise risk reduction actions was finalised in 2022. The list, developed collaboratively with over 100 experts, informs activities to prevent the entry, establishment and spread of exotic species that can negatively impact Australia's environment and/or social amenity. As examples of pests known to cause severe negative impacts, the future threats of four of the weeds on the list are detailed here to support preventative action.

Keywords prevention, environmental biosecurity, Mikania vine, Manchurian wildrice, spiked pepper, mouse-ear hawkweed.

WHAT IS THE LIST?

In 2017, the independent review into the capacity of the national biosecurity system and its underpinning intergovernmental agreement delivered its final report, *Priorities for Australia's biosecurity system* (Craik *et al.* 2017). Recommendation 11 of the report was for a national priority list for exotic environmental pests and diseases to be developed in partnership with system participants. The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), and the then Department of Agriculture, led the development of this national priority list (ABARES 2021).

The resulting list, also known as the exotic environmental pest list or the EEPL, identifies pests, weeds, and diseases that are not present in Australia (or if present, under eradication) that pose the greatest threat to Australia's environment and social amenity. It is distinct from other national lists primarily focused on agricultural risks as it aims to strengthen the national biosecurity system by improving focus and awareness on environmental biosecurity. The EEPL is not an exhaustive list and does not aim to limit jurisdictions or industries from pre- or post-border actions targeting other pests or diseases. Rather, the list highlights the diverse array of environmental biosecurity risks that Australia faces from pests and diseases.

WHAT'S ON THE LIST?

The list contains 168 exotic species across eight thematic groups (weeds and freshwater algae, vertebrates, marine pests, native animal diseases, aquatic animal diseases, plant pathogens, terrestrial invertebrates, and freshwater invertebrates), and includes 19 weed species; see ABARES (2021) for full list. Of these, four species were assessed as higher risk weeds that pose the greatest risk to Australia's environmental biosecurity: Manchurian wildrice (*Zizania latifolia* (Griseb.) Turcz. ex Stapf, Poaceae); Mikania vine (*Mikania micrantha* Kunth, Asteraceae); Mouse-ear hawkweed (*Pilosella officinarum* Vaill., Asteraceae); and Spiked pepper (*Piper aduncum* L., Piperaceae).

HOW WERE WEEDS SELECTED?

Cross-sectoral collaboration was a key component of EEPL development, with ABARES working with over 100 experts across all taxonomic groups from governments, research institutions, museums, and other organisations. Experts participated in workshops to facilitate joint decisions on the purpose and methodology to determine the priority list. Experts also shortlisted candidate species and took part in a structured modified-Delphi expert elicitation process with a semi-quantitative assessment (ABARES 2021).

A total of 20 species in the weeds and freshwater algae group (which consist of 19 weeds) were shortlisted for further assessment. To be included in the short list, a species must: have demonstrated negative impacts on environment and/or social amenity; be exotic to Australia (i.e., not currently known to be present in Australia or, if present, subject to nationally agreed eradication); have at least one known or potential pathway of entry to Australia; have the potential to establish and spread in Australia; and have the potential for nationally important negative impacts on Australia's environment or social amenity.

The semi-quantitative assessment allowed for risk scoring and ranking within the thematic groups to determine the higher risk EEPL species based on

the likelihood of entry, establishment and spread, and the environmental and social amenity impacts. The four above-mentioned weed species were assessed as having a higher overall risk ranking for Australia.

FOUR EEPL WEEDS

Mikania vine *Mikania micrantha* is a rampant, smothering vine, native to Central and South America (Waterhouse 2003). It has invaded a range of tropical and sub-tropical areas, to become one of the most serious weeds across tropical Asia, the Indian sub-continent, and Pacific regions (Day *et al*. 2016). Seeds of mikania vine are light and readily dispersed by wind, but can also be dispersed by animals, water, human activity, and vehicles (S. Brooks, unpublished data). Abundant seasonal seed production forms a persistent soil seed bank, and it is readily capable of vegetative propagation from each stem node (Brooks and Jeffery 2018).

Mikania vine is a vigorous, perennial vine that is capable of climbing, entangling, and choking trees, shrubs, and fences (Day *et al*. 2016). It has invaded a wide variety of agricultural and environmental land uses across an exceedingly wide variety of damp habitats including wetlands. It is recognized as a serious environmental weed across many Pacific Islands and tropical to subtropical Asia, stretching north into Nepal and southern China (Day *et al.* 2016 and references there-in). Mikania vine is also a serious pest of pastures, plantations, and orchard crops. Day *et al.* (2016) provides a summary of 23 crops severely impacted by Mikania vine. The small seed could enter Australia as a contaminant of agricultural goods (Waterhouse 2003).

Mikania vine was listed on the first Northern Australia Quarantine Strategy (NAQS) weed list by Michael (1989). In Australia, Mikania vine was first discovered near Mission Beach in north Queensland in 1998 and was included in the nationally cost-shared 'National Tropical Weeds Eradication Program' when it commenced in late 2003 (Waterhouse 2003). While present on mainland Australia, it is the subject of an eradication program. Mikania vine was included on the EEPL due to the risks of further introductions leading to wide-spread impacts over wet coastal areas of northern and eastern Australia.

Mouse-ear hawkweed *Pilosella officinarum* [syn. *Hieracium pilosella* L.], is a perennial daisy, native to Eurasia. It spreads via aggressive stolons, forming new rosettes and creating monocultures that can exclude all other species (French and Watts 2020). It has invaded areas in Asia, North and South America, and New Zealand, where it causes severe impacts (CABI 2022). Currently, two small incursions are under formal eradication in the Australian Alps (New South Wales and Victoria; Hamilton *et al.* 2015).

Mouse-ear hawkweed can have a major impact on native plant communities and associated biodiversity by altering soil properties, nutrient cycling, and overall community structure (Espie 2001). It grows vigorously (French and Watts 2020), reproduces asexually, and its seeds are spread by wind. It can outcompete native plants by secreting chemicals into the soil that prevent the germination and growth of other plants (McIntosh *et al.*1995). Seeds of mouse-ear hawkweed are very small and may be unintentionally introduced into Australia on clothing, shoes, or outdoor equipment. Hygiene is critical, especially given the extensive infestations in New Zealand and the likelihood of recreational travel between those areas and Australian alpine regions.

Alpine regions are extremely vulnerable to Mouse-ear hawkweed invasion, as it can rapidly displace native vegetation, including inter-tussock vegetation in alpine environments (Espie 2001). This may reduce their aesthetic value and could cause the loss of rare and threatened plants and animals that depend on these alpine communities.

The impact of Mouse-ear hawkweed is severe in New Zealand, where over six million hectares are invaded, with significant impacts to conservation and production values (Espie 2001). Mouse-ear hawkweed is also a serious risk to agricultural productivity, as it is unpalatable to stock. Invasions are estimated to reduce the value of agricultural production by up to NZ$4.4 million annually (Grundy 1989) in New Zealand, with further social impacts to farmers and land managers. Mouse-ear hawkweed could establish in a broad range of habitats across large areas of southeastern Australia (Weed Futures 2019), including New South Wales, Victoria, Tasmania, and South Australia. A preventative approach is warranted given the risks mouse-ear hawkweed poses to a variety of conservation and production environments.

Spiked pepper *Piper aduncum* is a slender-stemmed tree native in Central and South America (Mexico to Argentina), where it occurs from sea level to *c.* 2000 m ASL (POWO 2022). It is invasive in deforested areas of the Amazon Basin within its native range, and Malaysia, Indonesia, the Philippines, Papua New Guinea, Solomon Islands, Vanuatu, Fiji, Hawaii and Florida where it is an introduced species (Hartemink 2010, Padmanaba and Shiel 2014, Waterhouse pers. obs.) The only Australian records are from Christmas Island where it has been known since 1987 (AVH 2022, Hartemink 2010, Waterhouse 2003). Recognition of the threat posed by spiked pepper to northern Australia led to its inclusion on the second and subsequent editions

of the NAQS weed list (Waterhouse and Mitchell 1998) and recently the EEPL. Its introduction to Australia is prohibited (BICON 2022) and it is classified as a prohibited species under Queensland and Northern Territory biosecurity legislation.

Spiked pepper is a pioneer species which readily establishes, persists, and spreads in natural and human-induced disturbances such as tree fall gaps, landslips, riparian zones, roadsides, recently logged forests, mine sites, and gardens (Hartemink 2010, Padmanaba and Shiel 2014). Growing to 8 m tall and often multi-stemmed, it forms impenetrable stands (B. Waterhouse pers obs). Its invasiveness results from a rapid growth rate to reproductive maturity, high biomass accumulation, prolific and continuous seed production, domination of the soil seed bank and ability to resprout vegetatively from stem fragments or after damage (Hartemink 2006). The tiny seeds are dispersed long distances by birds, bats and as contaminants on footwear, vehicles, and forestry/mining equipment (Hartemink 2010, Padmanaba and Shiel 2014). It is cultivated as an ornamental shrub and a 'living fence' in Papua New Guinea (Hartemink 2006, Waterhouse, pers. obs) and has ethnobotanical and medicinal uses, raising the potential for seeds to be traded over the internet (Hartemink 2010). Spiked pepper could become a serious environmental weed in tropical and subtropical forests from far north Queensland through to north-eastern NSW, as well as adjacent agricultural and pastoral lands. These forests are highly fragmented and experience increasingly frequent seasonal disturbances from tropical cyclones, damaging storms, floods, and bushfires. Continued surveillance for this species is essential due to its potential to reach northern Australia associated with nomadic fruit bats and birds moving from neighbouring landmasses, or via ports and airports as an accidental contaminant with travelers and equipment from infested areas.

Manchurian wildrice *Zizania latifolia* is a giant perennial rhizomatous aquatic and wetland grass up to 4 m tall. Plants form dense, tall infestations on waterbody margins, riverbanks, floodplains, tidal flats, and flood-prone pasture and cropping land. Manchurian wildrice is native to eastern Asia where it is a common emergent aquatic species (Hung *et al*. 2008). Manchurian wildrice is reported as naturalised in relatively few countries, with New Zealand being the first reported country outside of Asia (Champion 2020). It is also naturalised in five European countries and Hawaii but there are few reported sites in any of these countries. There are also records of cultivated food plant specimens from mainland North America (Champion 2020).

Manchurian wildrice forms monocultures within both its native and introduced range. Dense stands are a major barrier to water body use, regeneration of native species, particularly where the plant is perennial with no winter die-back. Manchurian wildrice displaces short-stature vegetation and envelops taller individual indigenous plants that are unable to produce progeny within the dense sward (Champion 2020). Based on impacts seen in New Zealand, it could cause serious impacts to both freshwater and estuarine native plant and animal communities including internationally important Ramsar wetlands, protected freshwater and coastal wetlands, and lagoons across most of Australia.Manchurian wildrice contributes to riverbank slumping and bank failure, causing flooding of adjacent pastures and providing further habitat for Manchurian wild rice. Although short young foliage is palatable to cattle, tall, dense plants become unpalatable (Champion 2020).

Introduction to New Zealand was via mudbricks contaminated with viable plant material and it was erroneously spread as an erosion/flood control plant within New Zealand (Champion 2020). The threat posed by Manchurian wildrice has been recognised in New Zealand since its introduction around 1900 (Arnold 1937). However, a concerted effort to manage the plant nationally did not occur until 2008, when it was classified as a Notifiable Organism and one of 13 National Interest Pest Responses (Champion and Hofstra 2010), with an operational plan aimed to eradicate all populations of this species from the four regions where it occurs. Manchurian wildrice was ranked as New Zealand's third worst aquatic weed (Champion and Clayton 2000), behind *Phragmites australis* (Cav.) Trin.ex Steud. and *Hydrilla verticillata* (L.f.) Royle, both native to Australia but also subject to national eradication programmes in New Zealand.

OVERVIEW

Australia's National Priority List of Exotic Environmental Pests, Weeds and Diseases (EEPL) provides an opportunity to raise awareness and target prevention activities at organisms that pose the greatest environmental biosecurity risks. For weeds, the four species described here are critical targets for prevention activities and for considering actions, such as eradication, should prevention fail. Implementing activities to ensure all weeds on the list do not establish and impact Australia in future is recommended. An implementation plan is being developed to coordinate mitigation actions for EEPL species.

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REFERENCES

ABARES (2021). The National Priority List of Exotic Environmental Pests, Weeds and Diseases: Information Paper (V2.0), ABARES report to client prepared for the Chief Environmental Biosecurity Officer, Department of Agriculture, Water and the Environment, Canberra, ACT. CC BY 4.0.

Arnold, E.H. (1937). Manchurian rice grass (*Zizania latifolia*): its occurrence and distribution in the Northern Wairoa District. *The New Zealand Journal of Agriculture* 55, 3, 129–33.

Australasian Virtual Herbarium (AVH) (2022). Council of Heads of Australasian Herbaria https://avh.chah.org.au, accessed 01 May 2022

Australian Biosecurity Import Conditions Database (BICON), (2022). Department of Agriculture, Water and the Environment BICON - Import Conditions (agriculture.gov.au), accessed 01 May 2022.

Brooks, S. and Jeffery, M. (2018). Progress in the eradication of *Mikania micrantha* from Australia. Proceedings of the 21st Australasian Weeds Conference, eds S Johnson, L Weston, H Wu and B Auld. pp. 350–3. (The Weed Society of New South Wales, Sydney).

CABI (2022). *Pilosella officinarum* (mouse-ear hawkweed). In, Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc. accessed 01 May 2022.

Champion, P.D. (2020). Management of Manchurian Wild Rice (*Zizania latifolia*): Information review. NIWA Client Report 2020208HN, Hamilton.

Champion, P.D. and Clayton, J.S. (2000). Border control for potential aquatic weeds. Stage 1 Weed risk model. *Science for Conservation,* 141. Department of Conservation, Wellington.

Champion, P.D. and Hofstra, D.E. (2010). Manchurian wild rice (*Zizania latifolia*) control. Proceedings of the 17th Australasian Weeds Conference, Christchurch. 318–20.

Craik, W., Palmer, D. and Sheldrake, R. (2017). Priorities for Australia's biosecurity system, An independent review of the capacity of the national biosecurity system and its underpinning Intergovernmental Agreement, Canberra.

Day, M.D., Clements, D.R., Gile, C., Senaratne, K.A.D., Shen, S., Weston, L.A. and Zhang, F. (2016). Biology and impacts of Pacific Islands invasive species. 13. *Mikania micrantha* Kunth. (Asteraceae). *Pacific Science* 70, 3, 257–85.

Espie, P. (2001). Hieracium in New Zealand: ecology and management, AgResearch Ltd, Mosgiel, New Zealand). 66 pp.

French, K. and Watts, E. (2020) Differences in vegetative growth of two invasive hawkweeds at temperatures simulating invaded habitats at two altitudes. *Scientific Reports* 10, 2180.

Grundy T.P. (1989). An economic evaluation of biological control of Hieracium. Research Report - Agribusiness & Economics Research Unit, Lincoln College Canterbury, New Zealand, No. 202: 41pp.

Hamilton, M.A., Cherry, H. and Turner, P.J. (2015). Hawkweed eradication from NSW: Could this be the first? *Plant Protection Quarterly* 30, 110–5.

Hartemink, A.E. (2006). *Invasion of Piper aduncum in the shifting cultivation systems of PNG.* CIP-Gegevens Koninklijke Bibliotheek, Den Haag.

Hartemink, A.E. (2010). The invasive shrub *Piper aduncum* in Papua New Guinea: A Review. *Journal of Tropical Forest Science* 22, 2, 202–13.

Hung, L.Q., Asaeda T., Kallibala, M. and Mnaya, B.J. (2008). Effects of nutrient concentration and litter cover on quantitative shoot parameters and belowground biomass of *Zizania latifolia* (L). *Chemistry and Ecology* 24, 5, 357–65.

McIntosh, P.D., Loeseke, M., and Bechler, K. (1995). Soil changes under mouse-ear hawkweed (*Hieracium pilosella*). *New Zealand Journal of Ecology* 19 1, 29–34.

Michael, P.W. (1989). *Review Paper on Weeds of Concern to Northern Australia.* Report to the Bureau of Rural Resources.

Padmanaba, M. and Shiel, D. (2014). Spread of the invasive alien species *Piper aduncum* via logging roads in Borneo. *Tropical Conservation Science* 35–44.

Plants of the World Online, (2022). (POWO) Facilitated by the Royal Botanic Gardens, Kew; http://www.plantsoftheworldonline.org/ (retrieved 4 May 2022)

Waterhouse, B.M. (2003). Know your enemy: Recent records of potentially serious weeds in northern Australia, Papua New Guinea and Papua (Indonesia). *Telopea* 10, 1, 477–85.

Waterhouse, B.M. and Mitchell, A.A. (1998). *Northern Australia Quarantine Strategy Weeds Target List*. Second edition. Australian Quarantine and Inspection Service Miscellaneous Publication 6/98.

Weed Futures (2019). Macquarie University; http://www.weedfutures.net/species.php?id=2067 http://www.weedfutures.net/species.php?id=2067(retrieved 20 June 2022).