Future Northland Pastures: 5. Potential sleeper weeds of pastoral systems in Northland, New Zealand

Christopher E. BUDDENHAGEN[1]* and Zachary NGOW[1]

[1]*BSI - AgResearch Group, Ruakura Research Centre, Hamilton, New Zealand*
*Corresponding author: chris.buddenhagen@agresearch.co.nz

Abstract
We identified sleeper weeds: species that are already naturalised but remain limited in distribution and are likely capable of spreading into pastures in Northland, New Zealand. The species were significant agricultural weeds overseas, including subtropical species that could expand with climate change. We identified 33 potential sleeper weeds, comprising four grasses, twenty-two broadleaf herbs, one succulent herb, and six shrubs. The low forage quality grasses (*Chloris gayana*, *Digitaria ciliaris*, *Melinis repens, Setaria sphacelata*) are known to invade pastures. Six species toxic to livestock were identified. Three quarters of all the species are known problems in subtropical or tropical areas globally, so may be emerging problems under climate change. Regular incipient weed surveys and farmer reporting in both urban and agricultural areas are crucial, as these locations are often overlooked. Vigilance in detecting unusual plants, coupled with strict farm hygiene, remains the best strategy to prevent new weed spread.

Keywords: invasive species, incipient invader, pasture

Introduction
Declines in productivity and resilience of pastures in Northland have been attributed to climate change by farmers and scientists (Garcia et al. 2021; Marmont et al. 2024; Teixeira et al. 2024). Apart from changes in yields for key pasture species like ryegrass (*Lolium* species) and clover (*Trifolium repens* L.) there is a belief that weed impacts to pastures may be increasing, as some weeds are released from environmental constraints. For widespread weeds, there may be little to do other than adjust on-farm management practices. For incipient weeds there is a possibility of a more strategic approach, and "sleeper" weeds could be a key group to address. Sleeper weeds are naturalised introduced plants that remain restricted in range for an extended period (often decades) but can subsequently shift to a rapid rate of spread and become seriously invasive (Groves 2006). Identifying potential sleeper weeds can allow mitigative action, including eradications (though this is rarely feasible), containment or prevention of spread. The transition from slow to rapid population growth—often reflected as a distinctly two-phase curve—can be difficult to distinguish from typical exponential growth. Factors triggering this shift (i.e., causing a sleeper weed to "wake up") may include eco-evolutionary processes such as hybridisation e.g., knotweed in North America (Gillies et al. 2016), spread to suitable habitats combined with habitat modification e.g., *Hieracium pilosella* L (Rose et al. 1998), arrival of pollinators or other mutualists e.g., the wasp pollinator of *Ficus* spp. (Gardner and Early 1996), and density dependent changes in reproductive rates (Tobin et al. 2011). Many of these factors are linked to human-mediated changes that affect spread. Climate change may also enable some low-abundance naturalised species (sleeper weeds) to increase in prevalence, through mechanisms such as earlier or more frequent flowering, and improved dispersal and establishment as conditions become more favourable (Sheppard et al. 2016). In particular, ornamental garden plants originating from warmer native ranges are likely to naturalise and become invasive when climatic constraints are lifted (e.g., *Archontophoenix cunninghamiana*, *Psidium guajava* and *Schefflera actinophylla* (Sheppard et al. 2016)).

Explanations for sleeper weeds "waking up" and shifting to higher rates of spread and impact often emphasise biological factors. However, weeds are frequently spread long distances by humans, and along with subsequent local dispersal can also increase spread rates. For example, during the post-European colonisation of New Zealand, when many plants were first introduced, burdock (*Arctium minus*) and nodding thistle (*Carduus nutans* L.) had multiple early occurrences recorded in disparate regions of both islands, suggesting human-mediated spread. This occurred despite early attempts to control their spread through legislation such as the Control of Thistles Acts of 1854 (Wellington) and 1857 (Auckland). Many important weeds in New Zealand have relatively poor natural dispersal—for example, *Tradescantia fluminensis* Vell. does not produce seed in New Zealand (Heenan et al. 2023). Similarly, most grass and sedge seeds fall close to parent plants, and bird dispersal is rare. Long-distance dispersal is often facilitated by intentional planting or the movement of vehicles, equipment, livestock, fodder, seed contaminants, gravel, and people. The spread of sleeper weeds in pastures, like other weeds, is best mitigated by implementing weed hygiene measures on a farm-by-farm basis.

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The ability to identify and mitigate the threat sleeper weeds pose is dependent on the quality of the information regarding identification, taxonomy and distribution. New Zealand has >22,000 introduced plant species, at least 1798 naturalised species, and 1043 species that are 'casual' i.e., that occasionally occur in the wild and may be sustained from cultivated plants (Brandt et al. 2021). Consequently, there is a long list of species, including those currently with a limited range, that could potentially spread rapidly. Here, we limit our focus to threats to Northland pastures, in the context of declining forage productivity and pasture persistence, both of which have been attributed to climate change (Garcia et al. 2021; Marmont et al. 2024; Teixeira et al. 2024). For naturalised and casual species, we apply the 'weed elsewhere' concept (Randall 2016), and use publicly available spatial distribution data to generate a list of potential sleeper weeds for Northland.

Materials and Methods

Our goal was to identify potentially serious future sleeper weeds by balancing hazard (likelihood of establishment) with consequence (severity of impact), using a strict definition of sleeper weeds: species naturalised in New Zealand but rare in Northland.

We screened a list of 'casual' and 'naturalised' plants in New Zealand compiled by Brandt et al. (2021**)**, focusing on species present in Northland and in fewer than seven other regions across the country. We further filtered Brandt's list to include only herbs (forbs and graminoids) and shrubs (excluding trees and vines), as these groups are of greater concern in pasture systems. A two-step screening process, applying the same set of criteria, was used. First, we combined regional occurrence data from Brandt et al. (2021) with agricultural weed records from Randall's compendium (Randall 2017) to generate a shortlist. This shortlist was then refined using updated occurrence records and regional reassessments from current data (GBIF 2025). The screening criteria are described in more detail below.

Species were assessed for weediness using Randall's Global Compendium of Weeds (Randall 2017)**;** those with fewer than 31 agricultural weediness references were excluded. We also excluded species not recorded in Northland within the past century (e.g., *Erigeron annuus* (L.) Pers., *Lolium temulentum* L.), as well as crop species (e.g., sweet potato), primarily environmental weeds (e.g., *Coix lacryma-jobi* L.), and aquatic weeds (e.g., *Pistia stratiotes* L.). We prioritised species known to be problematic in warm-temperate, subtropical, and tropical climates to account for potential climate change effects.

Occurrence data were obtained from the Global Biodiversity Information Facility (GBIF) using the R package rgbif (Chamberlain and Boettiger 2017; Chamberlain et al. 2021; R Core Team 2022). These data included digitised herbarium records and iNaturalist observations (the latter excludes cultivated occurrences). Potential sleeper weeds were defined as species naturalised or casual in New Zealand, with 15 or fewer occurrences in Northland, present in seven or fewer New Zealand regions, and a total of 50 or fewer observations nationwide.

Results

We identified 33 potential sleeper weeds, including four grasses, twenty-two broadleaf herbs, one succulent herb and six shrubs (Table 1). The data for all the species assessed is available from Figshare: https://doi.org/10.57935/AGR.28916726.v1

Discussion

The most reliable indicators of a species invasiveness are its history of naturalisation outside its native range, weediness elsewhere, and presence in climatically similar regions (Pheloung et al. 1999; Mack et al. 2007; Randall 2016). Our analysis applies this rationale to introduced plants in Northland, and considers their affinity for warm temperate, subtropical and tropical climates. We highlight some potential sleeper weeds, where concerns have been raised regarding their impact on agriculture, especially in pastures. The overall number of weed records in Randall's Global Compendium (2017) was compared to those specifically mentioning agricultural impacts (Table 1). None of the shortlisted potential sleeper weeds were regarded as exclusively problematic for agriculture.

A key caveat here is the issue of data quality, which relies on recording accurate species occurrence data. Even botanists can suffer plant blindness, for example many sedges and grasses are difficult to distinguish by anyone but specialist botanists. Often people favour collection of data in natural areas, islands, along walking tracks, and near their homes in urban areas, which may bias data. Nevertheless, the data currently available via GBIF and iNaturalist, while potentially biased, is better than earlier researchers could access, and serves as a starting point for identification of likely sleeper weeds. It is common that more occurrences will be revealed, especially under the proper scrutiny that occurs when a weed-led management program is initiated, where spatial delimitation is needed (Panetta and Lawes 2005; Downey and Sheppard 2006; Buddenhagen and Tye 2015). This is likely no matter how recently a species has been identified as newly naturalised, or if it is suspected of having a limited distribution. This delimitation step is key to assessing feasibility of "weed-led" management and could see the sleeper species we identified as being infeasible for eradication or containment (Timmins et al. 2000; Timmins 2004).

There are four grasses with low value as forages identified known to invade grasslands in warm temperate and subtropical climates: *Chloris gayana* Kunth (Rhodes grass), *Digitaria ciliaris* (Retz.) Koeler (summer grass, southern crabgrass), *Melinis repens* (Willd.) Zizka (Natal grass) and *Setaria sphacelata* (Schumach.) Stapf and C.E.Hubb. ex Moss (South African pigeon grass). *Digitaria ciliaris* competes with desirable pasture species and ceases vegetative growth upon flowering, leaves a gap in the pasture, providing the opportunity for further weed establishment (Jones et al. 2021). *Melinis repens* invades overgrazed pastures (Gutiérrez Gutiérreza et al. 2019, Hidalgo-Triana et al. 2022). *Chloris gayana* and *S. sphacelata* have some forage value, both of these species have been introduced to Northland and have been subject to previous efforts to identify subtropical pasture species for future forage systems (Crush and Rowarth 2007; Teixeira et al. 2024), but also exhibit weedy tendencies. Several *C. gayana* cultivars are used in Australia, but its feed quality declines over time, and it is emerging as a weed in Australian crops (Desai and Chauhan 2021) and regarded as a major weed in Queensland, South America, and Africa (Lonsdale 1994, Low 1997). *Setaria sphacelata* is an environmental weed in Australia (Low 1997), and it is closely related to yellow bristle grass *Setaria pumila* (Poir.) Roem. Schult. (Dowsett et al. 2018) which has low value as a forage. *Setaria sphacelata* has 38 references as an agricultural weed in Randall's Compendium (Table 1).

Other identified sleeper weeds include shrubs such as *Lantana montevidensis* L. (trailing lantana) and *Psidium guajava* L. (yellow guava), with known pastoral impacts in subtropical areas (Carlson 1952, Day and McAndrew 2002). *Leucaena leucocephala* (Lamark) de Wit (river tamarind) is a morphologically variable species that is a fast-growing legume shrub or small tree with a persistent seedbank that can form dense stands, which is a widespread weed globally, but also promoted as an alternative forage crop (Walton 2003). *Senna pendula* (Willd.) H.S.Irwin et Barneby (buttercup bush), another leguminous shrub, is a major weed in eastern Australia (Paynter et al. 2003). *Tecoma stans* (L.) Juss. ex Kunth (trumpet flower) is an exotic woody shrub observed as an invader of degraded pastures in Brazil.

Carthamus lanatus L. (saffron thistle) found in New Zealand is the subspecies *baeticus* (Boiss. & Reut.) Nyman, which is regarded as synonym of *C. creticus* L. (the currently accepted name in New Zealand, Biota of New Zealand accessed 6 May 2025, https://biotanz.landcareresearch.co.nz/scientific-names/66b38b7d-106c-4151-b36d-d4103d881537). This taxon appears to be regulated in Australia where it is widespread in eastern and southern regions (Peirce 1992), and it is currently regulated in Tasman-Nelson, Marlborough, Manawatu-Wanganui, Canterbury, Hawkes Bay and Auckland regions. *Psidium guajava* L. is also regulated in the Auckland region.

Ambrosia artemisiifolia L. (annual ragweed), *Dittrichia graveolens* (L.) Greuter (stinkwort), *Tagetes minuta* L. (stinking Roger), and *Tolpis barbata* (L.) Gaertn (umbrella milkwort) are wind-dispersed weeds with known congeneric weeds in New Zealand. Mugwort is difficult to kill in pastures due to its rhizomatous spread (Aulakh 2020). Among the herbaceous weeds identified are some that were observed in imported coco-peat coir: *Amaranthus spinosus* L. (spiny amaranth), *Amaranthus viridis* L. (green amaranth), *Commelina communis* L. (Asiatic dayflower), *Evolvulus nummularius* (L.) L. (roundleaf bindweed), *L. leucocephala* and *Richardia brasiliensis* Gomes (white-eye) (James et al. 2011). Other herbaceous weeds identified are those that grow in damp pasture: *Bidens tripartita* L. (swamp beggar's ticks), *Lysimachia nummularia* L. (creeping Jenny) and *Veronica peregrina* L. (purslane speedwell).

Toxic, or unpalatable weeds, such as *Ammi majus* L. (Bishop's flower) and *Asclepias curassavica* L. (bloodflower) will be avoided by stock and compete with pasture (Gunning 1949; Dollahite et al. 1978). One succulent herb, *Kalanchoe pinnata* (Lam.) Pers (air plant), was identified, and while typically existing on the margins of pasture (rock outcrops and fence lines), has caused poisoning of livestock in Australia (McKenzie et al. 1987) and it is also a weed of concern for the Department of Conservation (McAlpine 2024). *Datura ferox* L. (long-spined thornapple) has both long spines and toxic alkaloids in its dry fruit, and like its more common congener *D. stramonium*, is frequently the cause of livestock poisoning (Vitale et al. 1995). *Cestrum aurantiacum* Lindl. is another invasive shrub that is toxic to livestock, e.g., a problem in Brazilan systems (Bezerra et al. 2023).

As our goal was to identify potentially serious future pasture weeds from the list of species naturalised in New Zealand but rare in Northland, this excluded non-naturalised cultivated plants or slightly more abundant taxa, as well as well-known emerging threats that could spread widely. For example, while *Senecio madagascariensis* Poir is of increasing concern to farmers, it is too common to include as a sleeper weed (Dymock and Winks 2024; Schmidt-Lebuhn et al. 2024). Similarly, *Andropogon virginicus* L. (broomsedge), an aggressive coloniser of nutrient-poor pastures (Butler et al. 2002) has been increasing in the Far North District. Other species that had more than fifteen observations in Northland (thus excluded) but fit the other criteria included *Allium vineale* L., *Hakea gibbosa* (Sm.) Cav., *Juncus capitatus* Weigel, *Psidium cattleianum* Afzel. ex Sabine and *Sida rhombifolia* L.. We also excluded 33 species, that would otherwise qualify, because they were present in more than seven other New Zealand regions, which may have led to some omissions of emerging threats in Northland. Climate change impacts were not assessed through complex modelling; instead, we included species that are serious weeds in warm-temperate, subtropical and tropical climates elsewhere (Table 1). The caveat on this work is that "prediction is hard, especially about the future". Climate matching suggests that Northland's current and future conditions resemble parts of the Auckland, Waikato, and Bay of Plenty (Beukes et al. 2021) so many of these sleeper weeds could potentially affect those regions too.

Practical implications

Managing sleeper weeds—whether the species identified here or others yet to be recognised—requires ongoing vigilance. Scientists, botanical society members, and farmers should document unusual plant occurrences in agricultural systems. Traditionally, trained botanists have been more likely than non-experts to detect newly naturalised species (Hosking et al. 2004). Hiring botanists to survey rural areas and urban–rural interfaces would enhance early detection. However, citizen science platforms such as iNaturalist (https://inaturalist.nz/) and Find-A-Pest (http://www.findapest.nz/) are increasingly enabling community-based detection (Sullivan et al. 2019).

Targeted surveys and citizen science efforts should prioritise sites that represent future climatic conditions (e.g., drier, warmer, or wetter environments) and urban–rural interfaces where plant introduction rates are high. Further research is needed to better understand the likelihood of these species "waking up" and expanding in abundance and distribution (see Introduction). The potential sleeper weeds discussed here provide a foundation for prioritising species for surveillance and management.

Practically, farmers should monitor their properties for emerging plant problems and maintain strong weed hygiene. Key practices include cleaning equipment, ensuring contractors follow biosecurity measures, minimising farm feed movement, and quarantining livestock in weed-free paddocks before and after long-distance transport.

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REFERENCES

Aulakh JS. 2020. Role of nitrogen and herbicides in integrated management of mugwort (*Artemisia vulgaris*) in cool-season forage grasses. *Invasive Plant Science and Management 13*: 189-198. Retrieved 2 May 2025 from: https://www.cambridge.org/core/product/identifier/S193972912000019X/type/journal_article

Beukes P, Babylon A, Griffiths W, Woodward S, Kalaugher E, Sood A, Chapman D. 2021. Modelling perennial ryegrass (*Lolium perenne*) persistence and productivity for the Upper North Island under current and future climate. *Resilient Pastures Symposium: Research and Practice Series 17*: 297–-06. Retrieved 17 October 2023 from: https://www.nzgajournal.org.nz/index.php/rps/article/view/3450

Bezerra JJL, Pinheiro AAV, Lucena RBD. 2023. Poisoning in ruminants caused by species of the genus *Cestrum* L. (Solanaceae) in Brazil: A review of toxicological and phytochemical evidence. *Toxicon 236*: 107348. Retrieved 2 May 2025 from: https://linkinghub.elsevier.com/retrieve/pii/S0041010123003343

Brandt AJ, Bellingham PJ, Duncan RP, Etherington TR, Fridley JD, Howell CJ, Hulme PE, Jo I, McGlone MS, Richardson SJ. 2021. Naturalised plants transform the composition and function of the New Zealand flora. *Biological Invasions 23*: 351-366. https://doi.org/10.1007/s10530-020-02393-4

Buddenhagen CE, Tye A. 2015. Lessons from successful plant eradications in Galapagos: commitment is crucial. *Biological Invasions 17*: 2893-2912. http://dx.doi.org/10.1007/s10530-015-0919-y

Butler TJ, Stritzke JF, Redmon LA, Goad CL. 2002. Broomsedge (*Andropogon virginicus)* Response to Herbicides and Burning. *Weed Technology 16*: 18-22. http://www.bioone.org/doi/abs/10.1614/0890-037X(2002)016[0018:BAVRTH]2.0.CO;2

Carlson NK. 1952. Grazing Land Problems, Molokai Island, Territory of Hawaii. *Journal of Range Management 5*: 230-242. Retrieved 5 March 2025 from: https://www.jstor.org/stable/3894146?origin=crossref.

Chamberlain S, Barve V, Mcglinn D, Oldoni D, Desmet P, Geffert L, Ram K. 2021. *rgbif: Interface to the global biodiversity information facility API*. https://CRAN.R-project.org/package=rgbif.

Chamberlain S, Boettiger C. 2017. R Python, and Ruby clients for GBIF species occurrence data. *PeerJ PrePrints*. PeerJ, Inc. https://doi.org/10.7287/peerj.preprints.3304v1

Crush JR, Rowarth JS. 2007. The role of C4 grasses in New Zealand pastoral systems. *New Zealand Journal of Agricultural Research 50*: 125-137. http://dx.doi.org/10.1080/00288230709510287

Day MD, McAndrew TD. 2002. Status of *Charidotis pygmaea* (Coleoptera: Chrysomelidae) as a biological control agent of *Lantana montevidensis* (Verbenaceae) in Australia. *Biological Control 23*: 27-34. Retrieved 27 February 2025 from: https://linkinghub.elsevier.com/retrieve/pii/S1049964401909831

Desai HS, Chauhan BS. 2021. *Chloris truncata* and *Chloris virgata*. *Biology and Management of Problematic Crop Weed Species*. Elsevier, pp. 113-129. Retrieved 26 February 2025 from: https://linkinghub.elsevier.com/retrieve/pii/B9780128229170000069

Dollahite JW, Younger RL, Hoffman GO. 1978. Photosensitization in cattle and sheep caused by feeding *Ammi majus* (greater Ammi; Bishop's-Weed). *American Journal of Veterinary Research 39*: 193-197.

Downey PO, Sheppard AW. 2006. Site- versus species-based approaches to weed management in Australia. In: Preston C, Watts JH, Crossman ND. Eds. *Proceedings of the 15th Australian Weeds Conference*. Adelaide.

Dowsett CA, Buddenhagen CE, James TK, McGill CR. 2018. Yellow bristle grass *(Setaria pumila)* germination biology. *New Zealand Plant Protection 71*: 72-84. https://doi.org/10.30843/nzpp.2018.71.154

Dymock JJ, Winks CJ. 2024. Invertebrate and fungal associations of the pastoral weed, Madagascar ragwort, *Senecio madagascariensis* Poir, in Northland, New Zealand, and implications for biocontrol. *New Zealand Journal of Agricultural Research*: 1-10. http://dx.doi.org/10.1080/00288233.2024.2435402

Garcia SC, Kemp S, Clark C, Ota N, Islam M, Kriticos D. 2021. What's next for the New Zealand dairy feed-base? Learnings from climate analogues. *Resilient Pastures Symposium: Research and Practice Series 17*: 149-162. https://doi.org/10.33584/rps.17.2021.3486

Gardner RO, Early JW. 1996. The naturalisation of banyan figs (*Ficus* spp., Moraceae) and their pollinating wasps (Hymenoptera: Agaonidae) in New Zealand. *New Zealand Journal of Botany 34*: 103-110. https://doi.org/10.1080/0028825X.1996.10412697

GBIF. 2025. Global Biodiversity Information Facility. Retrieved 15 April 2025 from: http://gbif.org.

Gillies S, Clements DR, Grenz J. 2016. Knotweed (*Fallopia* spp.) invasion of North America utilizes hybridization, epigenetics, seed dispersal (unexpectedly), and an arsenal of physiological tactics. *Invasive Plant Science and Management 9*: 71-80. http://dx.doi.org/10.1614/IPSM-D-15-00039.1

Groves RH. 2006. Are some weeds sleeping? Some concepts and reasons. *Euphytica 148*: 111-120. http://dx.doi.org/10.1007/s10681-006-5945-5

Gunning OV. 1949. Suspected buttercup poisoning in a jersey cow. *British Veterinary Journal 105*: 393. https://www.sciencedirect.com/science/article/pii/S0007193517531826

Gutiérrez Gutiérreza OG, Morales Nieto CR, Villalobos González JC, Ruíz Barrera O, Ortega Gutiérrez JÁ, Palacio Nuñez J. 2019. Composición botánica y valor nutritivo de la dieta consumida por bovinos en un área invadida por pasto rosado [*Melinis repens* (Willd.) Zizka]. *Revista Mexicana de Ciencias Pecuarias 10*: 212-226. http://dx.doi.org/10.22319/rmcp.v10i1.4451

Heenan PB, Cheeseman DF, Mitchell CM, Dawson MI, Smith LA, Houliston GJ. 2023. Genetic diversity of *Tradescantia fluminensis* complex (Commelinaceae) naturalised in Australia, New Zealand and South Africa. *New Zealand Journal of Botany 61*: 23-37. http://dx.doi.org/10.1080/0028825X.2022.2055479

Hidalgo-Triana N, Casimiro-Soriguer Solanas F, Solakis Tena A, Pérez-Latorre AV, García-Sánchez J. 2022. *Melinis repens* (Willd.) Zizka subsp. *repens* (Poaceae) in Europe: distribution, ecology and potential invasion. *Botany Letters 169*: 390-399. http://dx.doi.org/10.1080/23818107.2022.2080111

Hosking JR, Waterhouse BM, Williams PA. 2004. Are we doing enough about early detection of weed species naturalising in Australia. *14th Australian Weeds Conference: Papers and Proceedings. Weed Management: Balancing People, Planet, Profit*.

James TK, Champion PD, Bullians M, Rahman A. 2011. Weed biosecurity breach through coco peat imports. *Weed Management in a Changing World*. Asian-Pacific Weed Science Society, The Sebel Cairns. https://researchoutput.csu.edu.au/ws/portalfiles/portal/9712399/PID33773conference_20_Proceedings.pdf

Jones EAL, Contreras DJ, Everman WJ. 2021. *Digitaria ciliaris*, *Digitaria ischaemum*, and *Digitaria sanguinalis*. . *Biology and Management of Problematic Crop Weed Species*. Elsevier, pp. 173-195. http://dx.doi.org/10.1016/B978-0-12-822917-0.00014-8

Lonsdale WM. 1994. Inviting trouble: Introduced pasture species in northern Australia. *Australian Journal of Ecology 19*: 345-354. http://dx.doi.org/10.1111/j.1442-9993.1994.tb00498.x

Low T. 1997. Tropical pasture plants as weeds. *Tropical Grasslands 31*: 337-43.

Mack RN, Von Holle B, Meyerson LA. 2007. Assessing invasive alien species across multiple spatial scales: working globally and locally. *Frontiers in Ecology and the Environment 5*: 217-220. http://dx.doi.org/10.1890/1540-9295(2007)5[217:AIASAM]2.0.CO;2

Marmont B, Neal M, Minnee E. 2024. The economic impacts of declining pasture harvest on Northland

and Waikato dairy farms. *Journal of New Zealand Grasslands*: 237-242. https://doi.org/10.33584/jnzg.2024.86.3703

McAlpine K. 2024. List of environmental weeds in New Zealand 2024. *Science for Conservation*: 1-42. https://www.doc.govt.nz/news/media-releases/2024-media-releases/rapid-growth-for-weeds-list/

McKenzie RA, Franke FP, Dunster PJ. 1987. The toxicity to cattle and bufadienolide content of six Bryophyllum species. *Australian Veterinary Journal 64*: 298-301. https://doi.org/10.1111/j.1751-0813.1987.tb07330.x

Panetta FD, Lawes R. 2005. Evaluation of weed eradication programs: the delimitation of extent. *Diversity and Distributions 11*: 435-442. http://dx.doi.org/10.1111/j.1366-9516.2005.00179.x

Paynter Q, Csurhes SM, Heard TA, Ireson J, Julien MH, Lloyd J, Lonsdale WM, Palmer WA, Sheppard AW, Klinken RDV. 2003. Worth the risk? Introduction of legumes can cause more harm than good: an Australian perspective. *Australian Systematic Botany 16*: 81-88. http://dx.doi.org/10.1071/SB01025

Peirce J. 1992. The biology of Australian weeds, 23. *Carthamus lanatus* L. *Plant Protection Quarterly (Australia) 7*: 86-95.

Pheloung PC, Williams PA, Halloy SR. 1999. A weed risk assessment model for use as a biosecurity tool evaluating plant introductions. *Journal of Environmental Management 57*: 239-251. https://doi.org/10.1006/jema.1999.0297

R Core Team. 2022. *R: A language and environment for statistical computing*. Vienna, Austria. https://www.R-project.org/

Randall RP. 2016. Can a plant's cultural status and weed history provide a generalised weed risk score? *Proceedings of the 20th Australasian Weeds Conference*: 5-2.

Randall RP. 2017. *A global compendium of weeds. 3rd Edition.*

Rose AB, Basher LR, Wiser SK, Platt KH, Lynn IH. 1998. Factors predisposing short-tussock grasslands to *Hieracium* invasion in Marlborough, New Zealand. *New Zealand Journal of Ecology 22*: 121-140. https://www.jstor.org/stable/24054685

Schmidt-Lebuhn AN, Egli D, Grealy A, Nicholls JA, Zwick A, Dymock JJ, Gooden B. 2024. Genetic data confirm the presence of *Senecio madagascariensis* in New Zealand. *New Zealand Journal of Botany 62*: 1-13. https://doi.org/10.1080/0028825X.2022.2148544

Sheppard C, Burns B, Stanley M. 2016. Future-proofing weed management for the effects of climate change: is New Zealand underestimating the risk of increased plant invasions? *New Zealand Journal of Ecology 40*: 398-405. http://dx.doi.org/10.20417/nzjecol.40.45

Sullivan JJ, Meurk CD, Dawson MI, Hutchison M. 2019. Crowdsourcing the discovery of new plant naturalisations in Canterbury using iNaturalist NZ. *Canterbury Botanical Society Journal 50*: 54-66.

Teixeira CSP, Olykan ST, Moot DJ. 2024. A review of grass species yields and growth rates in Northland, New Zealand. *New Zealand Journal of Agricultural Research*: 1-24. http://dx.doi.org/10.1080/00288233.2024.2351614

Timmins SM. 2004. How weed lists help protect native biodiversity in New Zealand. *Weed Technology 18*: 1292-1295. Retrieved 2 May 2025 from: http://www.bioone.org/doi/abs/10.1614/0890-037X%282004%29018%5B1292%3AHWLHPN%5D2.0.CO%3B2

Timmins SM, Owen SJ, Buddenhagen CE. 2000. New Zealand–a weedy paradise. *Wildland Weeds Articles. Winter*: 8-12.

Tobin PC, Berec L, Liebhold AM. 2011. Exploiting Allee effects for managing biological invasions. *Ecology Letters 14*: 615-624. https://doi.org/10.1111/j.1461-0248.2011.01614.x

Vitale AA, Acher A, Pomilio AB. 1995. Alkaloids of *Datura ferox* from Argentina. *Journal of Ethnopharmacology 49*: 81-89. https://doi.org/10.1016/0378-8741(95)90035-7

Walton C. 2003. The biology of Australian weeds. 42. *Leucaena leucocephala* (Lamark) de Wit. *Plant Protection Quarterly 18 (3)*: 90-98. https://caws.org.nz/plant-protection-quarterly-and-australian-weeds-archive/

Table 1 Plant species we identified as potential sleeper weeds of pasture. The number of published weed records in the Global Compendium by Rod Randall (2017) is compared to the number that specifically mention it as a weed of agriculture. Occurrence records for Northland are sourced from the Global Biodiversity Information Facility (https://www.gbif.org/).

	Species	Common Name	Family	Form	Lifespan	Status in 2020 (Brandt)	Weed records	Ag-weed records	GBIF oc-currences (Northland)	Year last observed (Northland)	Range incl. sub-tropical areas
1.	*Amaranthus spinosus*	spiny amaranth	Amaranthaceae	herb	annual	Naturalised	543	395	1	1970	yes
2.	*Amaranthus viridis*	green amaranth	Amaranthaceae	herb	annual	Naturalised	549	402	5	2013	yes
3.	*Ambrosia artemisiifolia*	annual ragweed	Asteraceae	herb	annual	Naturalised	514	342	1	1975	yes
4.	*Ammi majus*	Bishop's flower	Apiaceae	herb	annual	Naturalised	210	99	4	2023	no
5.	*Amsinckia calycina*	yellow gromwell	Boraginaceae	herb	annual	Naturalised	58	42	1	1948	no
6.	*Artemisia vulgaris*	mugwort	Asteraceae	herb	perennial	Casual	246	192	1	1967	yes
7.	*Asclepias curassavica*	bloodflower	Apocynaceae	herb	perennial	Casual	304	162	3	2021	yes
8.	*Bidens tripartita*	swamp beggar's ticks	Asteraceae	herb	annual	Naturalised	102	62	1	2009	no
9.	*Carthamus lanatus*	saffron thistle	Asteraceae	herb	annual	Naturalised	209	132	2	1972	no
10.	*Cestrum aurantiacum*	green cestrum	Solanaceae	shrub	perennial	Naturalised	76	44	23	2024	yes
11.	*Chloris gayana*	Rhodes grass	Poaceae	caespitose	perennial	Naturalised	214	117	13	1982	yes
12.	*Commelina communis*	Asiatic dayflower	Commelinaceae	herb	annual	Casual	203	91	1	2007	no
13.	*Datura ferox*	long-spined thornapple	Solanaceae	herb	annual	Naturalised	188	114	2	1985	yes
14.	*Digitaria ciliaris*	tropical summer grass	Poaceae	caespitose	annual	Naturalised	333	176	6	2013	yes
15.	*Dittrichia graveolens*	stinkwort	Asteraceae	herb	annual	Naturalised	102	40	4	2021	no
16.	*Evolvulus nummularius*	roundleaf bindweed	Convolvulaceae	herb	perennial	Casual	80	47	1	2008	yes
17.	*Kalanchoe pinnata*	air plant	Crassulaceae	succulent herb	perennial	Naturalised	164	37	2	2002	yes
18.	*Lantana montevidensis*	trailing lantana	Verbenaceae	shrub	perennial	Naturalised	84	31	4	2022	yes
19.	*Lepidium virginicum*	pepper grass	Brassicaceae	herb	annual	Naturalised	421	193	4	1972	yes
20.	*Leucaena leucocephala*	white leadtree	Fabaceae	tree-shrub	perennial	Casual	603	183	2	2002	yes
21.	*Lysimachia nummularia*	creeping Jenny	Primulaceae	herb	perennial	Naturalised	121	78	2	2021	no
22.	*Melinis repens*	Natal grass	Poaceae	caespitose	annual or perennial	Casual	241	58	2	2024	yes
23.	*Melochia corchorifolia*	chocolate weed	Malvaceae	herb-subshrub	annual	Casual	87	62	1	2022	yes
24.	*Mercurialis annua*	annual mercury	Euphorbiaceae	herb	annual	Naturalised	176	90	1	2023	yes
25.	*Oenothera rosea*	rose evening primrose	Onagraceae	herb	perennial or biennial	Naturalised	176	79	1	2009	yes
26.	*Psidium guajava*	yellow guava	Myrtaceae	tree-shrub	perennial	Naturalised	501	227	4	2006	yes
27.	*Richardia brasiliensis*	white-eye	Rubiaceae	herb	annual	Casual	141	104	2	2008	yes
28.	*Senna pendula*	buttercup bush	Fabaceae	shrub	perennial	Casual	93	44	44	2014	yes
29.	*Setaria sphacelata*	South African pigeon grass	Poaceae	caespitose	perennial	Casual	124	38	3	1973	no
30.	*Tagetes minuta*	stinking Roger	Asteraceae	herb	annual	Naturalised	343	207	1	2002	yes
31.	*Tecoma stans*	trumpet flower	Bignoniaceae	tree-shrub	perennial	Casual	241	71	1	2018	yes
32.	*Tolpis barbata*	umbrella milkwort	Asteraceae	herb	annual	Naturalised	58	44	7	2025	no
33.	*Veronica peregrina*	purslane speedwell	Plantaginaceae	herb	annual	Naturalised	295	124	6	2024	yes