PSGR

Physicians & Scientists for Global Responsibility

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Submission

New Zealand Environment Protection Authority

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Physicians and Scientists for Global Responsibility Charitable Trust (PSGR) work to educate the public on issues of science, medicine, technology (SMT). PSGR work to encourage scientists and physicians to engage in debate on issues of SMT, particularly involving genetics and public and environmental health.

Summary

This Call for Information on glyphosate creates an opportunity to respond to the NZEPA and query practices concerning 'controversial' substances such as glyphosate. This is because the glyphosate-based herbicides (GBHs) are commonly applied tank mixed, and applied in rotations with other herbicides, and together these chemical mixtures increase pollutant pressure on soil, water and air, while increasing risk of detection in export markets.

Herbicide mixtures are applied because New Zealand has a herbicide resistance problem. There is inadequate interdisciplinary scientific resourcing to strategically monitor and assess the pressure on soils and aquatic systems, and so herbicidal applications are the 'cheap' option.

There is 'new information' and glyphosate should be risk assessed (See **Section [C]**). The NZEPA has never conducted a formal RA of GBHs, only a cancer review.

Intensive herbicide reliance produces a cascading effect where risk extends beyond immediate farmer/applicators to families, neighbours and aquatic ecosystems (and risk to potable water), to offshore food safety risk as detections are increasingly likely on food in offshore markets.

Banning home use may have little overall impact. The greatest use of glyphosate in New Zealand is 'professional', from applications before, during and after crop and pasture planting; in horticulture; alongside roads, railways; in public areas and around public amenities and on water. Removal of use for non-professionals will remove some exposure to the public. However, the judgements in U.S. court cases have demonstrated a greater incidence of cancer among farmers and applicators, who are frequent users of GBHs.

Applicator exposure is a big problem. The NZEPA has not appropriately engaged with the greater problem of herbicide mixture use to combat herbicide resistance and the frequency of exposures to farmers, horticulturalists/growers and vegetation managers, often for territorial and local authorities, or councils (TLAs). The aggregate use of herbicides, and the scientific and anecdotal literature which reveals farmers and applicators are frequently exposed - despite following practice as prescribed on the label.

Scientific research documents that regular pesticide use shows users are commonly exposed, even by users who are fastidious about protective equipment. This was a major 'reveal' of the U.S. court cases, and is why farmers and applicators are at risk from glyphosate-related illness.

This response is in two parts, the first part concerns the CFI, and the second part responds directly to the CFI.

Part 1 is structured into three sections. Section [A] Outlines the greater global problem of pollution and the role herbicides play. **Section [B]** discusses the problem of a CFI; **Section [C]** the failure of the NZEPA to acknowledge new information; and **Section [D]** the case of neonicotinoids.

Part 2, responds directly to the Call for Information and the NZEPA 28 April 2021 submission paper.

PSGR provide comments relating to **Section [4]**; Mitigation measures and controls; **Section [5]** Impact on Māori; **Section [6]** as 'technical information', which we would refer to as the scientific literature; and **Section [7]** the 'benefits and alternatives' and **Section [8]** Hearing views.

PART 1.

[A] Background research: Call for Information

1. In this Call for Information (CFI), relevant questions have remained outside the scope, such as requiring information on spills and contamination, health conditions, herbicide resistance and mixtures commonly tank mixed with GBH formulations.

2. **Weed resistance is a greater driver of herbicide pollution**. Global pesticide use increased by 80% between 1990-2017.[1] Herbicide sales constitute 45% of chemical pesticide sales in New Zealand.[2] Increasingly harmful herbicides are applied to cope with increasing herbicide resistance.[3] [4]

3. Mixtures of herbicides are the 'norm', contaminating soils globally.[5] [6] [7] [8]

4. **Tank mixing increases pressure on the environment.** GBH formulations will be applied at the recommended rate *and* will be tank mixed with other herbicides.[9] One spray will have 2 or 3 times the amount of active ingredient applied, plus the adjuvants and organosilicon surfactants.

5. In order to combat resistance, different herbicide mixtures with different modes of action[10] are commonly applied. New Zealand may have over 12 glyphosate-resistant species.[11] Recent journal literature has been opaque concerning the extent of local glyphosate resistance.

6. **European moves more swiftly to ban hazardous substances.** The range of pollutants banned in Europe released into air, water and soil in New Zealand is growing rapidly. European banned pesticides (including herbicides) in use include diquat, chlorpyrifos, dichlorvos, bifenthrin, atrazine, simazine, hexazinone, methyl bromide, sodium fluoroacetate, mancozeb, carbaryl and more… Quantities released into the environment are not documented, mixtures are common but not regulated.

7. **Chemical regulators throughout the world face a crisis of trust.** Glyphosate is the poster child of this crisis. Critical scientific papers outline how regulatory science is outdated, while not consider real world exposures. Weighting in RA is biased towards industry data selected and supplied by the manufacturers,

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[1] Boedeker et al 2020. The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review. BMC Public Health 20:1875

[2] Buddenhagen et al 2019. Costs and risks associated with surveying the extent of herbicide resistance in New Zealand. New Zealand Journal of Agricultural Research, DOI: 10.1080/00288233.2019.1636829

[3] New York Times. Attack of the Superweeds. https://www.nytimes.com/2021/08/18/magazine/superweeds-monsanto.html?

[4] Heap. International Herbicide Resistant Weed Database. http://www.weedscience.org/Home.aspx

[5] Silva et al 2019. Pesticide residues in European agricultural soils – A hidden reality unfolded. Science of The Total Environment. 653:1532-1545

[6] Tang & Maggi 2021. Pesticide mixtures in soil: a global outlook. Letter. Environ. Res. Lett. 16:044051

[7] Da Silva et al 2021. Pesticides in a case study on no-tillage farming systems and surrounding forest patches in Brazil. Nature 11:9839 DOI: 10.1038/s41598-021-88779-3

[8] Raffa & Chiampo 2021. Bioremediation of Agricultural Soils Polluted with Pesticides: A Review. Bioengineering. 8:92

[9] Beckie 2021. Herbicide resistance management strategies: How do they compare with those for insecticides, fungicides and antibiotics? Perspective. DOI 10.1002/ps.6395

[10] Mode of action – the target site where a pesticide will cause physiological disruption to the target species.

[11] New Zealand Winegrower 2015. https://www.ruralnewsgroup.co.nz/wine-grower/wg-general-news/herbicide-resistance

rather than peer reviewed literature. [12] [13] The word 'trust' now features prominently in NZEPA annual reports, perhaps due to recognition of this problem.

8. **Herbicides are the 'cheap' option when ecosystem costs are not factored into cost (or risk)-benefit scenarios.** Industry applications and NZEPA decision documents reveal that NZEPA risk-benefit analyses over-emphasise industry claims. Emphasis is placed on risk to production (GDP) if herbicides are withdrawn.

9. Herbicide mixtures which bioaccumulate and degrade ecosystem services are not factored in as economic costs in NZEPA risk-benefit analysis. Off-target effects are not considered in cost-benefit scenarios such as detection by offshore regulatory regimes, the potential for herbicides to speed antibiotic resistance and the cost of stripping emerging contaminants out of drinking water. Instead, the major 'risk' that is effectively valued is based on risk to production tonnages, based on data supplied by industry.

10. Central to the nature of this CFI is a wish to place on the public record that there is extensive evidence of a systemic reluctance by New Zealand's regulatory agency and associated authorities to adopt an integrated risk assessment based on a mix of toxic compounds used by categories of user 'integrated user risks' and categories of food which accumulate many different toxins to create an 'integrated food-product consumer risk'.

11. Capable stewardship requires integration to ensure appropriate foresight, insight and oversight.[14] Economic benefit should outweigh end-points which retain trust in regulators: the safety and protection of categories of user; safety and protection of people exposed to end-products; and safety and protection of a healthy environment. These endpoints include the protection of ecosystem services and the protection of Papatūānuku –the protection of the mauri (life force) of water and the protection of drinking water (waiunu).

12. **As mixtures are the 'norm'. Avoiding looking at mixture toxicity is unscientific.** Current evidence indicates that there is a predominant regulatory focus on enabling chemical products to be used in NZ on the bases of singular substances not inclusive of toxic synergies within trade-name products; not inclusive of toxic exposures of categories of user; not inclusive of integrated total toxic loads in end-food-products; and not inclusive of accumulative and synergistic toxicity in the environment.

13. **Endocrine disruption carries little weighting in decision-making.** Unlike other jurisdictions, New Zealand lacks policy drawing attention to low level 'sub-lethal' risk from endocrine disrupting activities that interact at the level of the hormone. This cascades into an absence of scientific research, such as research considering cumulative herbicide exposures to users that can produce sublethal synergistic and or additive effects at environmentally relevant levels.[15] [16] [17] [18]

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[12] Myers et al 2016. Concerns over use of glyphosate-based herbicides and risks associated with exposures: a consensus statement. Environmental Health 15:19

[13] Robinson et al 2020. Achieving a High Level of Protection from Pesticides in Europe: Problems with the Current Risk Assessment Procedure and Solutions. European Journal of Risk Regulation. DOI:10.1017/err.2020.18

[14] Boston, J., Bagnall, D., & Barry, A. (2019). Foresight, insight and oversight: Enhancing long-term governance through better parliamentary scrutiny. Institute for Governance and Policy Studies. School of Government Victoria University of Wellington.

[15] Hasenbein et al 2015. The use of growth and behavioral endpoints to assess the effects of pesticide mixtures upon aquatic organisms. Ecotoxicology DOI 10.1007/s10646-015-1420-1

[16] Martin et al. 2021. Ten years of research on synergisms and antagonisms in chemical mixtures: A systematic review and quantitative reappraisal of mixture studies. Environment International 146:106206 doi:https://doi.org/10.1016/j.envint.2020.106206

[17] Siviter et al 2021. Agrochemicals interact synergistically to increase bee mortality. Nature 596389-392

[18] Mesnage et al 2019. Transcriptome profile analysis reflects rat liver and kidney damage following chronic ultra-low dose Roundup exposure. Environmental Health. DOI 10.1186/s12940-015-0056-1

14. **Regional pressures from pesticides differ.** While horticulture yields more than broadacre crops, horticultural land generates on average ten times the aquatic ecotoxicity hazard and five times more human toxicity hazard than a hectare of broadacre crops [19]

15. **Europe's risk assessments scientifically remain far superior to risk assessment in New Zealand.** While insufficiently transparent and subject to conflicts of interest[20], European assessments are more scientifically thorough and there is a line of sight between toxicity and potential for authorisation, or the decline of an application. New Zealand's reliance on 'cost-benefit' is less transparent and muddled, skewing NZEPA deliberation to favour industry claims as there is no line of sight between toxicity and regulation.[21] [22] [23]

16. The European Environmental Agency has taken a lead in recognising escalating pollution from synthetic chemicals, and the cocktail effect of chemical mixtures.[24] This has informed the development of the Healthy Planet for All EU Action Plan[25] and the Farm to Fork Strategy which includes a reduction of pesticide use by 50%.[26] There is no integrated approach in New Zealand.

17. The Parliamentary Commissioner for the Environment (PCE) has remarked on the absence of local knowledge, monitoring and environmental science 'leaving researchers to cobble together piecemeal solutions'. In particular, the PCE has recognised the absence of a clear line of sight that can lead to strategic long-term action.[27]

18. As the PCE has stated:

> I am not confident that there is a coherent basis for our national investment in environmental science. I am particularly concerned that there is no mechanism that links the ongoing demand environmental reporting makes for an understanding of complex ecological processes that evolve over decades, and a science funding system that is constantly searching for innovation, impact and linkages to the ever-changing demands of business and society.[28]

19. We question if the NZEPA and Ministry for the Environment has engaged in consultation with their Treaty partners as to the increasing range of banned chemicals in our soil and water and strategies by which the substantial scientific resources harnessed in European chemical stewardship, through the EFSA and the European Chemicals Agency (ECHA), might be harnessed to protect New Zealand soil and water.

20. **Drinking water is at risk if current standards are relied upon.** For example, we wonder what the public and what Māori would think of the European Commission Drinking Water Directive 98/83/EC, which stipulates a maximum concentration of any individual pesticide in drinking water of 0.1 µg/L and maximum concentration of the total sum of all pesticides present (including metabolites) as limited to

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[19] Navarro et al 2021. Pesticide Toxicity Hazard of Agriculture: Regional and Commodity Hotspots in Australia. 55:2;1290-1300 DOI: 10.1021/acs.est.0c05717

[20] Robinson et al 2020. Achieving a High Level of Protection from Pesticides in Europe: Problems with the Current Risk Assessment Procedure and Solutions. European Journal of Risk Regulation. DOI:10.1017/err.2020.18

[21] Eg. Decision discussion for Paraquat (APP203301); 600g/L glyphosate Crucial (APP203611) & Grunt (APP204109)

[22] NZEPA 2020. Risk Assessment Methodology for Hazardous Substances. https://www.epa.govt.nz/assets/Uploads/Documents/Hazardous-Substances/Risk-Assessment-methodology/Risk-Assessment-Methodology-for-Hazardous-Substances-How-to-assess-the-risk-cost-and-benefit-of-new-hazardous-substances-for-use-in-New-Zealand-v2.docx

[23] Kaltenhauser et al 2017. Relevance and reliability of experimental data in human health risk assessment of pesticides. Reg.Tox & Pharm. 88

[24] EEA. (2018). Chemicals in European Waters: Knowledge Developments. EEA Report 18/2018. European Environmental Agency.

[25] European Commission 2021. Zero pollution action plan. https://ec.europa.eu/environment/strategy/zero-pollution-action-plan_en

[26] Farm to Fork Strategy. https://ec.europa.eu/food/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf

[27] PCE 2020. A review of the funding and prioritisation of environmental research in New Zealand

[28] PCE 2019. Focusing Aotearoa New Zealand's environmental reporting system. P.6

0.5 µg/L. New Zealand has no policy for 'aggregate toxicity' from emerging contaminants including pesticides.

21. **Glyphosate drinking water levels are remarkably high.** New Zealand currently relies on a 1981 Monsanto Biodynamics study to glyphosate establish potential drinking water levels. This was set in 1985.[29] Using unpublished 20-year-old data, the World Health Organisation (WHO) claims that no formal guideline value is necessary and assert that exposures of glyphosate up to 0.9mg/L (or 900 µg/L) is safe, and maintaining that such a high level is unlikely to be detected. The Drinking Water Standards for New Zealand have adopted the WHO's perspective. [30]

22. Unlike the European Commission, the WHO is not democratically accountable. The glyphosate levels, set in 1985 were set based on industry data submissions.

23. **The European Commission has embedded a stronger application of the precautionary principle in European legislation**.[31] This has enabled decisions to be undertaken when science continues to be uncertain, in the public interest. A strong application might better enable the Crown to honour Treaty of Waitangi obligations.

24. **The HSNO Act and accompanying Methodology Order implement a weak form of precaution.[32]**

25. A stronger application of the precautionary principle might also be recognised as a process similar to the actions of Māori to place a rāhui on an area for protective reasons. For example, a rāhui would not be placed on collection of pipi before all the pipi was harvested to extinction.

26. **Cabinet budgeting can flip the knowledge base.** There is potential for economic analyses to explore the costs of integrated strategies. These alternatives currently appear more expensive than chemical regimes as pollution in soil, marine, freshwaters and drinking water, and frequent user health is not taken into account.

27. **Cabinet budgeting can support rapid uptake of integrated weed management and associated tech in agriculture.** New technology is advancing swiftly.[33] Remote controlled mulching and mowing, high speed mechanical technologies, cover cropping and shallow tilling to manage weed seed populations. Are all components in a suite of strategies that protect soil and water.[34]

28. **Cabinet budgeting can assist with transition of TLAs and public authorities away from intensive dependence on industrial chemical agriculture.** This includes asset management in urban environments, roadside, utilities and railway tracks, and Department of Conservation work.

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[29] WHO 2017 Guidelines for Drinking Water Quality. Fourth Edition.

[30] Ministry of Health 2018. Volume 3 Datasheets. Part 2.3. Chemical and physical determinands: Pesticides. Guidelines for Drinking-water Quality Management for New Zealand, June 2018

[31] Iorns Magallanes 2018. Permitting Poison: Pesticide Regulation in Aotearoa New Zealand. EPLJ, 456-490.

[32] Iorns Magallanes 2018. Permitting Poison: Pesticide Regulation in Aotearoa New Zealand. EPLJ, 456-490.

[33] E.g. Grazer (New Zealand) Mowing/mulching in difficult to access areas. https://www.grazer.co.nz/
E.g. Roadside, urban, agriculture. https://zasso.com/products/
E.g., Cassini Grasskiller https://www.youtube.com/watch?v=W_aTuzSqTSY
E.g., Roadside Dücker, Gerhard, GmbH & Co. KGLSM 740 guiding post mower https://www.youtube.com/watch?v=7-pXAv0W2-I&t=54s
Eg. Urban Foamstream. https://www.youtube.com/watch?v=KD7B658U_gU

[34] E.g., Merfield 2019. Integrated weed management in arable crop systems. Foundation for Arable Research.

29. Organic consumers purchase organic product because it is more natural and pesticides residues and sprays are health protective, and orders of magnitude lower.[35] [36] The organics sector is growing, and key export markets include the U.S., China, Europe and Australia.[37]

30. **Is the CFI an unnecessary step?** With 6,000 chemicals to steward, the NZEPA is very busy. There are 40,000 to 60,000 industrial chemicals in commerce globally. 6,000 of these chemicals account for more than 99 per cent of the total volume. 62% of the volume of chemicals produced are hazardous to health.[38]

31. **The CFI can be integrated into a hazard/risk assessment.**

32. **Manmade pollution is threatening humanities 'safe operating space'.**[39] Government agencies acknowledge there is a *global pollution crisis*, driven predominantly by the release of manmade chemicals. Major work to shift policy is being being undertaken by the United Nations Environment Programme,[40] and the European Commission.[41]

[B] Why a Call for Information (CFI)?

33. Directing resources towards a CFI instead of directly towards risk assessment slows down the speed at which the NZEPA can engage science to identify harms and protect ecosystem services. In particular:

34. The CFI reveals that the NZEPA don't know how much pesticides are used. New Zealand stopped tracking herbicide, insecticide and other pesticide use and providing this information to the Food and Agriculture Organization (FAO) in 2009.[42] Tracking of volumes should, like other countries, be a normal operational practice and serve as an important indicator of pollution risk. Up until 2009 herbicide tonnages outstripped other pesticides, and tonnages were increasing.

35. CFIs appear to be undertaken for so-called controversial substances (eg. neonicotinoids). Industry heavily engages with these consultations. New Zealand's scientific community does not normally engage, as there is little funding for research to understand the effects of for example, glyphosate in New Zealand. In this way scientific 'authority' is tipped towards the interests of industry.

36. A CFI appears to delay risk assessment. See Section [C] example of neonicotinoid insecticides

37. Risk assessment should involve the potential, or likelihood of exposure to a hazardous substance. Instead of a separate CFI, this information should be integrated into risk assessment. The potential for exposure to glyphosate, is much higher than for many lesser used, but equally hazardous substances.

38. New Zealand does not have a set acceptable daily intake based on New Zealand data, but rather refers to the WHO-FAO determinations, based on old unpublished industry studies. The drinking water ADI level

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[35] Benbrook et al 2021. Organic Farming Lessens Reliance on Pesticides and Promotes Public Health by Lowering Dietary Risks. Agronomy 2021, 11, 1266. https://doi.org/10.3390/agronomy11071266

[36] Geissen 2021. Cocktails of pesticide residues in conventional and organic farming systems in Europe Legacy of the past and turning point for the future. Environmental Pollution 278: 116827

[37] Organics Aotearoa New Zealand. 2020/21 Time for Action. New Zealand Organic Sector Market Report.

[38] United Nations Environment Programme, 2019. Global Chemicals Outlook II From Legacies to Innovative Solution

[39] Steffen (2015) Planetary boundaries: Guiding human development on a changing planet. Science

[40] United Nations Environment Programme, 2019. Global Chemicals Outlook II From Legacies to Innovative Solution

[41] European Commission 2021. Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil

[42] http://www.fao.org/faostat/en/#data/RP/metadata See bulk downloads

of 0.3mg/kg bodyweight a day is based on a 1981 Monsanto study[43] set in 1985, and the dietary ADI level of 1mg/kg bodyweight is based on a 1993 Cheminova study and was set in 2006.[44] [45]

39. The CFI does not consider the co-occurrence of other herbicides that are either co-formulated, applied over the growing season or tank mixed to combat herbicide resistance.

    39.1. GBH ingredients are not disclosed, but increase toxicity and include heavy metals.[46] [47]

    39.2. Co-formulation adjuvant ingredients and additives represent an environmental risk.[48]

    39.3. Co-applied herbicides constitute a major environmental pollutant pressure.

    39.4. On New Zealand roadsides, a GBH formulation will be used as a tank mix, and/or rotated in a spray programme with (E.g.) herbicides metsulfuron, terbuthylazine and triclopyr.[49] Of these metsulfuron (or metsulfuron-methyl) are widely used in addition with glyphosate, but not included in groundwater surveys. Terbuthylazine used across many sectors and is a commonly detected herbicide in New Zealand groundwater.[50]

    39.5. In forestry, herbicides are used extensively in the establishment of planted forests. At least three herbicide applications are applied in the first two or three years.[51] Common herbicides terbuthylazine, glyphosate, hexazinone (banned EU), clopyralid, metsulfuron, triclopyr and picloram.[52] [53] The New Zealand Groundwater Survey reveals terbuthylazine and hexazinone are groundwater pollutants throughout New Zealand and picloram has been detected alongside glyphosate in Otago. Other common forestry herbicides include clopyralid and metsulfuron (or metsulfuron-methyl).

    39.6. Common herbicides used in cropping include glyphosate, diflufenican, fluroxypyr, MCPA, chlorsulfuron, halauxifen, pinoxaden, iodosulfuron, flufenacet, mecoprop and clopyralid.[54]

Herbicide Resistance

1. This CFI has excluded the increasing problem of herbicide resistance.

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[43] Bio/Dynamics Inc. (1981a) A lifetime feeding study of glyphosate (Roundup technical) in rats. Unpublished report prepared by Bio/Dynamics Inc., Division of Biology and Safety Evaluation, East Millstone, NJ. Submitted to WHO by Monsanto Ltd. (Project No. 410/77; BDN-77-416).
[44] Atkinson, C., Strutt, A.V., Henderson, W., Finch, J. & Hudson, P. (1993b) Glyphosate: 104 week combined chronic feeding/oncogenicity study in rats with 52 week interim kill (results after 104 weeks.). Unpublished report No. 7867, IRI project No. 438623, dated 7 April 1993, from Inveresk Research International, Tranent, Scotland. Submitted to WHO by Cheminova A/S, Lemvig, Denmark.
[45] Glyphosate. Joint FAO-WHO Meeting on Pesticide Residues. Pesticide residues in food – 2004: Part II toxicological evaluations. Report No. WHO/ PCS/06.1. Geneva. ISBN 978 92 4 166520 9. WHO published 2006
http://apps.who.int/iris/bitstream/10665/43624/1/9241665203_eng.pdf p. 160
[46] Mesnage, R., & Antoniou, M. (2018). Ignoring Adjuvant Toxicity Falsifies the Safety Profile of Commercial Pesticides. Frontiers in Public Health, 361.
[47] Defarge et al 2018. Toxicity of formulants and heavy metals in glyphosate-based herbicides. Toxicology Reports, 156-163.
[48] Chen et al. 2018. Are organosilicon surfactants safe for bees or humans? Science of the Total Environment, 612, 415-421.
[49] Cawthron Institute 2018. Potential Ecological Effects of Herbicide use on State Highway 6, Nelson.
[50] Close & Humphries 2019. National Survey of Pesticides and Emerging Organic Contaminants (EOCs) in Groundwater 2018. CSC19016 Institute of Environmental Science and Research Limited
[51] Saunders 2017 The economic costs of weeds on productive land in New Zealand. International Journal of Agricultural Sustainability, 15:4, 380-392, DOI: 10.1080/14735903.2017.1334179 p.385
[52] Baillie 2016. Herbicide concentrations in waterways following aerial application in a steepland planted forest in New Zealand. New Zealand Journal of Forestry Science (2016) 46:16 DOI 10.1186/s40490-016-0072-0
[53] Rolando et al 2013. A survey of herbicide use and a review of environmental fate in New Zealand planted forests. New Zealand Journal of Forestry 43.
[54] Ngow et al 2020. A herbicide resistance risk assessment for weeds in wheat and barley crops in New Zealand. PLoSONE15(6): e0234771.https://doi.org/10.1371/journal.pone.0234771

1.1. GBHs are high-risk herbicide for resistance (along with flumetsulam, atrazine, and pinoxaden. Whereas MCPA, paraquat (banned Europe) and isoproturon (banned Europe) are medium risk for herbicide resistance. [55] While recent papers have been somewhat reticent in clarifying the full extent of glyphosate resistance[56] [57] [58], New Zealand's glyphosate resistance problem may mirror Australia's resistance problem seen here:

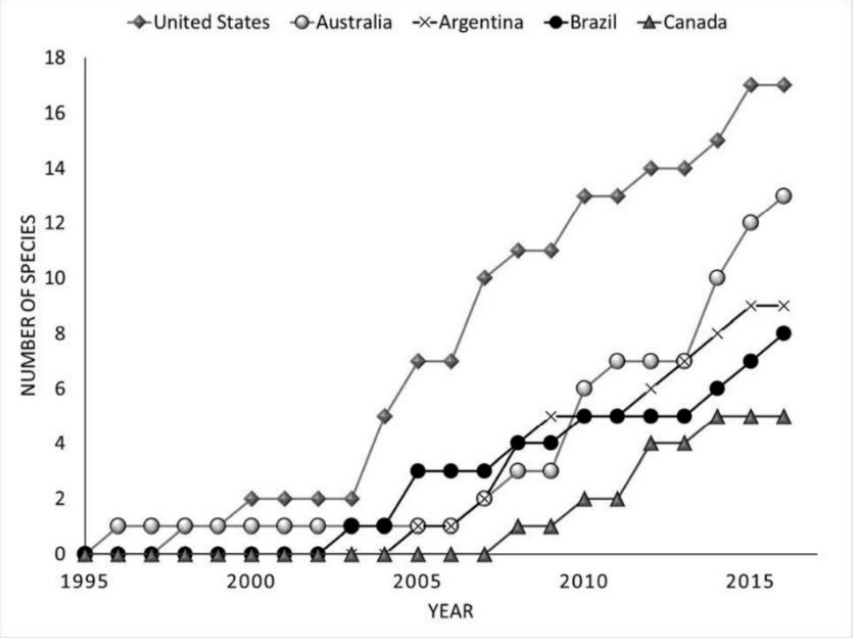

Figure 3. Chronological increase in glyphosate-resistant weed species for the five countries with the largest number of glyhosate-resistant weed species. Data from www.weedscience.org, last accessed April 20th 2017.

1.2. An enormous amount of uncertainty revolves around understanding the mechanisms of herbicide resistance. Herbicide development is often uncertain as enormously complex metabolic responses and pathways are involved.[59] [60]

1.3. Chemicals recommended for use in resistance management are often banned in the EU, often because of their persistence in the environment. However, no coordinated screening program to monitor herbicide persistence, bioaccumulation *and* impact in the environment is maintained.

[55] Ngow et al 2020. A herbicide resistance risk assessment for weeds in wheat and barley crops in New Zealand
[56] Ghanizadeh and Harrington 2019. Weed Management in New Zealand Pastures. Agronomy. 9:448
[57] Buddenhagen et al 2019. Costs and risks associated with surveying the extent of herbicide resistance in New Zealand.
[58] Ghanizadeh & Harrington 2021. Herbicide resistant weeds in New Zealand: state of knowledge. New Zealand Journal of Agricultural Research. DOI: 10.1080/00288233.2019.1705863
[59] Comont et al 2021. Evolution of generalist resistance to herbicide mixtures reveals a trade-off in resistance management. Nature communications 11:3086
[60] Li et al 2022. Herbicide promotes the conjugative transfer of multi-resistance genes by facilitating cellular contact and plasmid transfer. Journal of Environmental Sciences. 115:363-373

1.4. AgResearch scientists were recently surprised to find that instead of 5% of farms having herbicide resistant weeds, over 50% of farms tested, 54 out of 87 had herbicide resistance in weeds.[61] However papers are yet to clarify the extent of glyphosate-specific resistance.

2. Herbicide resistance is likely under-reported.

2.1. The FAR[62] recommends rotation of herbicides with differing modes of action to conventional herbicides such as glyphosate. Recommendations include propyzamide, pinoxaden, fenoxaprop-P-ethyl, flamprop-M-isopropyl (not approved EU).

2.2. FAR notes other herbicides for which resistance is shown - pinoxaden, haloxyfop (not approved EU), pyroxsulam, clodinafop, fenoxaprop (not approved EU), iodosulfuron, chlorsulfuron (not approved EU).

2.3. The FAR have discussed Australia's 'double knock' approach, where glyphosate is followed by the toxic pesticide paraquat (not approved EU).

3. Without the NZEPA recognising the pollution pressure driven by the use of tank mixing 'cocktails' of herbicides with different MOAs in order to combat herbicide resistance, an increasing range of gaps, or deficiencies will appear in government strategy:

3.1. Knowledge gaps are significant as herbicides are not tested in groundwater.

3.2. Of the herbicides listed by the FAR, propyzamide, pinoxaden, fenoxaprop-P-ethyl, fenoxaprop, flamprop-M-isopropyl, haloxyfop, pyroxsulam, clodinafop, iodosulfuron, chlorsulfuron, and paraquat are not tested for in New Zealand's groundwater survey.[63]

3.3. Herbicides that are likely to develop resistance, such as paraquat (EU banned) flumetsulam and pinoxaden, are not tested in the groundwater survey. Whereas atrazine is, and it is a problem in our groundwater.

3.4. The groundwater survey is not responsible for assessing the cumulative toxicity of persistent herbicides (such as the toxicity of the triazine class) in regional groundwater systems (water basins); nor conducting research into off-target effects, e.g., pollution of rural drinking water.

4. Gaps appear in drinking water stewardship.

4.1. Despite frequent environment use, maximum acceptable values (MAVs) are not set for these chemicals, to require them to be tested for in New Zealand drinking water. These chemicals are not mentioned in the Drinking Water Standards New Zealand, nor in the World Health Organisation Guidelines: propyzamide, pinoxaden, fenoxaprop-P-ethyl, fenoxaprop, flamprop-M-isopropyl, haloxyfop; pyroxsulam, clodinafop, iodosulfuron, chlorsulfuron, and paraquat.[64]

4.2. Therefore, there are no maximum acceptable values established for any of these herbicides, nor are they required to be screened.

4.3. The potential for endocrine disrupting mixtures in drinking water will be under-recognised.

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[61] Rennie. Weeding out herbicide resistance. Farmers Weekly August 16, 2021.
[62] Foundation for Arable Research. Integrated Weed Management Workshop, 22 July 2021 Ashburton.
[63] Close & Humphries 2019. National Survey of Pesticides and Emerging Organic Contaminants (EOCs) in Groundwater 2018. CSC19016 Institute of Environmental Science and Research Limited.
[64] Ministry of Health 2018. Volume 3 Datasheets. Part 2.3. Chemical and physical determinands: Pesticides.

4.4. Toxicity in New Zealand's environment will go under-recognised.

5. With glyphosate the tip of an iceberg, other alternative but highly toxic herbicides (such as paraquat) will be considered reasonable options for substitution.

6. Substances which are more prevalent in the environment such as glyphosate are not prioritised by the NZEPA.[65]

7. Issues particular to GBHs remain unaddressed:

   7.1. Glyphosate and metabolite AMPA persists and bioaccumulates in soil.[66] [67] [68]

   7.2. Higher strength 600g/L products not approved in safer jurisdictions (e.g. Europe) will continue to be released. While presumed to be tank mixed to appropriate active ingredient mix rates, higher active ingredient rates are highly possible (a situation of under-regulation).

   7.3. Low-dose glyphosate and GBH formulations may actually stimulate weed growth, due to a hormetic effect resulting in increased weed growth.[69]

   7.4. Phosphorous will increase nutrient runoff to increase pressures in aquatic systems.[70] This can result in glyphosate degrading more slowly, in lower phosphate environments aquatic plants and biota may scavenge phosphate).

8. Without recognising herbicide resistance as a driver of increased pesticide emissions, scientific research is unlikely to be funded to explore:

9. The potential for innovative non-chemical technologies to be developed.[71] [72]

10. Differential effects in warmer and cooler climates, and in different soil types.

11. Cocktail effects on soil and water microbiota and disruption to root-nutrient physiology.[73] [74] [75]

12. Toxic cocktail effects on aquatic ecosystems.[76]

13. Toxic cocktail effects as food contaminants.

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[65] NZEPA 2018. Flexible Reassessment Categorisation Screening Tool (FRCaST) support notes https://www.epa.govt.nz/assets/Uploads/Documents/Hazardous-Substances/Reassessments-programme/4fd22c5836/FRCaST-Tool-Notes.pdf

[66] EFSA 2015. Conclusion on the peer review of the pesticide risk assessment of the active substance glyphosate. 13(11):4302. https://doi.org/10.2903/j.efsa.2015.4302

[67] Da Silva et al 2021. Pesticides in a case study on no-tillage farming systems and surrounding forest patches in Brazil. Nature 11:9839 DOI: 10.1038/s41598-021-88779-3

[68] Tang et al 2019. Microcosm experiments and kinetic modeling of glyphosate biodegradation in soils and sediments. Science of the Total Environment. 658:105-115

[69] Brito et al 2018. Hormetic effects of glyphosate on plants. PestManagSci 74:1064–1070

[70] Hébert et al 2019. The overlooked impact of rising glyphosate use on phosphorus loading in agricultural watersheds.

[71] Eg. the LSM 740, by Dücker. https://www.youtube.com/watch?v=7-pXAv0W2-I

[72] Eg. Roller crimper development

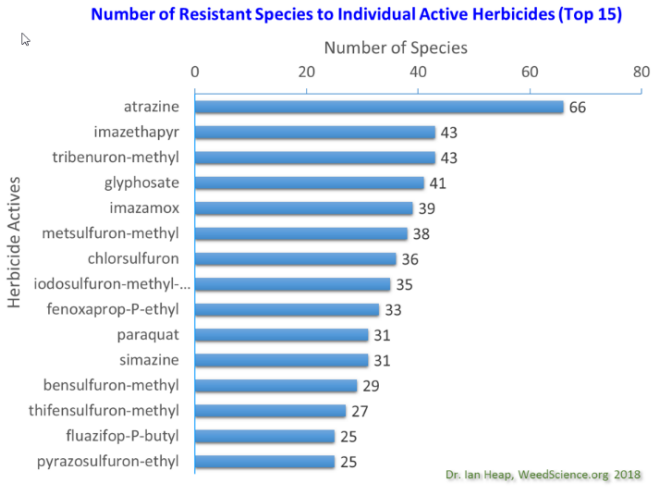
[73] Martinez et al 2018. Impacts of glyphosate-based herbicides on disease resistance and health of crops: a review. Environ Sci Eur 30:2

[74] Kumar et al 2021. Biodiversity of pesticides degrading microbial communities and their environmental impact. Biocatalysis and Agricultural Biotechnology. 31:101883

[75] Cesco et al 2021. The hidden effects of agrochemicals on plant metabolism and root-associated microorganisms. bioRxiv

[76] Sonithiphand et al 2019. Biodiversity of pesticides degrading microbial communities and their environmental impact. Environmental Science and Pollution Research 26:26765-26781

14. Bioaccumulation and soil damage, such as the impact on soil microbiota and the potential to interfere with soil fertility and nutrient take-up by crops and animal systems. [77] [78] [79] [80] [81]



[C] Yes there is new information – but there's a $1000 fee

15. Risk assessment can be triggered when there is new information on risk of a substance and a formal application is lodged under Section 62 of the HSNO Act . However the fee for this is now $1000.

16. The NZEPA's assertion that no new information has been identified is based around the logic that no-one has paid $1000 to ask that the committee consider whether there are grounds for reassessment.[82]

17. The current charge of $1000 is required for the committee to convene to *even decide* if there is new information to consider having a risk assessment. This has a chilling effect on requests that new information is considered. Most civil society groups lack such discretionary funding.

18. We note former MP Catherine Delahunty's experience in paying the fee for triclosan, followed by the NZEPA demanding Delahunty paid for 50% of the cost of risk assessment.

19. Many people have requested glyphosate is reassessed, including health scientists with extensive experience in cancer and epidemiology.[83]

20. However, because the $1000 fee has not been paid for a formal evaluation, and because the chief executive of the NZEPA[84] has not requested that the Authority decides whether there are grounds for

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[77] Rodriguez et al 2020. Omics Approaches to Pesticide Biodegradation. Current Microbiology 77:545-563
[78] Vasileiadis et al 2018. Blame It on the Metabolite: 3,5-Dichloroaniline Rather than the Parent Compound Is Responsible for the Decreasing Diversity and Function of Soil Microorganisms. Applied Environ. Microbiol. 84:22
[79] Karas et al 2018. Assessment of the impact of three pesticides on microbial dynamics and functions in a lab-to-field experimental approach. Science of the Total Environment. 637-638.
[80] Singh et al 2020.Pesticides in Crop Production: Physiological and Biochemical Action. Ch.6 Microbiome as Sensitive Markers for Risk Assessment of Pesticides. Online ISBN: 9781119432241
[81] Feld et al 2014. Pesticide Side Effects in an Agricultural Soil Ecosystem as Measured by amoA Expression Quantification and Bacterial Diversity Changes. PLOS ONE DOI:10.1371/journal.pone.0126080
[82] https://www.epa.govt.nz/applications-and-permits/fees-and-charges/
[83] Douwes, J., (2018). Carcinogenicity of glyphosate: why is New Zealand's EPA lost in the weeds? New Zealand Medical Journal, 82-89.
[84] See 62 (1) (a) & (b) https://www.legislation.govt.nz/act/public/1996/0030/latest/whole.html

reassessment (or in this case, a first ever risk assessment) - the information coming from the IARC and out of the court cases has not been considered as 'information'.

21. Section 62 does not specify that a fee must be paid.

22. New information regarding glyphosate and GBH formulation toxicity have been released:

23. New information: Released during U.S.A. court cases. Ongoing litigation confirms that farmers and applicators contracted cancer from using glyphosate.[85]

24. Transcripts from the Pilliod trial revealed that dermal exposure was understood by Monsanto to be much greater than levels of dermal exposure applied in regulatory monitoring scenarios.[86]

25. New information: The International Agency for Research on Cancer's finding that glyphosate probably causes cancer in humans, and definitely causes cancer in laboratory animals.[87]

26. New information includes the greater toxicity of the full formulation.[88] [89]

27. New information: Court decisions that decided that the 'secret' formulation ingredients hidden by commercial confidentiality agreements – should be disclosed as they are emissions – pollutants - in the environment.[90]

[D] Call for Information – a delaying tactic. E.g. Neonicotinoids

28. The CFI places unnecessary budgetary stress on NZEPA resources.

29. Risk assessments are the primary tool for understanding both the risk of a hazardous substance and the likelihood of exposure.

30. CFIs do not appear to have been widely used prior to a 2018 Call for Information on neonicotinoid insecticides.

31. Calls for Information not only delay risk assessment, but effectively push out the time taken to place controls on substances that would be protective of environmental and human health.

32. Such delay also grants time for new formulations to be approved and marketed, such as is happening in 2021, as new neonicotinoid formulations continue to be approved.

33. Consideration of usage patterns can be incorporated into risk assessment, as *risk* not only relates to the toxic characteristics of an individual substance, but to a substances' prevalence and persistence (and bioaccumulation) in the environment. Other factors contribute to the surrounding environments ecotoxicity, such as co-contaminants and nutrient levels.

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[85] Monsanto Roundup & Dicamba Trial Tracker https://usrtk.org/monsanto-roundup-trial-tracker-index/

[86] Pilliod et al. vs Monsanto Company. Reporters Transcript of Proceedings. April 11 2019. https://usrtk.org/wp-content/uploads/bsk-pdf-manager/2019/04/Trial-Transcript-Pilliod-April-11-2019.pdf

[87] IARC, 2015.International Agency for Research on Cancer. Some organophosphate insecticides and herbicides: tetrachlorvinphos, parathion, malathion, diazinon and glyphosate. Lyon, France

[88] Mesnage et al 2019. Insight into the confusion over surfactant co-formulants in glyphosate-based herbicides. Food and Chemical Toxicology. 128:137-145

[89] Mesnage et al 2021. In-depth comparative toxicogenomics of glyphosate and Roundup herbicides: histopathology, transcriptome and epigenome signatures, and DNA damage. bioRxiv. DOI: 10.1101/2021.04.12.43946

[90] General Court of the European Union. EFSA's decisions refusing access to the toxicity and carcinogenicity studies on the active substance glyphosate are annulled. Press Release No.25/19 https://curia.europa.eu/jcms/upload/docs/application/pdf/2019-03/cp190025en.pdf

34. The example of the Call for Information for neonicotinoid insecticides can help the government officials and the public understand why the current glyphosate CFI is problematic.

34.1. During August-December 2018 the NZEPA held a call for information for the three neonicotinoid insecticides clothianidin, imidacloprid and thiamethoxam. The data revealed that neonicotinoid treatments are used across hundreds of thousands of acres, in particular, on forage brassicas and grass pasture. (Use on forage brassicas and grass has never been approved in the European Union.)

34.2. If New Zealand had kept records of insecticide, herbicide, and pesticide tonnages for the FAO, this data could quickly have been accessed to assess the prevalence of neonicotinoids in New Zealand.

34.3. The NZEPA's 2018 response followed earlier European Food Safety Authority (EFSA) work considering the risk of clothianidin[91], thiamethoxam[92] and imidacloprid[93] to bees, released February 2018. The EFSA assessment determined that outdoor use was unsafe, due to the fact that the neonicotinoids were toxic to bees, persistent, and polluted surrounding environments. In May 2018 the EFSA advised that use of clothianidin[94], thiamethoxam[95] and imidacloprid[96] would be confined to greenhouses. Then following review of thiacloprid[97] the Commission proposed that thiacloprid would also not be approved. While some exemptions do exist, this act has succeeded in massively reducing the use of these insecticidal toxins widely across Europe.

34.4. Bayer appealed the restrictions in 2018. In 2021 the European Court of Justice determined the ban was reasonable. Importantly, the court found that the use of precaution in making the decision to restrict the neonicotinoids was validly used.

34.5. International data associate neonicotinoid insecticides with insect die-off and collapse globally.[98]

34.6. In New Zealand, the August 2018 CFI on neonicotinoids (clothianidin, imidacloprid and thiamethoxam) were released in September 2019.[99]

34.7. In November 2019 chief executive Allan Freeth placed a S.62 application to establish whether there were grounds for reassessment.[100] While the CFI results were briefly discussed, far more weighting was placed on international events, in particular, European Decisions.

34.8. In December 2019 the NZEPA announced that there were grounds for reassessment of clothianidin, thiamethoxam, imidacloprid, thiacloprid and acetamiprid.[101] It is notable that in the decision, the significant new information highlighted recent reports from European authorities. The 'Call for Information' had nothing to do with the decision of the committee that sufficient new information relating to the substance had become available.

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[91] EFSA 2018. Clothianidin https://doi.org/10.2903/j.efsa.2018.5177
[92] EFSA 2018. Thiamethoxam https://doi.org/10.2903/j.efsa.2018.5179;
[93] EFSA 2018. Imidacloprid https://doi.org/10.2903/j.efsa.2018.5178
[94] EFSA 2018. Clothianidin outdoor ban https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R0784&from=EN
[95] EFSA 2018. Thiamethoxam outdoor ban https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R0785&from=EN
[96] EFSA 2018. Imidacloprid outdoor ban https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R0783&from=EN
[97] EFSA 2019 Thiacloprid https://doi.org/10.2903/j.efsa.2019.5595
[98] Sánchez-Bayo, F., & Wyckhuys, K. 2019. Worldwide decline of the entomofauna: A review of its drivers. Biological Conservation, 8-27.
[99] Neonicotinoids in New Zealand Clothianidin, Imidacloprid and Thiamethoxam. September 2019. https://www.epa.govt.nz/assets/Uploads/Documents/Hazardous-Substances/Reassessments-programme/Neonicotinoids_in_NZ_Clothianidin_Imidacloprid_and_Thiamethoxam-summary.pdf
[100] https://www.epa.govt.nz/assets/FileAPI/hsno-ar/APP203949/APP203949_Final_Grounds_for_reassessment_Application_Form.pdf
[101] APP203949 https://www.epa.govt.nz/assets/FileAPI/hsno-ar/APP203949/APP203949_Final_Neonicotinoids_Decision_16-12-2019.pdf

34.9. As of August 2021, no information has been released. This is 3 years after the European outdoors ban, and the NZEPA continues to reapprove new neonicotinoid formulations.

PART 2. Direct response to the NZEPA 28 April 2021 submission paper

Part 4: Mitigation measures and controls

[4] How effective do you think these measures are in managing adverse effects that arise from using glyphosate products?

4.1 What mitigation measures do you put in place to limit environmental or human exposure to substances containing glyphosate?

1. Where PPE is the dominant mitigation measure, it is evident PPE measures are inadequate to protect farmers, horticulturalists/growers and vegetation managers from spills and dermal exposures from routine use.
2. There is no testing to assess exposures levels to local environments, neighbouring facilities and to farmers and applicators so any 'mitigation' lacks scientific foundation:
3. The Code of Practice NZS8409:2004[102] is now nearly 20 years old. It infers environmental limits will be respected. However, the NZEPA has not set, does not test for, nor enforce environmental exposure limits (EELs) or tolerable exposure limits (TELs). It would appear that the setting of EELs and TELs were initially envisaged in the HSNO Act however these intentions have been sidelined over time.

4.2 How effective are 'measures are in managing adverse effects that arise from using glyphosate products?'

4. Over the last 20 years political and economic resourcing to develop technologies to increase access to testing for councils and the general public has not been nurtured. Testing through established laboratories is expensive and understanding residue levels in roadsides and soils is scarce. Access to legal avenues to require government institutions to establish, set and enforce limits is not available.
5. Public authorities have not provided access for neighbours or bystanders dealing with contamination or spraydrift to sample human, animal, soil or vegetation for hazardous substances to prove contamination
6. Councils and institutions such as NIWA do not annually test for glyphosate, nor its metabolite AMPA in soil, water or sediments. AMPA is likely to persist in sediments but is rarely tested in sediment.
7. Glyphosate is not commonly tested for in local waters (Note: general pesticide tests (screens) do not include glyphosate in the suite of chemicals covered by the pesticide screen). Glyphosate is not a mandated pesticide to test for in New Zealand drinking water guidelines and unless councils specifically decide to test for glyphosate, the substance will not be tested for. Source water for drinking water is not normally tested.

[102] NZS 8409 (2004) (English): Management of agrichemicals [By Authority of New Zealand Environmental Protection Authority Management of Agrichemicals Code of Practice]

8. Despite New Zealand's aim for an innovative and high-technology scientific arena, bioaccumulation and chemical trespass beyond boundaries in agricultural regions and regional council regulation amounts to checking the weather conditions and looking at spray gear.

9. As there is no routine testing in New Zealand to understand how glyphosate degrades, and how its more toxic and persistent metabolite AMPA, persists in the environment there can be no response from the councils, applicators or the general public that can knowledgeably respond to this question.

4.4 Personal protective equipment (PPE)

10. The NZEPA follows pesticide industry in assuming that if PPE equipment is used according to guidelines there will be no adverse exposures.

11. However, there is substantial evidence that farmers and applicators are ordinarily exposed to pesticides including glyphosate – far more than industry and regulatory bodies assume.[103] This is because spills are common, and commonplace practices, such as taking gloves off for lunch or to answer the phone, result in exposures. (See 4.11)

4.6 Do you apply glyphosate products only when the weather conditions are favourable?

12. Assuming 'favourable conditions' are only required on the day of spraying is unscientific. As New Zealand has not carried out a relevant risk assessment there is no knowledge of how glyphosate persists in different climatic conditions and different soil types. It is rare for glyphosate to have degraded within 3 days, and the metabolite AMPA is more likely to persist from 50-200 or 300 days. [104] Yet this testing is not done in New Zealand.

4.7 Do you ever spray close to waterways, such as streams, lakes, rivers or ponds?

13. Councils commonly spray on and near water surfaces for aquatic weeds. We can see that the European Union have layers of legislation intended to prevent the pollution of water and groundwaters. However, glyphosate is commonly sprayed on water surfaces in New Zealand. Glyphosate has been detected in Otago groundwater. This is not surprising as cold, dark environments can lead to slower breakdown.

4.11 Do you believe these measures are adequate to keep people and the environment protected?

14. No. The international literature indicates GBHs are under-regulated, and that the human and environmental toxicity is underestimated by regulatory agencies.

15. No studies have been carried out to inform the public as to exposures from general handling and farmers and applicators to assess the degree to which exposures represent a threat. While New Zealand's science budget has increased significantly in recent years, funding schemes are not directed to understanding environmental pollutant pressures, nor do they carry enough flexibility for scientists to take long term research. Therefore, such work is 'drip fed' and sporadic. The NZEPA could direct scientific research to be undertaken to identify the body burdens from highly toxic and/or commonly used chemicals.

People:

[103] Boedeker et al 2020. The global distribution of acute unintentional pesticide poisoning
[104] EFSA 2015. Conclusion on the peer review of the pesticide risk assessment of the active substance glyphosate. 13(11):4302. https://doi.org/10.2903/j.efsa.2015.4302 p.56-58

16. Dermal exposure through spills and general use is common. Children of farmers and applicators often carry higher body burdens, as they become cross contaminated from frequent exposures.[105]

17. Applicators using hand-held sprayers or backpacks are much more exposed than operators in sealed tractor-cab environments. Contamination occurs through overalls, particularly to the chest, forearms and legs. Overalls can wear thin from use leading to more exposure through these pathways, and during disrobing.[106] Dermal exposures also occur through mobile phone use, from the steering wheel and from pesticide product containers. Natural face touching to the lower third of the face, the perioral region, along with hands, increases vulnerability to contamination. Protective gloves, kept in a public workspace, can be precontaminated by other workers. Reusable gloves can be much more highly contaminated than disposable gloves. [107]

18. Waterproof gloves, suitable boots and cotton overalls are recommended as personal protective equipment for the 600g/L Crucial glyphosate herbicide, that is the most highly concentrated glyphosate formulation available in the world, and intended for mixing.

19. The U.S. 'Roundup' trials have drawn attention to 'the importance of multiple exposure episodes per year, over multiple years, including a certain percentage of high-exposure episodes caused by application equipment problems, leaky hoses and valves, spills, wind, spray patterns and equipment clean-up and repair.[108]

20. Court transcripts reveal how skin epidermis acts as a reservoir, holding chemicals, which are then exuded over time, lengthening exposure time. Transcript revealed that urine testing to predict exposure to farmers excluded the greater quantities in faeces, effectively limiting estimation of farming family exposures.[109]

21. Gillezeau and colleagues noted upward trends in exposure, the higher body burdens of children, particularly in rural regions, but the paucity of studies to examine glyphosate levels in greater depth.[110] Generally exposed workers in horticulture then transport pesticides to households.[111]

22. The IARC were clear that glyphosate caused oxidative stress, while this was ignored by the NZEPA cancer review.[112] Greenhouse workers are subject to low-level ongoing exposures that commonly happen during mixing and loading and spraying which can alter hematological and biochemical parameters. [113]

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[105] Gillezeau et al 2019. The evidence of human exposure to glyphosate: a review. Environmental Health 18:2

[106] Spaan et al 2020. Performance of a Single Layer of Clothing or Gloves to Prevent Dermal Exposure to Pesticides. Annals of Work Exposures and Health. 64:3;311-330

[107] Connolly et al 2019. Evaluating Glyphosate Exposure Routes and Their Contribution to Total Body Burden: A Study Among Amenity Horticulturalists. Annals of Work Exposures and Health, 2019, Vol. 63, No. 2, 133–147

[108] Benbrook 2020. Shining a Light on Glyphosate-Based Herbicide Hazard, Exposures and Risk: Role of Non-Hodgkin Lymphoma Litigation in the USA. European Journal of Risk Regulation, 11;498–519. P.514

[109] Pilliod et al. vs Monsanto Company. Reporters Transcript of Proceedings. April 11 2019. https://usrtk.org/wp-content/uploads/bsk-pdf-manager/2019/04/Trial-Transcript-Pilliod-April-11-2019.pdf

[110] Gillezeau et al 2019. The evidence of human exposure to glyphosate: a review. Environmental Health 18:2

[111] Tamaro et al 2018. Characterization of Organophosphate Pesticides in Urine and Home Environment Dust in an Agricultural Community. 23:2;174-187

[112] Douwes, J., 't Mannetje, A., McLean, D., Pearce, N., Woodward, A., & Potter, J. (2018). Carcinogenicity of glyphosate: why is New Zealand's EPA lost in the weeds? New Zealand Medical Journal, 82-89.

[113] García-García et al 2016. Occupational pesticide exposure and adverse health effects at the clinical, hematological and biochemical level. Life Sciences 145:274-283

23. Farmworkers In a recent 2019 study of 'amenity horticulturalists' such as applicators working for councils involved in park and roadside spraying, it was more common for participants to have detectable residues – as a body burden, than to not have detectable residues.[114]

24. Regulators appear to under-value the degree of exposure applicators and farmers have to herbicides. Benbrook has noted that regulators have traditionally not considered dermal exposure endpoints, and have not required studies looking at this pathway of exposure, noting 'the uncertainty embedded in current GBH applicator dermal exposure estimates is a striking example of how both the public and private sectors have failed to produce credible, real-world exposure and risk estimates.'[115]

25. Global reporting under-emphasises the problem of acute poisoning that is non-fatal, but harmful to health. A recent paper estimated there are 385 million cases of poisoning from pesticides per year, of which 11,000 are fatal.[116] The resulting health burden has received little attention.

26. These regulatory gaps became evident in the Roundup trials. For example, while the U.S. Environmental Protection Agency (USEPA) had assumed a 'default' dermal absorption value of 3%, based on studies from the 1980's, the Roundup trials revealed that the additive surfactants increased absorption above 3%, that the company knew this, but that this data was not supplied to regulators.

27. Surfactants and other additives and ingredients in herbicide formulations, such as cadmium,[117] increase the potential toxicity of the formulation. These co-ingredients are a 'black hole' in pesticide toxicology often kept secret, and never measured in the environment.[118] [119]

28. The IARC placed considerable weight on exposure through dermal absorption and the potential for the formulation to be toxic, whereas the USEPA considered diet as the predominant route and focussed on the single chemical glyphosate.

29. Antibiotic resistance is recognised as a catastrophic threat to human health. Considerable data points to the potential for pesticides, including herbicides to speed antibiotic resistance in soil and water.[120] [121] [122] [123] Wastewater and sewage sludge in addition to herbicides exacerbate this risk. [124] [125] [126] [127] These off-target effect deserves much more scientific attention that it currently receives.

Environment:

[114] Connolly et al 2019. Evaluating Glyphosate Exposure Routes and Their Contribution to Total Body Burden: A Study Among Amenity Horticulturalists. Annals of Work Exposures and Health, 2019, Vol. 63, No. 2, 133–147
[115] Benbrook 2020. Shining a Light on Glyphosate-Based Herbicide Hazard, Exposures and Risk. P.517-518
[116] Boedeker et al 2020. The global distribution of acute unintentional pesticide poisoning
[117] Defarge et al 2018. Toxicity of formulants and heavy metals in glyphosate-based herbicides. Toxicology Reports, 156-163
[118] Valle et al 2019. Glyphosate detection: methods, needs and challenges. Environmental Chemistry Letters 17:291–317
[119] Mesnage et al 2017 Insight into the Confusion over Surfactant Co-Formulants in Glyphosate-Based Herbicides.
[120] Liao et al. 2021Herbicide Selection Promotes Antibiotic Resistance in Soil Microbiomes
[121] Jun et al. 2019. Effects of sub-lethal concentrations of copper ammonium acetate, pyrethrins and atrazine on the response of Escherichia coli to antibiotics. F1000Research, 8.
[122] Kurenbach et al 2018. Agrichemicals and antibiotics in combination increase antibiotic resistance evolution. PeerJ 6:e5801; DOI 10.7717/peerj.5801
[123] Zhang et al 2020 Glyphosate escalates horizontal transfer of conjugative plasmid harboring antibiotic resistance genes. Bioengineered. 12:1:63-69
[124] Mandal et al. 2019. Bacterial Adaptation to Co-resistance. Springer. DOI 10.1007/978-981-13-8503-2
[125] Sorinolu et al 2020. Antibiotic resistance development and human health risks during wastewater reuse and biosolids application in agriculture. Chemosphere. 129032
[126] Piña et al 2020 On the contribution of reclaimed wastewater irrigation to the potential exposure of humans to antibiotics, antibiotic resistant bacteria and antibiotic resistance genes – NEREUS COST Action ES1403 position paper. JECE 8:102131
[127] Law et al 2021. Biosolids as a Source of Antibiotic Resistance Plasmids for Commensal and Pathogenic Bacteria. Front. Microbiol. 12:606409. doi: 10.3389/fmicb.2021.606409

30. Pesticide mixtures bioaccumulate and contaminate soil at rates that damage soil function, but that also leach into surrounding environments. Soil contamination results in unintended effects on non-target organisms, reducing microbiota by impairing the rhizosphere invertebrate, fungal and bacterial communities, and reduces the efficiency of nitrogen fixing rhizobic bacteria. [128] [129]

31. Pesticides interact with other stressors, such as climatic conditions to increase organism vulnerability[130] [131], and pesticide use is a recognised driver of insect decline.[132]

32. The New Zealand environment is unable to be protected as glyphosate is sprayed widely, there is no scientific research being undertaken to connect the toxic risk of the retail formulations and their undeclared co-formulants,[133] nor to assess the pressure from heavy metals such as cadmium and lead[134], that are contained in pesticide formulations. No apparent local work is being carried out to estimate the toxicity of current mixtures applied to counteract increasing herbicide resistance, and the body burdens and stress on endemic populations of koura, tuna and other fish.

33. Pesticide contamination of soil is a global problem '64% of global agricultural land (approximately 24.5 million km2) is at risk of pesticide pollution by more than one active ingredient, and 31% is at high risk. Among the high-risk areas, about 34% are in high-biodiversity regions, 5% in water-scarce areas and 19% in low- and lower-middle-income nations'.[135] [136] [137] [138]

34. However, only a handful of studies confirm that New Zealand's environment is contaminated with cocktails of plant protection products, or pesticides. Work taken to understand commonly used rotations or tank mixes of pesticides is scarce, for a nation reliant on agriculture. New Zealand soils are not homogenous, pesticides react differently in different soils, there is no single degradation rate. The pesticides that persist in soil, also persist in our groundwater.[139] [140] [141] [142] The absence of routine monitoring produces the ignorance required in order to prevent both political and public license for heavier regulation, but it also prevents science and innovation being directed to the development of new technologies that do not harm the environment. Our PCE has commented on the terrible state of environmental science.

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[128] Tang & Maggi 2021. Pesticide mixtures in soil: a global outlook. Letter. Environ. Res. Lett. 16:044051

[129] Nettles et al 2016 Influence of pesticide seed treatments on rhizosphere fungal and bacterial communities and leaf fungal endophyte communities in maize and soybean. Applied Soil Ecology 102:61-69

[130] Siviter et al 2021. Agrochemicals interact synergistically to increase bee mortality. Nature 596389-392

[131] Baier et al. 2016. Non-target effects of a glyphosate-based herbicide on Common toad larvae (Bufo bufo, Amphibia) and associated algae are altered by temperature. PeerJ 4:e2641. doi: 10.7717/peerj.2641

[132] Sánchez-Bayo, F., & Wyckhuys, K. (2019). Worldwide decline of the entomofauna: A review of its drivers. Biological Conservation, 8-27.

[133] Mesnage, R., Defarge, N., de Vendômois, J., & Séralini, G. (2014). Major Pesticides Are More Toxic to Human Cells Than Their Declared Active Principles. Biomed Res Int, Article ID 179691.

[134] Defarge, N., de Vendômois, J., & Séralini, G. (2018). Toxicity of formulants and heavy metals in glyphosate-based herbicides. Toxicology Reports, 156-163.

[135] Tang et al 2021. Risk of pesticide pollution at the global scale. Nature Geoscience 14:206-210

[136] Hough 2021. A world view of pesticides. Nature Geoscience 14:183-4

[137] Silva et al 2019. Pesticide residues in European agricultural soils – A hidden reality unfolded. Science of The Total Environment. 653:1532-1545

[138] Prasad 2020. Agrochemicals Detection, Treatment and Remediation https://doi.org/10.1016/C2018-0-02947-3

[139] Sarmah et al 2009 Dissipation and sorption of six commonly used pesticides in two contrasting soils of New Zealand. Journal of Environmental Science and Health Part B, 44:4, 325-336

[140] Close & Humphries 2019. National Survey of Pesticides and Emerging Organic Contaminants (EOCs) in Groundwater 2018. CSC19016 Institute of Environmental Science and Research Limited

[141] Hageman et al 2019. Current- Use Pesticides in New Zealand Streams: Comparing Results from Grab Samples and Three Types of Passive Samplers. Environmental Pollution, 254, 112973. https://doi.org/10.1016/j.envpol.2019.112973

[142] Pook & Gritcan 2019 Validation and application of a modified QuEChERS method for extracting neonicotinoid residues from New Zealand maize field soil reveals their persistence at nominally hazardous concentrations. Environmental Pollution. 255:1;113075

35. The absence of science means that the latest science cannot be adopted. For example, crustacean molting appears affected via endocrine disruption, but without integrating new omics technologies these effects may be difficult to identify.[143]

Part 5: Impacts on Māori

5.1 / 5.2

1. We have previously discussed the long-standing exclusion of synthetic chemicals in 10 years of freshwater policy and the failure of the Crown to provide sufficient scientific resourcing to assert rangatiratanga and kaitiakitanga.[144]
2. This absence of scientific resourcing has produced the conditions of 'no evidence', where despite synthetic pesticides sales of $350 million annually, 45% of which are herbicides[145], no institution has a mandate to undertake ongoing and comprehensive research to ensure the obligations of the Treaty of Waitangi are upheld.
3. The failure of the NZEPA and the Ministry for the Environment (the Ministry with oversight of the NZEPA) to monitor and assess synthetic chemical pressures on soil organisms, fresh and marine water and aquatic organisms – to recognise pollution - represents an ongoing malfunction in the trust relationship between Māori and the Crown. Scientists require secure long-term funding to undertake this work, and it is presently not available in Aotearoa.[146]
4. Both NZEPA and MfE should have called for monitoring of endemic taonga species to ensure access to customary fishing and traditional riverside food gathering was not impaired by synthetic pesticides.
5. Roadside spraying and the persistence of sprayed pesticides removes capability for Māori to safely forage in public spaces.
6. High fat taonga species such as tuna may be particularly vulnerable. Toxic chemicals often accumulate in body fat.

Part 6: Technical information

1. Regulatory risk assessment is increasingly controversial as it prioritises industry data over newer data revealing harm at environmentally relevant levels. The data that continues to be relied on to establish safe levels of exposure, is old, private and outdated.
2. **Case study: Current technical approaches fail to protect New Zealand drinking water.** The 2018 Drinking Water Standards for New Zealand (DWSNZ), consider a range of data drawn from regulatory assessment around the world. WHO data does not look at recent published and peer reviewed literature.[147]

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[143] Zou 2020. Invisible endocrine disruption and its mechanisms: A current review. General and Comparative Endocrinology. 293:113470
[144] The Soil & Health Association and PSGR. 2019 Aotearoa/New Zealand Policy Proposals on healthy waterways: Are they fit for purpose. ISBN 978-0-473-50130-3 p
[145] Buddenhagen et al 2019. Costs and risks associated with surveying the extent of herbicide resistance in New Zealand. New Zealand Journal of Agricultural Research, DOI: 10.1080/00288233.2019.1636829
[146] PSGR 2021. Submission Inquiry on the Natural and Built Environments Bill: Parliamentary Paper. https://www.parliament.nz/resource/en-NZ/53SCEN_EVI_111944_EN5726/8198a3a6ee8b84a7a3280403dff3dace72ef2d50
[147] Ministry of Health 2018. Volume 3 Datasheets. Part 2.3. Chemical and physical determinands: Pesticides

3. The primary document that the 2018 DWSNZ relied on to assert that there is no need for a guideline value in drinking water is the World Health Organisation (WHO) 2017 drinking water guidelines. [148] However, the WHO, in 2017, continue to rely on a 1981 Monsanto study, which identified harm at the 32 mg/kg level of exposure that was then declared 'safe' or the no observable effect level,[149] to set the so-called safe level of 0.3mg/kg claim that 'establishment of a formal guideline value for glyphosate and AMPA is not deemed necessary'.[150] The WHO assert a 0.9mg/L (900 µg/L) health based value based on a 60-kg adult consuming 2 litres of drinking-water per day, and allocating 10% of the ADI to drinking-water.

4. This analysis establishes a false sense of security for health authorities. It excludes risk to vulnerable groups, for example the realistic scenario that a 14kg toddler could consume one litre per day.

5. **Endocrine disruption gap.** The current process of testing for endocrine disrupting chemicals (EDCs) is 'dangerously slow and inefficient'[151] and insensitive, it does not reflect real life exposure risk[152] [153] nor risk to vulnerable populations.[154]

    5.1. For example, the New Zealand drinking water analysis of glyphosate relies on the 2017 European Union study to dismiss endocrine effects to oestrogen/ androgen/ thyroid/ steroidogenesis signalling pathways (EATS).

    5.2. Regulatory parameters for endocrine disruption have not kept up with new science. Since the development of the EATS framework around 2013, the range of hormone signalling non-EATs pathways can be evaluated for risk have extended.[155]

    5.3. New Zealand has no centre of excellence, nor scientific research group tasked with researching pollutants and endocrine disruption, and so it is unlikely that the DWSNZ reference group could delve deeply into drinking water contamination by EDCs.

    5.4. These protocols are replicated across a wide range of toxic pesticides where peer reviewed studies, kept out of assessment as applicants do not provide them - demonstrate harmful at environmentally relevant levels (rather than the high levels tested in isolated laboratory conditions).

    5.5. At this stage, the European standard of 0.1 µg/L (.0001mg/L) for any one substance, and maximum concentration of the total sum of all pesticides present (including metabolites) of 0.5 µg/L (0.0005), can be considered the safest drinking water standards that should be adopted by New Zealand.

6. **Industry controls the data.** This is because firstly, the primary data that is considered by regulators to be the 'authoritative' data in risk assessment, is selected and supplied by the industries concerned with approval of the substance under assessment. Omission of published peer reviewed studies, via use of the

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[148] WHO 2017 Guidelines for Drinking Water Quality. Fourth Edition. P.374

[149] WHO 2005. Glyphosate and AMPA in Drinking-water WHO/SDE/WSH/03.04/97. Bio/Dynamics Inc. (1981a) A lifetime feeding study of glyphosate (Roundup technical) in rats. Unpublished report prepared by Bio/Dynamics Inc., Division of Biology and Safety Evaluation, East Millstone, NJ. Submitted to WHO by Monsanto Ltd. (Project No. 410/77; BDN-77-416).

[150] WHO 2005. Glyphosate and AMPA in Drinking-water WHO/SDE/WSH/03.04/97. P.9

[151] Kassotis et al 2020. Endocrine-disrupting chemicals: economic, regulatory, and policy implications. The Lancet 8:719-730

[152] Margina et al 2019. Overview of the effects of chemical mixtures with endocrine disrupting activity in the context of real-life risk simulation (RLRS): An integrative approach (Review). World Academy of Sciences Journal 1:157-164

[153] Solecki et al 2017. Scientific principles for the identification of endocrine-disrupting chemicals: a consensus statement. Arch.Toxicol. 91:1001-1006

[154] Demeneix and Slama 2019. Endocrine Disruptors: from Scientific Evidence to Human Health Protection. Study commissioned by the PETI Committee of the European Parliament,

[155] Martyniuk, et al 2021. Emerging concepts and opportunities for endocrine disruptor screening of the non-EATS modalities, Environmental Research. doi: https://doi.org/10.1016/j.envres.2021.111904.

industry developed Klimisch approach which maintains that the most reliable studies would follow test guidelines and good laboratory principles. This has been found to introduce a bias which favours industry data[156], while leading to the down-weighting and exclusion of peer reviewed literature, which often integrates modern technologies that are more sensitive and more likely to detect harm from a substance.

7. **Protocols lead to the downgrading of peer-reviewed studies.** It seems that mostly, the methodologies used in Europe have been developed or promoted by industry, and insufficient attention has been paid to the structure of the development process of the OECD methodologies. Study trials are not pre-registered, and industry has capability to select studies that reveal their chemical in a positive light. Each active ingredient is considered in isolation, despite the fact that pesticides such as glyphosate are marketed as a formulation, and adjuvant ingredients increase toxicity. Occupational exposures are under-estimated. Humans are commonly exposed to other co-contaminants, such as low levels of fungicides and insecticides in food. Insufficient attention is paid to vulnerable populations, such as pregnant women, infants and children.[157]

8. **Dismissal of problematic data.** Regulatory science can exclude or downplay problematic data,[158] [159] and also value outdated or inadequate science while excluding peer reviewed and published studies.[160] [161] This practice consists of dismissing and downplaying adverse effects in the control group, often by claiming the observed changes fall within historic controls. Bruning and Browning cited a glyphosate study which dismissed tumors in salivary glands. The same study went on to declare the safe level of acceptable daily intake for glyphosate.[162] [163] Yet 'remarkable' changes in salivary glands have occurred when rodents were dosed at levels lower than WHO-FAO studies.[164]

9. Benbrook and colleagues propose four solutions[165] to deepen scientific knowledge and improve trust in risk assessment: End near-sole reliance on industry supported studies; place more weight on mechanistic data and low-dose studies; Increase funding for human biomonitoring, particularly of vulnerable populations; Integrate high- throughput technologies which can identify multiple biomarkers and identify metabolic dysregulation (metabolomics has been used in clinical medicine for over a decade).

10. The NZEPA may refer to the outcome of the European assessment which is currently in process. The process was set in place when the 'applicant', the Glyphosate Renewal Group formally applied to renew the approval, and in 2020, submitted a dossier of scientific studies. This dossier was assessed by the European Assessment Group on Glyphosate, and in June 2021 passed to the European Food Safety Authority (EFSA) as an RAR – a renewal assessment report, while a proposal for classification and

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[156] Kaltenhäuser et al 2017. Relevance and Reliability of Experimental Data in Human Health Risk Assessment of Pesticides. Regulatory Toxicology and Pharmacology. 88:227-237

[157] Robinson et al 2020. Achieving a High Level of Protection from Pesticides in Europe.

[158] Douwes, J., (2018). Carcinogenicity of glyphosate: why is New Zealand's EPA lost in the weeds? New Zealand Medical Journal, 82-89.

[159] Portier 2020. A comprehensive analysis of the animal carcinogenicity data for glyphosate from chronic exposure rodent carcinogenicity studies. Environmental Health 19:18

[160] Burtscher Schaden et al 2017. Glyphosate and cancer: Buying science. White paper. GLOBAL 2000, Vienna.

[161] Nersesyan & Knasmueller 2021 Evaluation of the scientific quality of studies concerning genotoxic properties of glyphosate https://usrtk.org/wp-content/uploads/2021/06/Comments-concening-GLY_25.03.21-with-signatures-1.pdf

[162] Bruning J., Browning S 2017. Public Health Concern: Why did the NZ EPA ignore the world authority on cancer? ., Green Party of Aotearoa New Zealand.

[163] Glyphosate. Joint FAO-WHO Meeting on Pesticide Residues. Pesticide residues in food – 2004: Part II toxicological evaluations. Report No. WHO/ PCS/06.1. Geneva. ISBN 978 92 4 166520 9. WHO published 2006 http://apps.who.int/iris/bitstream/10665/43624/1/9241665203_eng.pdf p.128-129 and p157-160

[164] Ahmed et al 2018. Histopathological changes in the tongue, palate and parotid gland after exposure to glyphosate. AADJ 1:1:17-22.

[165] Benbrook et al 2021. Commentary: Novel strategies and new tools to curtail the health effects of pesticides. Environmental Health volume 20: 87 2021

labelling was sent to the European Chemicals Authority (ECHA). A draft report has been released and public consultations in the European Union will commence in September.[166] [167]

11. Europe moves quickly to ban toxic chemicals than Anglo nations. USA, New Zealand and Australian regulators apply a risk-based approach to analyse the likelihood of exposure with the potential effects of exposure. By contrast, the European Union legislation recognises that carcinogenic, mutagenic, toxic for reproduction, endocrine disrupting, and persistent, bioaccumulative and toxic for the environment (PBT), persistent organic pollutants are hazardous.[168] Scientists cannot expressly determine the precise level that, for example, a carcinogen or endocrine disruptor causes harm, and so the European Union acts more swiftly to ensure the population is not exposed to these chemicals.[169]

12. Europe moves more quickly than the other Anglo-nation regulators to withdraw authorisations of persistent and toxic pesticides and remove the hazard at source. Technical analyses in the EU draw clear links between health hazard and persistence and accumulation in the environment, particularly in groundwater.

13. There is no scientific feedback into the NZ regulatory system to understand environmental and human health hazard. The NZEPA does not require studies on accumulation and persistence in the New Zealand environment, nor human biomarker studies, in order to gauge health risk.

14. Due to the transparency requirements in the European Union, this assessment will be more transparent and involve more public accountability than other jurisdictions, such as the World Health Organisation and Food and Agriculture Organization Joint Meeting on Pesticides. Recent European court trials have decided that formulation ingredients, normally kept secret, should be publicly declared.

15. However, continued public skepticism concerning industry control over data will remain with the European assessment. A recent paper reviewing mutagenic and genotoxic studies submitted to regulators, found that most were not of sufficient quality required to be submitted for risk assessment. Many were outdated, either not to guidelines established by the OECD or using out of date guidelines.[170] Newer testing processes are not required and scientists have commented that new biomarker technologies may be more appropriate to detect harm from hazardous substances. The NZEPA reliance on industry data, in comparison to the IARC's more open policy, has previously been commented on by New Zealand epidemiology and cancer experts.[171]

16. Regulators have not kept pace with new knowledge relating to the biological pathways of impact by glyphosate, for example:

    1.1. Traditional biochemical and histopathological measurements may miss metabolic changes which can be picked up by high throughput omics technologies. The evidence that glyphosate formulations are much more toxic than the single active ingredient glyphosate, has now been demonstrated through epigenome (DNA methylation) profiling to cause DNA damage.[172]

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[166] EFSA Glyphosate. https://www.efsa.europa.eu/en/topics/topic/glyphosate

[167] Procedure and outcome of the draft Renewal Assessment Report on glyphosate, June 2021 https://ec.europa.eu/food/system/files/2021-06/pesticides_aas_agg_report_202106.pdf

[168] Waras et al 2020. Law and regulations to control pesticide exposure among the general population: Comparing the Australian and the European Union pesticide regulatory system. Preprints 2020120117

[169] Demeneix, B., & Slama, R. (2019). Endocrine Disruptors: from Scientific Evidence to Human Health Protection. requested by the European Parliament's Committee on Petitions. PE 608.866 - March 2019. Brussels: Policy Department for Citizens' Rights and Constitutional Affairs.

[170] Nersesyan & Knasmueller 2021 Evaluation of the scientific quality of studies concerning genotoxic properties of glyphosate

[171] Douwes, J., (2018). Carcinogenicity of glyphosate: why is New Zealand's EPA lost in the weeds? New Zealand Medical Journal, 82-89.

[172] Mesnage et al 2021. In-depth comparative toxicogenomics of glyphosate and Roundup herbicides: histopathology, transcriptome and epigenome signatures, and DNA damage

1.2. Oxidative stress: New studies continue to confirm oxidative stress as an outcome of exposures.[173] General occupational work with pesticides results in detectable levels in the body which can produce biomarkers for oxidative stress.[174]

1.3. Liver and Kidney damage[175] Including gendered risk.[176] [177]

1.4. Glyphosate induces inter-systemic effects on exposed populations which directly impact health and resilience. As an example, a recent study found that reduced antioxidative ability, disturbed liver metabolism, promoted inflammation and suppressed immunity. Effects were observed at the lowest dose of 0.2mg/kg.[178]

Part 7: Benefits and alternatives to glyphosate products

1. Technological Alternatives

2. The New Zealand government dedicates substantial budgeting to development of new genetics technologies. In contrast, funding to support non-chemical and integrated weed management practices is negligible. Currently approval is being sought for bio-control methods for at least 3 out of 6 weeds.[179] However, there are dozens of weeds that are resistant to glyphosate and the other herbicides that are commonly sprayed alongside glyphosate, including atrazine, metsulfuron-methyl, chlorsulfuron, paraquat, simazine and 2,4-D.[180] [181] Will an insect be imported for each herbicide tolerant weed species?

3. Biocontrol measures which match an imported predator to a weed, for each of the approximately dozens if weeds that are resistant to herbicides appear to be an inefficient alternative to non-chemical measures, as a 'pill for every ill' which opens a Pandora's box of unknown unknowns.[182]

4. Other technologies, such as mysterious bio-agents[183] [184] currently being tested by Dow AgroSciences remain undeclared to the public. The NZEPA acts to support commercial confidentiality, rather than ensure transparency for public purposes. There is little capacity for scientific scrutiny as the entire process is kept secret.

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[173] Milić M, Žunec S, Micek V, et al. (2018) Oxidative stress, cholinesterase activity, and DNA damage in the liver, whole blood, and plasma of Wistar rats following a 28-day exposure to glyphosate. Arh Hig Rada Toksikol 69(2):154-168 doi:10.2478/aiht-2018-69-3114

[174] Ledda et al 2021. Oxidative stress and DNA damage in agricultural workers after exposure to pesticides. Journal of Occupational Medicine and Toxicology 16:1

[175] Mesnage et al 2021. Multi-omics phenotyping of the gut-liver axis reveals metabolic perturbations from a low-dose pesticide mixture in rats. Communications Biology. https://doi.org/10.1038/s42003-021-01990-w

[176] Mesnage et al 2019. Transcriptome profile analysis reflects rat liver and kidney damage following chronic ultra-low dose Roundup exposure. Environmental Health. DOI 10.1186/s12940-015-0056-1

[177] Magueresse-Battistoni 2021. Endocrine disrupting chemicals and metabolic disorders in the liver: What if we also looked at the female side? Chemosphere. 268:129212

[178] Zheng et al 2021. Effects of chronic glyphosate exposure on antioxdative status, metabolism and immune response in tilapia (GIFT, Oreochromis niloticus). Comparative Biochemistry and Physiology, Part C. 239:108878

[179] Rennie. August 16, 2021. Project to pull bio-control levers. Farmers Weekly. P.15

[180] Heap. 2021. Number of Resistant Species to Individual Active Herbicides (Top 15) http://www.weedscience.org/Pages/Graphs/activebyspecies.aspx

[181] Heap 2021 Chronological increase in Resistant Weeds Globally. http://www.weedscience.org/Pages/ChronologicalIncrease.aspx

[182] Harms et al 2021. Climate Mismatch between Introduced Biological Control Agents and Their Invasive Host Plants: Improving Biological Control of Tropical Weeds in Temperate Regions. Insects 12:549

[183] APP204104 Decision Document https://www.epa.govt.nz/database-search/hsno-application-register/view/APP204104

[184] Official Information Act request ENQ-41522-M5H0W8

5. In addition, biocontrol technologies which use biotechnology tools including RNAi, gene-drive, CRISPR-Cas9, and PROTAC to target weed metabolism and growth arrive with an entirely new set of risk factors. In order to succeed, these technologies would alter multiple targets with different mechanisms.[185] These technologies, once deployed into the environment carry significant unknown risks, including the potential for horizontal gene transfer (inter-specific hybridization) into local species, altering or suppressing local populations.[186] Other new technologies which can potentially be deployed to target weeds includes penetration technologies, which are biological-molecule-based products that can be developed to damage DNA.[187]

6. The new gene editing techniques are techniques of genetic modification, and this has been upheld by the European Court of Justice. New Zealand legislation does not permit the release of genetically engineered, including edited, organisms to be released into the environment. New Zealand regulations do not prevent laboratory-based research where the bulk of this work is undertaken. These new technologies continue to be less precise then proponents claim, while exhibiting potential for off-target effects. [188]

7. New Zealand tends to be optimistic concerning the potential for new technologies that once emitted into the environment, carry potential risk due to application at scale.[189] While scientists are funded to develop new technologies there is no institution – no bioethics council - tasked to scientifically assess and model issues of risk, ethics, and long-term uncertainty around individual bio-control measures. Measures to document off-target effects have been poor.[190] The 2018-2019 campaign undertaken by the Royal Society Te Apārangi, demonstrated that the Society and collegial scientists employed to develop biotechnologies, which carry potential for licensing and IP benefits, were much more likely to position gene editing technologies as beneficial, rather than to outline potential risk.

8. If funded, risk modelling could compare at scale the implications of ongoing and multiple biocontrol live-organism releases for multiple weed species, versus weed management and mechanical technologies. It could consider the risk from gene drive technology, or the problem of applying gene editing technologies to develop herbicide sensitivity in weed crops and the problem of horizontal gene transfer. This work is not currently happening.

9. Integrative Alternatives

10. New Zealand is currently handicapped by short term and precarious funding for public good science that is unlikely to result in the development of techniques or technologies that carry with them potential for licensing or IP benefits. New Zealand lacks an institution with long-term funding to explore non-chemical weed management specifically for agriculture and horticulture. It is doubtful that there is support for vegetation management for local and regional councils to shift away from non-chemical regimes.

11. The economic benefit from non-chemical and integrative science occurs over the longer term, and can include the protection of groundwater, freshwater and drinking water from herbicides, however this

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[185] The role of population and quantitative genetics and modern sequencing technologies to understand evolved herbicide resistance and weed fitness. Perspective DOI 10.1002/ps.5988

[186] Kumaran et al. 2020 Gene technologies in weed management: a technical feasibility analysis. Curr Op Insect Science 38:6-14

[187] Heinemann & Walker 2019. Environmentally applied nucleic acids and proteins for purposes of engineering changes to genes and other genetic material. Biosafety and Health. http://dx.doi.org/10.1016/j.bsheal.2019.09.003

[188] Eckerstorfer et al 2021. Biosafety of Genome Editing Applications in Plant Breeding Considerations for a Focused Case-Specific Risk Assessment in the EU. BioTech 10:10. https://doi.org/10.3390/biotech10030010

[189] Heinemann et al 2021. Differentiated impacts of human interventions on nature: Scaling the conversation on regulation of gene technologies. Elem Sci Anth. 9:1

[190] Heinemann et al 2010. Evaluation of Horizontal Gene Transfer Monitoring Experiments Conducted in in New Zealand Between 2004-2009. Journal of Organic Systems, 6(1), 2010

work remains undone. There is no integrative scientific research to assess and predict combinatory effects on agricultural systems and model risk from increased pesticide pollution, climate and soil variations, drought risk and nutrient availability. Such an environment could create the conditions for innovative feedback loops and development opportunities.

12. Alongside scientific precarity, the pathways of knowledge to farmers, horticulturalists/growers, vegetation managers and TLAs to manage weeds are incoherent and poorly funded by central government. There does not appear to be funding for science nor agricultural extension services to build knowledge on chemical free management. Integrated pest management strategies often require years to assess. However this type of long term, highly practical (but less 'innovative') research falls outside most funding schemes which demand high levels of novelty and ability to publish in high ranking journals. Defunding advisory, or public extension education has removed a vital feedback mechanism for seeding agricultural innovation back in the local scientific research enterprise.[191]

13. An example of long-term work includes the Danish weed seed banks study which over 50 years has demonstrated how weeds change with intensive chemical agriculture and how seed banks then adjust with stricter chemical regulation.[192]

14. There is no funding nor scientific research for non-chemical technologies that could be rolled out through New Zealand regions, such as in-line tillage-roller crimper[193] and electricidal technologies. These technologies would be integrated with strategies such as cover cropping. Government funding to encourage new businesses and set up state owned enterprises to support the introduction and rolling out of non-chemical and integrated weed management approaches could support farmers, horticulturalists/growers and vegetation managers to transition from herbicide dependency while reducing the economic harm.

15. The Foundation for Arable Research has been restricted by funding, and has mostly operated practicably without excess capacity to engage in a paradigm changing shift.

16. Funding for independent research and extension services is critical to support transition. New Zealand agricultural media cannot apply a critical perspective, as the advertising revenue from agrichemical and vet health sales are substantial, particularly when placed on the front page of the paper.

17. Controls can be placed on annual aggregate herbicide use:

- Herbicide use can be considered as an aggregate. E.g., herbicides might only be applied twice annually, once before each growing season.

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[191] Busse et al 2018. Innovation mechanisms in German precision farming. Precision Agric 15:403-426.
[192] Andreason et al 2018. Decreasing diversity in the soil seed bank after 50 years in Danish arable fields. Agriculture, Ecosystems and the Environment. 259:61-71
[193] Navarro-Miró et al 2019. Agroecological service crops managed with roller crimper reduce weed density and weed species richness in organic vegetable systems across Europe. Agronomy for Sustainable Development 39: 5

- Banning of herbicidal applications as desiccant or dry down applications on human food and animal feed crops.
- Banning of herbicides on and near water surfaces
- Extension of time window before stock may be put on a sprayed-out field.
- Roadside and urban use of herbicides can be restricted to swab applications of perennial species.

18. Controls on aggregate herbicide use can be supported by wider policy:

19. New Zealand is proud of its status as a minimal subsidiser of agriculture.

20. We recognise the political difficulty for farmers, horticulturalists and other food producers. They are faced with constraining mortgages produced by increasing land prices (often caused by offshore pressure from international investors on prices).International commodity prices frequently exert downwards pressure on prices; and supermarket duopoly environments largely control prices paid in the domestic market. Grower co-operative environments that enable farmers to work together to set prices were largely dismantled in the 1980s. In this environment, paying for staff to manage weeds, or importing new mechanical technologies is unlikely and infeasible, if chemical alternatives are much cheaper.

21. New Zealand can develop government policies and promote education and research to assist and farmers, horticulturalists/growers and vegetation managers to transition away from chemical intensive agriculture and to prioritise scientific research to ensure long term stewardship of soil and water is integrated into agricultural scientific research, free of political interference.

22. Government funding can financially support farmers and TLAs to transition away from intensive dependence on industrial chemical agriculture, in effect, following the lead of the European Union and their environmental and Farm to Fork strategies, which aim to reduce pesticide use by 50% by 2030.

23. Suggestions: Agriculture.

- Alternatives to glyphosate, and companion herbicides, therefore require a change in agri-culture – in order to regain local and international trust in food production.
- Science and extension can assist farmers, horticulturalists/growers and vegetation managers to understand non-chemical weed control so they can identify the best alternatives to herbicides and therefore create the environment for commercial machinery suppiers to import the required machinery
- Stock rotation across cropping systems can improve weed management more effectively than use of different herbicides with different modes of action.[194]
- Mechanical technologies are advancing swiftly[195].
- Resourcing to assist farmers, horticulturalists/growers and vegetation managers manage integrated systems and manage seeding dates, forage crop rotations, timing and intensity of grazing can be provided.

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[194] MacLaren et al 2018. Livestock in diverse cropping systems improve weed management and sustain yields whilst reducing inputs. Journal of Applied Ecology. 56:144–156.

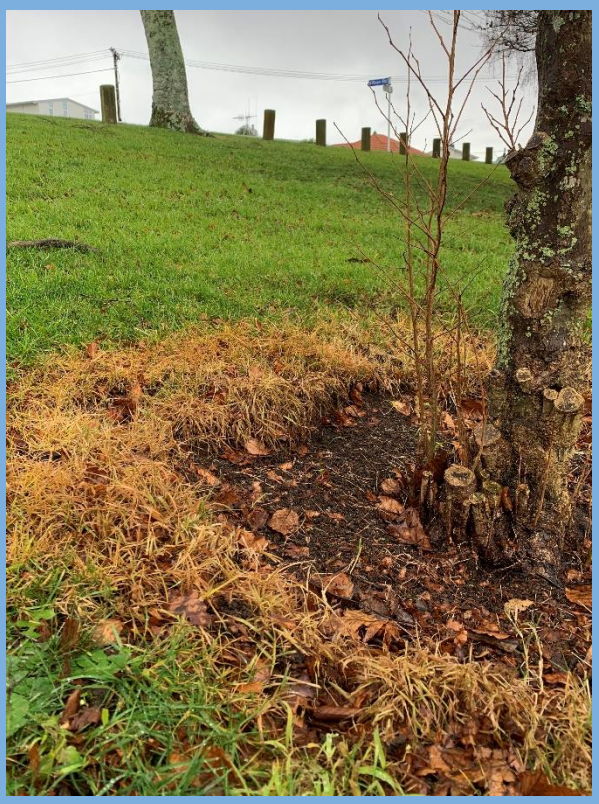
[195] E.g. Grazer (New Zealand) Mowing/mulching in difficult to access areas. https://www.grazer.co.nz/
E.g. Roadside, urban, agriculture. https://zasso.com/products/
E.g., Cassini Grasskiller https://www.youtube.com/watch?v=W_aTuzSqTSY
E.g., Roadside Dücker, Gerhard, GmbH & Co. KGLSM 740 guiding post mower https://www.youtube.com/watch?v=7-pXAv0W2-I&t=54s

- Encouraging for example, goat meat production, particularly in non-cropping regions as an environmentally sustainable protein source (goats eat a wider range of weeds).[196]
- Weeds may have nutritional benefits and be more digestible than common feed crops.[197] [198] [199] [200] [201]

24. Suggestions: In roadside and urban environments

- Under-estimation of harm and under-regulation 'normalises' the spraying of GBHs in public places.

E.g. Tauranga, Bay of Plenty, August 2021



[196] Kadim et al 2012. Nutritive value and quality characteristics of goat meat. CABI
[197] Abaye et al 2009. The Nutritive Value of Common Pasture Weeds and Their Relation to Livestock Nutrient Requirements
[198] Khan et al 2017. A comparative assessment of proximate and elemental composition six weedy grasses for their potential use as fodder. Progress in Nutrition 20:1;182-190
[199] Khan et al 2020 Assessment of Proximate and Nutritional Contents in Selected Weedy Grasses for Potential Use as Fodder in District Charsadda, KP. Life and Environmental Sciences 57:2;83-94
[200] Diaz-Medina et al 2021. In vitro nutritional quality and antioxidant activity of three weed species as feed additives for sheep in the Central Highlands of Mexico. 53:394
[201] Kirilov et al 2016. Determination of Composition and Palatability of Certain Weeds. International Journal of Agricultural Science and Food Technology2:1;041-043

- There has been an absence of funded independent research to both analyse international developments and assist transition away from roadside and urban chemical environments.
- Low growth species can be seeded around roadside marker pegs and signs, and specialist equipment funded to mow at height.
- Education and investment can support transition for TLA officials and contractors dependent on herbicide technologies to shift towards newer non-polluting technologies.
- New technologies can trim around roadside poles (Dücker), along roadsides (Zasso); be used for urban weeds and to clean around utilities (Foamstream) and can mow difficult to access terrain (Grazer). [202]
- Funding can explore the potential for autonomous mowing.

Part 8: Hearing your views

1. Scale 1-5 – [4] quite aware

2. Do you think the rules and controls are enough to manage the risks? If not, please specify why.

No. Glyphosate is not regulated in New Zealand, and new approvals of high concentration glyphosate that must be tank mixed has recently increased this risk.

3. The use of glyphosate impacts people's health? Yes.

1. Due to the under-regulation of glyphosate it is likely the public will be exposed, while farmers, applicators and their families are likely to have higher exposures. Glyphosate is increasingly demonstrated to be endocrine disrupting, to harm liver and kidneys, and damage the microbiome.

2. Glyphosate is one of a suite of toxic herbicides that farmers, horticulturalists/growers and vegetation managers are exposed to and regular users will be likely to experience occupational diseases associated with pesticide use such as Parkinsons, cancer and mental health problems.

3. The Ministry of Primary Industries has a relaxed attitude to domestic glyphosate contamination.[203] Glyphosate can be sprayed directly on human food crops, such as cereals and lentils before harvest. Wheat, oats and barley can often have very high levels of glyphosate detected. While there is a limit of 0.1mg/kg (0.1ppm) on domestically produced food. In 2017 the Ministry for Primary Industries confirmed glyphosate residues were detected in 26 out of 60 wheat samples. Twenty of the samples contained glyphosate above the MRL of 0.1 mg/kg.[204] when glyphosate was detected above the limit, no line of sight identified that steps have been taken to mandate levels below the limit.

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[202] E.g. Grazer (New Zealand) Mowing/mulching in difficult to access areas. https://www.grazer.co.nz/
E.g. Roadside, urban, agriculture. https://zasso.com/products/
E.g., Roadside Dücker, Gerhard, GmbH & Co. KGLSM 740 guiding post mower https://www.youtube.com/watch?v=7-pXAv0W2-I&t=54s
Eg. Urban Foamstream. https://www.youtube.com/watch?v=KD7B658U_gU

[203] MPI 2015. New Zealand Total Diet Study 2015/16 Response to submissions on the Study Proposal Consultation MPI Information Paper No: 2015/16. ISBN No: 978-1-77665-139-9

[204] The 2015/2016 Report on Pesticides in Fresh and Frozen Produce A survey under the Food Residues Surveillance Programme (FRSP) MPI Technical Paper No: 2017/3https://bit.ly/3jcFHzc

4. In addition, imported food such as Australian wheat, can have quite high levels.[205] If New Zealand consumers were aware New Zealand standards were stricter – and enforced – demand would be likely to increase for domestic production.

See also 4.11

4. The use of glyphosate impacts the environment? Yes. See 4.11

5. The use of glyphosate impacts on public spaces? Yes.

Glyphosate when sprayed in public areas will persist longer than recognised by applicators and the public. Lacking any scientific screening to assess persistence, this should not be sprayed in urban environments.

6. What positive or negative impacts do you think glyphosate products have on environmental, economic, social and cultural wellbeing?

The total herbicide use to combat herbicide resistance has increased herbicidal pollutant pressure on our land and in water.

The NZEPA appears to lack the language and culture to recognise this cumulative pressure and balance the economic claims of industry with the risk that current pesticide regimes are damaging the environment. Polluted environments lose their mauri, their life force, and cannot be enjoyed socially or culturally or for health giving properties. In particular, families then stay away and over time the connection between people and land erodes, and the land and water are even less able to be defended.

The NZEPA requires assistance and direction from the Ministry for the Environment, the PCE and the other agencies on how to balance the claims of industry relating to the GDP value of production, and the cost to the environment from increasing pesticide loads, including the decline of water quality and the long-term threat to drinking water. TLAs over-emphasise neatness over health and appear unwilling to transition to less rigorously sprayed environments, despite almost every TLA hearing from local publics protesting current spraying regimes.

7. Available and easy to buy for everyone, or available to professional users only?

Glyphosate should be available for agricultural use only and annual applications should be restricted to three times a year. Glyphosate should be prohibited on and near water surfaces and prohibited from roadside and other amenity use, including along railway tracks.

The NZEPA can engage in cross-agency discussions to encourage central government policies that support transition. Central government funding should be provided for:

Urban, roadside and railway siding use:

- TLAs and NZTA to convert to mechanical and electrothermal use along roadsides and alongside railways;

[205] 25th Australian Total Diet Study. See Appendices. https://www.foodstandards.gov.au/publications/Pages/25th-Australian-Total-Diet-Study.aspx

- Conversion to electrothermal, hot water/steam technologies that can be used in urban environments, including for the cleaning of amenities.
- Redesign of vegetative problem areas along railways and roads so that mechanical equipment can effective.
- Education for integrated weed management with a focus on non-chemical techniques.
- Public relations to help build public understanding of the problem of herbicide resistance and the need to shift to non-chemical means.

Agriculture

- Provide increased funding to help farmers, horticulturalists and growers manage weeds non-chemically.
- Long-term scientific research:
- Recognising the importance of long-term funding for independent scientific support in agriculture that will not necessarily be considered 'innovation' – but rather, public good science.
- Explore best practice globally and filter this information back to farmers, horticulturalists/growers and vegetation managers through extension services.
- Work with farmers in different climatic/soil conditions to connect the science to their own conditions – and fill in the knowledge gaps;

8. How do you think it would affect you or New Zealand if the use of glyphosate products was further restricted?

It would be of overall benefit to human and environmental health as well as economically, socially, culturally. as continued offshore detections, and continued growth in banned substances in our water and soils will continue to problematise international claims that New Zealand is a safe food producer. These issues are likely to grow as detection technologies are become cheaper and more mobile.

9. Please provide any additional comments you have about glyphosate and its use in Aotearoa New Zealand

New Zealand was the first regulator to approve high concentration 600g/L glyphosate. NZEPA may be the weakest regulatory jurisdiction among high income nations in the OECD nations, and the range of European banned pesticides in our environment is striking. High concentration glyphosate must always be tank mixed if it is to be applied at the rate recommended on the label, and as contamination is common, farmers and applicators are even more likely to be exposed with a product that is developed to be tank mixed and marketed to be compatible with a wide range of companion herbicides, in order to counteract herbicide resistance.
Officials working under the Hazardous Substances and New Organisms Act are required to 'protect the environment, and the health and safety of people and communities, by preventing or managing the adverse effects of hazardous substances and new organisms.'[206] The HSNO Act gives officials the power to take action and set controls to protect human and environmental health.
Dependence on the claims of other regulatory agencies in weaker jurisdictions than Europe, or approving substances before more stringent regulators have approved them in no way can protect health and environment. This perpetuates pollution and increases risk of contamination of drinking water and of food.

[206] Hazardous Substances and New Organisms Act 1996. Sn 4. Purpose of Act. https://www.legislation.govt.nz/act/public/1996/0030/latest/whole.html#DLM382991

Most compellingly weak regulation pushes out and delays the adoption of innovative solutions that could increase water and food security for future generations.

Hearing your views: The following information was not considered as part of the CFI and should be information relevant to use in New Zealand:

- Reports by farmers, growers and applicators to Worksafe and ACC following dermal exposure from spills and accidents.
- Data on Parkinson's, Alzheimer's, mental illness, prostate cancer and multiple myeloma in farmers
- Scientific research exploring persistence and degradation of glyphosate in New Zealand soils, including in urban, conservation and agricultural environments where GBHs are commonly used.
- Common tank mixes and co-formulants and herbicides that are commonly applied in cropping/horticulture/forestry/roadside/viticulture and on waterways.

Conclusion

1. We've responded to this Call for Information in this way, to publicly illustrate that this NZEPA activity does not represent the most strategic way the NZEPA can protect human and environmental health. As with the rest of the world, New Zealand is faced with the extinction of precious taonga species.[207] Pesticides are a key driver of environmental degradation.

2. Glyphosate is the 'poster child' of this crisis. Herbicide resistance and the complex chemical herbicide regimes that are consequently applied to compensate for this market failure, require a systemic and strategic response across government. This will protect human and environmental health, and prevent nasty surprises in offshore export markets, as we have seen with glyphosate detection in honey.

3. A consequence of resistance is the aggregation of herbicide mixtures in soil and water. Biocontrol and biosecurity measures mooted as replacements of herbicides reflect a linear approach, tracking one invasive species, or introducing one species to deal with one weed. Narrowly targeted gene editing and bio-control measures also leave open the potential for adverse and unintended impacts.

4. Short term funding, and commercial responses are unlikely to represent efficiency over the long term – as there is little capacity to assess aggregated risk from multiple technical responses that remain highly uncertain. Risk scales differently when rolled out anthropogenically, genes can transfer horizontally across species[208], and introduced species may adversely target indigenous flora or fauna. Unintended consequences are difficult to predict. Our science industry places little value in this work.

5. Risk assessment has never been undertaken for glyphosate in New Zealand. A Call for Information can be integrated into assessment. Such calls appear enacted for politically controversial pesticides, - which the science increasingly shows that the substance is more harmful to human and environmental health than regulatory science recognises. The neonicotinoid decision to undertake risk assessment emphasised international developments, rather than local use patterns. The Call for Information for neonicotinoids effectively delayed a comprehensive risk assessment. In the meantime, more neonicotinoid formulations are approved for dispersal into the environment.

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[207] Joy, M. & McLean, S. (2019) Despite its green image, NZ has world's highest proportion of species at risk. The Conversation. April 30, 2019. https://theconversation.com/despite-its-green-image-nz-has-worlds-highest-proportion-of-species-at-risk-116063

[208] Heinemann et al 2021. Differentiated impacts of human interventions on nature: Scaling the conversation on regulation of gene technologies. Elem Sci Anth. 9:1

6. The overarching HSNO Act, the legislation that gives the NZEPA power to steward hazardous substances, requires officials to act to protect human and environmental health. However, the purposes of the HSNO Act are undermined by lower order regulations and protocols, such as the new Risk Assessment Methodology. The Methodology is overly reliant on linear modelling and bases decision-making around data supplied by the applicant. These processes, which do not require disclosure of applicant/industry data, are too opaque to ensure effective accountability in decision-making.

7. The issues that constrain risk assessment and prevent scientific independence are systemic and outlined by others.[209] Conflicts of interest pervade risk assessment, harmful effects are frequently downplayed or dismissed and peer reviewed literature dismissed. Many up-to-date knowledges, practices and methodologies, such as recognising subtle pathways of endocrine disruption, have been adopted and applied in medical science and toxicology, without controversy, or positioned as controversial or are ignored, in regulatory science.

8. Current risk assessment assumes that humans and ecosystems only face a single impact from a specific pesticide, with sufficient time following after application to allow the population to recover to former levels. This is a worrying underestimation of risk to agrichemical users, and to biodiversity.[210]

9. These issues which are well recognised in the scientific literature, effectively 'defang' the NZEPA, reducing its power to protect human health and the environment as the Act requires.

10. State science funding has been overwhelmingly directed towards an 'innovation' system which emphasises an applied, or commercially valuable end to the research. Over this time, scientific research on genetics, engineered organisms and general research with direct commercial potential has scaled up dramatically in New Zealand. Similarly, funding for biosecurity and biocontrol has escalated.

11. Science to support environmental health has not equivalently scaled up. For example, research on soil pollution and soil nutrition, pesticidal effects on the rhizosphere, or research on microbiota-root-nutrient interactions and nutrition-disease research is rare and often short term, in comparison to scientific funding for technological development.

12. As a consequence there is no integrated public interest science system that can undertake, free of political interference, long-term research to monitor and evaluate synthetic chemicals in aquatic and terrestrial environments, nor conduct long-term human biomonitoring. Basically, neither public officials nor the general public, comprehends what is going on in our soil, water, air and human bodies with regards to pesticides. Regional industry emissions are not tied to water monitoring, and intensive production regions do not have monitoring that accurately reflects diffuse pesticide emissions. While patchy (but good) science is undertaken[211], it is not extensive nor long-term.

13. In short, our science system is relatively powerless in helping New Zealanders recognise the relevant factors which drive biodiversity decline and health impact from pesticides. This sector could undertake long term research on soil/water – pollution interaction and feedback into the regulatory system. Our science system can incorporate interdisciplinary complexities[212], considering, for example, the impact of seasonal applications; bioaccumulation in soil, water and sediment; mixture effects and low sub-lethal effects that impact predator prey relationships and intergenerational fertility of vertebrate and non-

[209] Robinson et al 2020. Achieving a High Level of Protection from Pesticides in Europe.
[210] Brühl & Zaller 2019. Biodiversity Decline as a Consequence of an Inappropriate Environmental Risk Assessment of Pesticides. https://doi.org/10.3389/fenvs.2019.00177
[211] E.g. the emerging contaminants work at Cawthron Institute
[212] Hernandez et al 2019. Critical assessment and integration of separate lines of evidence for risk assessment of chemical mixtures. Archives of Toxicology 93:2741–2757

vertebrates. It can look at risk to pregnant mothers, infants and children, particularly children of farmers, growers and applicators.

14. Safe, healthy food is critical to national security, and that protection of water and soil - agriculture - for future generations is key to national security.

15. Government policies can be rolled out to assist farmers, horticulturalists/growers, vegetation managers and TLAs shift to non-chemical agriculture. This can be undertaken via increased resourcing to illustrate the pressure of intensive chemical agriculture on ecosystem resources, to educate and inform on long-term integrated weed management methods to ensure farms remain fertile and productive and introduce and aid in the establishment of new machinery technologies across pasture, arable, horticulture and amenity vegetation systems.

16. Scientific advisory, or extension services, have historically been a vital and independent link between farmers, horticulturalists/growers and vegetation managers that were able to consider not only short term, but long-term patterns, but were reduced with 1980s budget cuts. In the 21st century, high-tech data can be engaged to evaluate the interaction of soil organisms, soil types, climactic conditions and farm use. Extension services crucially, feedback problems into the science community, seeding R&D.

17. The current system is unable to value organic agriculture below a simple GDP/productivity metric. Organic agriculture places less stress on freshwater, groundwater and drinking water, and may be a tool to maintain and promote ecosystem services and human health.[213] Our state economic system is geared to ignoring freshwater pollution. National freshwater stores are simply valued in terms of stocks and flows, not in the absence of persistent, and bioaccumulating pollutants.

18. As long as science remains patchy and unintegrated, and public-sector scientists are scarce (and funding precarious) there will be no authoritative voice to shift public opinion, pressure regulators to update their scientific approach and advise officials across government. In this gap, pollution increases, those that predominantly release the chemicals into the environment – the farmers – and rare scientists that speak up - become the scapegoats. This is what we see with regards to nitrate pollution in New Zealand.

19. Glyphosate is but one pollutant, but without addressing the overarching framework that farmers, horticulturalists, applicators, as well as the NZEPA and public scientists are embedded in; and without drawing attention to the knowledge that is *not* produced, but that could underpin paradigm shifting change to protect human and environmental health, we are destined to continue to erode our soil, water, air, and export reputation at speed.

[213] Benbrook et al 2021. Organic Farming Lessens Reliance on Pesticides and Promotes Public Health by Lowering Dietary Risks. Agronomy. 11:1266. DOI 10.3390/agronomy11071266