Soil & Health Association (Est. 1941)
Healthy Soil, Healthy Food, Healthy People

To: The New Zealand Environmental Protection Authority

SUBMISSION DOCUMENT: Call for Information on Glyphosate

From: The Soil & Health Association September 23, 2021

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SUBMISSION DOCUMENT

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1. RISK ASSESSMENT NEEDED

The Soil & Health Association questions why this Call for Information (CFI) has not been incorporated within a risk assessment. New Zealand has never conducted a risk assessment of glyphosate-based herbicides (GBHs). This Call for Information effectively delays long overdue risk assessment of GBHs while delaying any regulatory measures that might be enacted as a response to risk assessment to protect health.

Unintentional spills and poisoning are common.[1] The U.S. court cases about glyphosate's harm to human health have drawn attention to the common incidence of dermal exposure, or unintentional pesticide poisoning. [2] With evidence of exposures being common, the claim by the NZEPA and Bayer that glyphosate is safe as used on the label is incorrect in practice. Farmers, growers and

[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] 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.

applicators – 'professional and commercial users' (PCUs) – are much more exposed than home users. Exclusively withdrawing glyphosate from home and non-professional use will not be sufficient to protect public health.

ACTION REQUESTED: Soil & Health asks that the EPA conduct a risk assessment of glyphosate and glyphosate-based herbicides (full formulae available for sale and use in Aotearoa New Zealand) and that studies included in the risk assessment are made available[3] to the public.

2. HERBICIDE RESISTANCE

GBHs are commonly mixed with other herbicides because weeds are becoming resistant to GBHs and other commonly used herbicides. Scientists recently identified herbicide-resistant weeds in 50% of farms that were studied, ten times more than expected.[4] In order to kill weeds, multiple herbicidal mixtures are frequently sprayed together or in rotation. Total herbicide emissions have increased and the NZEPA has failed to draw attention to the cumulative risk of increased herbicidal emissions.

3. SOIL AND WATER POLLUTION

These total herbicide emissions accelerate pollution in soil and water. Increased spraying in warmer months increase stress to soil and water organisms and threaten human health. The more toxic breakdown metabolites – including glyphosate's breakdown metabolite aminomethylphosphonic acid (AMPA) – can persist in sediment and groundwater for years. Off-target harms from increasing herbicide mixtures in the environment include contamination risk of source and drinking water.

Our CFI response highlights the information directly relating to GBH health risk – but importantly, the need for governance structures that can actively protect healthier environments and promote public interest research. Long-term environmental pressure from bioaccumulating herbicides which render biosystems uninhabitable is a form of market failure.

The state, through laws and regulation, the monitoring of the environment and the actions taken to protect the environment, is in place to protect public goods. The cumulative load of herbicidal mixtures erodes water quality, reducing access to potable water, and damages soil health. This inevitably represents a cost to society. The NZEPA must look at pressure from herbicides together, not simply focus on one chemical at a time.

The failure to recognise anthropogenic chemical pollution is institutionalised across the New Zealand government. There is no feedback loop of science into the regulatory sphere identifying how diffuse anthropogenic synthetic chemical pressures tip river systems into decline and decay.

Cost-benefit analyses conducted by the NZEPA, chemical industry applicants and private actors contracted by the NZEPA direct their focus to agricultural productivity. Agricultural productivity is only one aspect of value. There is no institution established in Aotearoa New Zealand that can supply data which examines value in different ways.

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[3] As per General Court of the European Union. (2019). Press Release No 25/19. Judgment in Cases T-716/14 Anthony C. Tweedale v European Food Safety Agency (EFSA) and T-329/17 Hautala and Others v EFSA. Luxembourg: General Court of the European Union. Retrieved from https://curia.europa.eu/jcms/upload/docs/application/pdf/2019-03/cp190025en.pdf

[4] Rennie. Weeding out herbicide resistance. *Farmers Weekly* August 16, 2021

There is no funding to consider the economic cost of regulation to safeguard ecosystem services economically and culturally. Interdisciplinary scientific and economic research can draw attention to the cascade of costs that arise when emissions are not regulated, and instead bioaccumulate as toxic mixtures in the environment. Ground water and drinking water are public goods – yet whether water is healthy or produces sickness – is unrecognised in national water accounting which only considers water stocks and flows.[5] We are not forecasting the potential costs of stripping out contaminant anthropogenic chemicals from drinking water, to ensure the water is potable and safe for commercial and private activity.[6]

The value of established agricultural practices such as organics that produce less pressure on soil and water ecosystems[7] remains largely outside government discussions. Tax policy to prevent contamination of groundwater from forestry herbicides, and to reduce herbicide use remains unexplored.[8] The absence of feedback loops between science and agriculture have worsened this situation. The removal of agricultural extension services severed an independent information source for farmers to improve farm health and productivity but also removed innovation feedback loops back into the science community.

Recognising herbicide harm creates conditions conducive to technological development. Europe quickly regulates when persistent pesticides risk polluting water, and progress to develop safer public-good technologies such as mechanical weeding have accelerated.[9] (See Annex).

4. Key points concerning the CFI

We firstly make 3 important points and then, below, we directly respond inline to NZEPA questions contained in the CFI documents.

(1) Soil & Health calls for the NZEPA to reassess glyphosate and conduct a thorough risk assessment.

The relevant NZEPA committee has never convened to discuss whether there is new information relating to the effects of glyphosate.

There is new information relating to glyphosate that produces grounds for risk assessment or reassessment.

- The world authority on cancer, the International Agency for Research on Cancer, determined that glyphosate and GBHs probably causes cancer in humans;[10]

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[5] Griffiths, J, Zammit, C, Wilkins, M, Henderson, R, Singh, S, Lorrey, A, Shankar, U, Vargo, L, Anderson, B, & Purdie, H (2021). New Zealand water accounts: Update 2020. NIWA report prepared for Stats NZ Tatauranga Aotearoa.
[6] Schröter et al. (eds.), Atlas of Ecosystem Services: Drivers, Risks, and Societal Responses. Springer https://doi.org/10.1007/978-3-319-96229-0_31
[7] Geissen et al 2021. Cocktails of pesticide residues in conventional and organic farmingsystems in Europe e Legacy of the past and turning point for the future. Environmental Pollution 278:116827,
[8] Skevas 2020 Evaluating alternative policies to reduce pesticide groundwater pollution in Dutch arable farming. 63:4, 733-750, DOI: 10.1080/09640568.2019.1606618
[9] Oliviera et al 2021. Advances in Agriculture Robotics: A State-of-the-Art Review and Challenges Ahead. Robotics 2021, 10, 52. https://doi.org/10.3390/robotics10020052
[10] IARC, 2015.International Agency for Research on Cancer. Some organophosphate insecticides and herbicides: tetrachlorvinphos, parathion, malathion, diazinon and glyphosate. Lyon, France

- Through the court-directed discovery process in the U.S. court cases where plaintiffs claimed harm to human health from GBHs, substantial scientific literature supporting the IARC's finding was produced;
- Cancer from pesticides exposure is a recognised occupational disease for farmers.[11] Herbicides are the most commonly applied pesticide[12] and glyphosate is the most widely applied herbicide.[13]
- The U.S. court cases (and further appeals) found that GBHs such as Roundup caused cancer in farmers, growers and applicators;[14] and
- Following the court cases, Bayer (manufacturer of Roundup) has committed to increase the $11.6 billion payout by $4.5 billion.[15]

Despite this, the chief executive of the NZEPA has not requested that a NZEPA committee convene to decide whether there is new information relating to glyphosate's potential toxicity.

Many members of the public, and public health scientists,[16] have requested that glyphosate be risk assessed. However, the NZEPA does not consider that these requests constitute a formal application. As a result, the committee has never met. Claims from the NZEPA that there is no new information are based on the administrative technicality – that a formal application has not been made. This includes paying the $1000 application fee to trigger a meeting. The experience of former MP Catherine Delahunty with triclosan may have served as a warning to the public. Delahunty paid an application fee and then was asked by the NZEPA to pay $50,000 for half of a risk assessment.

(2) This Call for Information should have requested more specific information on evidence of harm and evidence on persistence in the environment from GBHs, rather than the more general request for information "relating to the effects of substances, positive and adverse; toxicology…" etc.

Such information would include:

- Frequency of incidences of dermal exposure.
- Formal reporting to WorkSafe, DHBs, ACC, and the National Poisons Centre of spills, accidents and dermal exposure.
- Testing of soil and sediment to understand GBH persistence in urban and rural environments.

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[11] Stoop 12.09.2018. Pesticides and cancer among farmers: the rush towards irrefutability. https://www.europeanscientist.com/en/features/pesticides-and-cancer-among-farmers-the-rush-towards-irrefutability/
Stoop. 27.07.2018. Pesticides and cancer among farmers: the rush towards irrefutability (second part). https://www.europeanscientist.com/en/features/pesticides-and-cancer-among-farmers-the-rush-towards-irrefutability-second-part/
[12] 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
[13] Douwes, J., (2018). Carcinogenicity of glyphosate: Why is New Zealand's EPA lost in the weeds? *New Zealand Medical Journal*, 82-89.
[14] US Right to Know. https://usrtk.org/monsanto-papers/
[15] Grossman (2021) Bayer Plans for Roundup Litigation Claims Rising by $4.5 Billion. WSJ. July 29, 2021.
[16] Douwes, J., (2018). Carcinogenicity of glyphosate.

- Most common co-ingredients commonly tank-mixed or applied with GBHs, including herbicides, adjuvants and surfactants.
- Incidence of herbicide resistance of GBHs and of the other herbicides commonly applied with GBHs in tank mixes.
- Impact on circular economy, for example glyphosate contamination in fertiliser, reducing crop yield.

(3) To understand GBH and environmental and human health risks it is essential to address herbicide resistance.

Herbicide resistance is a ‘wicked’ global problem,[17] and has been severely underestimated in New Zealand. In a recent study scientists thought they might see 5% of farms with a resistance problem. Instead, they found 50% of farms had a herbicide resistance problem. [18] Herbicide resistance means that instead of using just one herbicide, such as Roundup, farmers and applicators will commonly tank-mix a range of herbicides, as well as other additives. The different herbicides are intended to kill weeds using different modes of action to target different metabolic pathways. [19] [20]

Mixtures of herbicides used in forestry[21] [22] farming and roadside sprays[23] contaminate New Zealand water[24], and much of the adverse effects of these mixtures are due to management of herbicide resistance. Trying to deal with herbicide resistance by using more herbicides drives pollution and increases potential harm across the landscape. Many of the recommended [25] are expressly banned in Europe because they persist and bioaccumulate in aquatic environments.

The NZEPA needs to recognise that resistance issues have increased the cumulative exposure to growers and applicators, as well as to the environment, and that mixtures increase health risk.

The NZEPA has not drawn attention to the increasingly toxic profile of herbicides recommended to be used alongside GBHs in weed management. These toxic mixtures accumulate in the environment and can cause harm at levels below the levels set for individual substances.[26] Globally, agricultural soil is recognised to be heavily polluted by a range of pesticides.[27] [28] The New Zealand

[17] Peterson et al 2017. The challenge of herbicide resistance around the world: a current summary. Pest Manag Sci 2018; 74: 2246–2259

[18] Rennie. Weeding out herbicide resistance. *Farmers Weekly* August 16, 2021

[19] 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

[20] Ghanizadeh & Harrington 2021. Herbicide resistant weeds in New Zealand: state of knowledge. *New Zealand Journal of Agricultural Research*. DOI: 10.1080/00288233.2019.1705863

[21] 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

[22] 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

[23] Cawthron Institute 2018. Potential Ecological Effects of Herbicide use on State Highway 6, Nelson

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

[25] Foundation for Arable Research. Integrated Weed Management Workshop, 22 July 2021 Ashburton.

[26] Kraus et al 2019. Contaminants and Ecological Subsidies. The Land-Water Interface. Springer ISBN 978-3-030-49480-3

[27] Tang, et al 2021. Risk of pesticide pollution at the global scale. *F. Nat. Geosci*. https://doi.org/10.1038/s41561-021-00712-5 (2021).

[28] Silva, V. et al. Pesticide residues in European agricultural soils—a hidden reality unfolded. *Sci. Total Environ*. 653, 1532–1545 (2019).

freshwater debate has excluded debate around anthropogenic chemicals for years.[29] This protectionist stance benefits the agrichemical industry more than New Zealand farmers, growers and applicators (PCUs) because PCUs are most at risk following spills and dermal contact.[30] [31] [32]

The cutting of scientific agricultural extension (knowledge dissemination) services, the direct line of communication between scientists and farmers, from the 1980s onwards, removed a critical pathway for feedback into the agricultural science system. This was the problem-solving pathway that could identify and weigh up important challenges in agriculture. The result was a lopsided science system, with funding or 'investment' in genetics that far outpaced funding for research into soil and nutrition, or funding to identify long term threats such as herbicide resistance. With a disproportionate focus on genetics-based productivity, and little funding to identify looming challenges, or market failures such as herbicide resistance and off-target contamination,[33] the capacity for critics to challenge current glyphosate and herbicide was limited. No scientists with relevant expertise had secure positions that would allow them to be outspoken.

Lacking a science enterprise with a mandate to research non-chemical and mechanical technologies, short-term funding was only available within self-financed industry sectors. The Foundation for Arable Research's startling finding that herbicide resistance is widespread is an unfortunate information lag that has reduced the capacity of the state to respond in a timely manner.

New Zealand's lag has prevented R&D opportunities for producers in specialty cropping and organics sectors that have had to rely on hand weeding while mechanical technologies advanced. It's meant that funding for integrated weed management has been off the policy agenda and it's resulted in a failure to educate and inform, and support the introduction of already available mechanical technologies at scale and pace.[34]

In the appendix we have listed papers which draw attention to the degree to which mechanical technologies have progressed – largely outside New Zealand.

For example, development in Germany has resulted in a myriad of non-chemical technologies that can be safely operated at a distance using remote control. Contractor Grazor uses IRUS Deltrack remote control mower and mulcher equipment that can work on a 50 degree incline safely,[35] to remove established 'old man' gorse. IRUS Deltrack equipment can be used to mulch forest slash and scrub, and mow along train tracks.[36] Roadside technologies have been developed to cut neatly around signposts.[37] Italian-made Green Climber and Robotech equipment operates similarly.

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[29] 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. https://psgr.org.nz/component/jdownloads/send/1-root/64-2019-freshwater

[30] Benbrook 2020. Shining a Light on Glyphosate-Based Herbicide Hazard, Exposures and Risk

[31] 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

[32] 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

[33] Muola et al 2021. Risk in the circular food economy: Glyphosate-based herbicide residues in manure fertilizers decrease crop yield. Sci Total Environ. 750:141422

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

[35] Grazor.co.nz. https://www.irus.de/produkte.php?p_id=11&lang=EN

[36] 2021 Promotional literature https://www.irus.de/files/Prospekt_Funkgesteuert_EN_2021-05_WEB.pdf

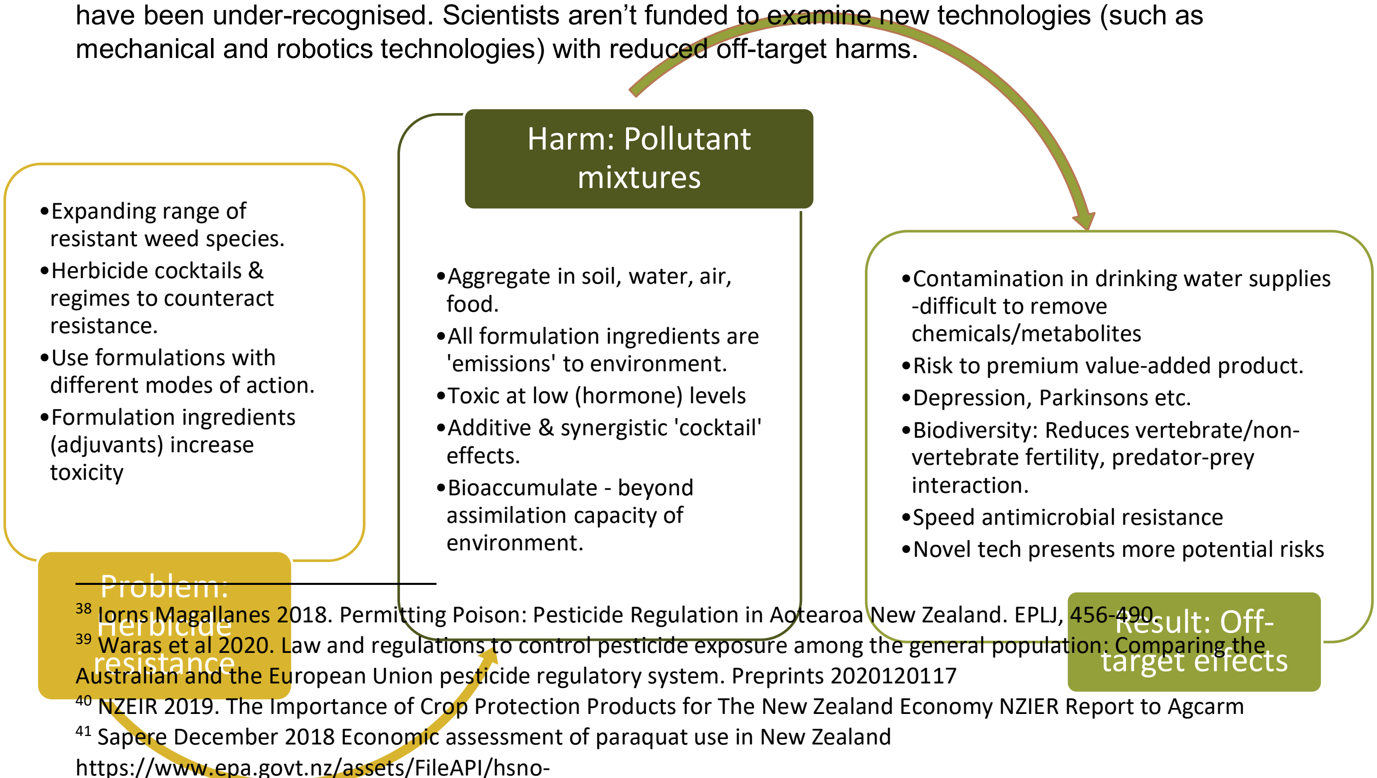
[37] Roadside Dücker, Gerhard, GmbH & Co. KGLSM 740 guiding post mower https://www.youtube.com/watch?v=7-pXAv0W2-I&t=54s

Operators report rapid uptake by lifestyle block owners, often to cut back scrub and gorse, or to clean alongside riverbanks prior to riparian replanting. Often once scrub has been cut back, sheep and goats can be run on the land, with reduced damage to slope and soil than cattle.

The NZEPA looks at risk-based cost-benefit of a product to support the approval and release of a chemical onto the market. By contrast, Europe's hazard-based system recognises that cancer-causing and endocrine-disrupting chemicals are hazardous – there is a big difference when there is a risk for a baby or an adult and the level at where harm happens is almost impossible to predict, so these chemicals cannot be released into the environment. Europe also applies the precautionary principle much more strictly than New Zealand.[38] New Zealand's regulatory system does not have these stringent checks and balances, instead operating like Australia, Canada and the U.S..[39]

Toxic herbicide use carries with it multiple risks: health risks to PCUs and their families; risks to soil health and water quality; risk of detection in international markets from the banned chemicals currently in use to replace glyphosate when weed species are resistant. Cost-benefit scenarios that support the herbicide use, rely only on productivity claims.[40] [41] [42] New Zealand lacks scientists employed outside the regulatory environment who can independently provide data to address the potential for soil pollution and degradation of ecosystem services and feed back this information to officials.[43]

New Zealand remains at risk if the prioritised replacement technologies carry with them uncertainties which include the release of biocontrol insects and gene-edited organisms into the environment. The absence of research and development directed to alternative technologies that do not contain these risks is striking. This means that technological gains in new mechanical and robotics technologies that can replace environmentally harmful GBHs and companion herbicides have been under-recognised. Scientists aren't funded to examine new technologies (such as mechanical and robotics technologies) with reduced off-target harms.



[38] Iorns Magallanes 2018. Permitting Poison: Pesticide Regulation in Aotearoa New Zealand. EPLJ, 456-490.
[39] 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
[40] NZEIR 2019. The Importance of Crop Protection Products for The New Zealand Economy NZIER Report to Agcarm
[41] Sapere December 2018 Economic assessment of paraquat use in New Zealand https://www.epa.govt.nz/assets/FileAPI/hsno-ar/APP203301/c34071b227/APP203301-Appendix-B-Sapere-economic-and-benefits-assessment.pdf
[42] See for example APP203611 Crucial, https://www.epa.govt.nz/assets/FileAPI/hsno-ar/APP203611/c4686971d9/APP203611_Final_Application_Form.pdf
[43] Costanza et al 2017. Twenty years of ecosystem services: How far have we come and how far do we still need to go? Ecosystem Services, 1-16.

5. Direct response to NZEPA 28 April 2021 submission paper.

Part 3: Use of glyphosate products

Our submission is drawn from requests placed by Steffan Browning in 2019-2020 to territorial local authorities (TLAs) and consolidated in a spreadsheet.[44]

3.2. Non-agricultural sector (for example, sports fields, council land, conservation areas, berms/edges of roads, controlling invasive plants, aquatic herbicide use). Page 7

The feedback demonstrates that guidelines used are inconsistent and spray guidelines include Growsafe, the Chemical Users Guide of Practice NZS8409:2004 and local guidelines. Spraying is often contracted out and it is not apparent that auditing of contractor and sub-contractors are undertaken to ensure they follow guidelines.

Many councils still spray around playgrounds and appear unaware that glyphosate might persist for longer than the spraying period.

Mechanical measures such as line trimming/weed eating, mulching and manual pulling are part of weed control measures. Steam weeding or hot water use is rare in New Zealand. Some councils have access to steam weeders but these seem not to be frequently used.

Most councils do not have a spray-free streets or parks policy, though many will not spray near properties when requested by property owners.

3.6 When and how often do you use glyphosate products?

TLA responses reveal that glyphosate volumes used by councils differ markedly. While in many cases volumes will increase proportionate to the area covered, large tonnages also demonstrates the greater exposure of the environment and people to spraying regimes across New Zealand.

Glyphosate is commonly used for aquatic weed control by councils (this practice is not approved in Europe).[45]

Volume (litres)	Note: example only
100-400	Masterton district (206L); Western Bay of Plenty; Whakatāne District (356)
400-1000	Otago (596); South Taranaki (800); Stratford (450); Waitomo (600)
1000+	Manawatu district (2000), Matamata-Piako (1200); Thames-Coromandel (1340); Wairoa (4000); Wellington (2425 roadside); Whangarei District Council (4075)

Part 4: Mitigation measures and controls

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

Growers and applicators will often wear waterproof gloves, suitable boots and cotton overalls, and this accords with requirements on the label. Some grower applicators will avoid spraying near waterways. A recent New Zealand study across industries reported that 2 out of 3 of the highest prevalence for self-reported exposure by industry were for herbicide and insecticide use.[46]

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[44] https://organicnz.org.nz/glyphosate/ **NZ Councils – current glyphosate use (Excel spreadsheet)**

[45] European Commission 2017. Review report for the active substance glyphosate. SANTE/10441/2017 Rev 2

[46] Firth HM, Rothstein DS, Herbison GP, McBride DI. Chemical Exposure among NZ Farmers. *Int J Environ Health Res*. 2007; 17(1):33-43. P.119

GBHs are approved for spraying on waterways, along roadsides and on Department of Conservation and other land including along train tracks. These environments are habitats for ground-dwelling species including insects, geckos, skinks and bird species (such as silvereyes/waxeyes) that graze on vegetation seeds. Due to the persistence of glyphosate and AMPA, rainfall in the days after spraying may carry the herbicides (and the accompanying adjuvants) further afield. Adjuvants include those such as the organosilicon-based surfactant Pulse Penetrant, which may particularly threaten invertebrate species.[47] However, organosilicons are not tested in the environment.

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

How PCUs deal with these adverse outcomes is an important question which requires long-term research to be undertaken to track PCU health over time.

4.3 Do you read and follow the label instructions?

Unintentional pesticide poisoning is common.[48] We understand that off-label use is common. The label on the product Crucial[49] intends that the glyphosate is applied with a wide range of compatible herbicides, due to the problem of herbicide resistance.

4.4 Personal protective equipment (PPE)

When PCUs follow PPE instructions and wear waterproof gloves, suitable boots and cotton overalls, they still remain highly exposed not only when clothes wear thin, but when gloves are reused or taken off, for example to hold a steering wheel, eat lunch or answer a mobile phone.[50] [51] Then when PCUs return home, the pesticides on their skin and clothing contaminates family members. As a result, higher levels of pesticides tend to be detected in family members.

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

Roadside sprayers have schedules to keep and are often contracted, with contractors and sub-contractors on minimal wages, and a requirement to cover a specific kilometre area in allocated time periods. While spray application may not happen on a rainy day, usually there is no consideration of the potential for run-off if there is rain in the week following application.

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

Many GBHs are approved for spraying on waterways and along drains to destroy invasive species. Crucial is developed with three different glyphosate salts – potassium, monomethylamine and ammonium, with ‘triple surfactant technology’.[52] Crucial is marketed as having been designed for greater penetration through better adhesion. This product has never been tested in the New Zealand environment, nor are the surfactants publicly declared or tested for toxicity. Pulse

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[47] Chen, J., Fine, J., & Mullin, C. (2018). Are organosilicon surfactants safe for bees or humans? *Science of the Total Environment*, 612, 415-421.

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

[49] Nufarm Crucial. World first 600g/L high strength liquid glyphosate formulation powered by triple salt, triple surfactant technology. https://nufarm.com/nz/product/crucial/

[50] 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

[51] 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

[52] https://cdn.nufarm.com/wp-content/uploads/sites/17/2019/07/07144835/204790-Nufarm-CRUCIAL-Brochure-Update-A5-WEB.pdf

penetrant, which is recommended to mix in with Crucial (as well as other herbicides), is also never tested. It is difficult to source local scientific studies researching how herbicides including glyphosate interact in waterways, such as the potential for degradation in contaminated environments, or how glyphosate might promote growth of cyanobacteria.[53]

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

No. Safety for the public and the environment is based on the setting of levels that can be monitored and regulated, but this has never happened in New Zealand.

The HSNO Act and the 2004 New Zealand Code of Practice (NZS 8409)[54] assumed that environmental exposure limits (EELs) and tolerable exposure limits (TELs) would be established for agrichemicals. These have not been established for pesticides. Buffer zones are created, rates of application are developed and recommended by industry, but there are no established levels for which exceedance results in regulatory action. Even if soil or human serum were being tested for glyphosate – no formal levels have been established which could be policed.

When the public complains of overspray – of a chemical exceeding a buffer zone, or crossing a boundary, there is no scientifically established method to understand if this has in fact occurred. This means that neighbouring properties can never be declared safe, because there is no scientific evidence that they are safe. Glyphosate persists far longer in the environment than the often claimed 'when it is dry to touch' or when 48 hours has passed.

The NZS 8409 continues to be a relevant guideline. Yet its primary objective, that levels would be established and that could be tested for and cannot been exceeded, has never been achieved.

Twenty-five year old Transit New Zealand national vegetation management guidelines which remain up to date[55], permit PCUs to vary application rates. The Guidelines state 'No spraying shall be done in the rain or when rain is forecast to fall before the manufacturer's labelled drying times'.[56] A recent Western Bay of Plenty Regional Council Air Policy stated 'signs should remain in place until all airborne spray has settled and the agrichemical has dried'.[57] There is no scientific evidence that supports the claim that when an herbicide solution is dry, it is safe.

GBH persistence in soil is dependent on temperature, humidity, soil type, microbiological activity, light, phosphorus levels, mineral content and soil type. Glyphosate persists 30 times longer in soil under cold, dry conditions, meaning regions with cold dry winters are vulnerable to GBH bioaccumulation. The main metabolite aminomethylphosphonic acid (AMPA) persists for even longer.[58] AMPA can contaminate groundwater and bind to and persist in sediment.[59] The European

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[53] Tansay et al 2021. Impact of Environmentally Relevant Concentrations of Glyphosate and 2,4-D Commercial Formulations on Nostoc sp. N1 & Oryza sativa L. Rice Seedlings. *Front Sustain Food Syst* DOI 10.3389/fsufs.2021.661634

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

[55] Official Information Act Request NZ Transport Agency OIA-8137

[56] Transit New Zealand Specification for Vegetation Control. TNZ C21. P.9

[57] Bay of Plenty Regional Council 2020. Plan Change 13 (Air Quality) to the Regional Natural Resources Plan. V10. P.13

[58] Bento et al 2016. Persistence of glyphosate and aminomethylphosphonic acid in loess soil under different combinations of temperature, soil moisture and light/darkness. *Science of the Total Environment* 572:201-311

[59] Grandcoin et al 2017. AminoMethylPhosphonic acid (AMPA) in natural waters: Its sources, behavior and environmental fate. *Water Research* 117:187-197

Union has estimated that the time it takes for half the initial amount of glyphosate applied (the half life) is 143.3 days for glyphosate and 514.9 days for AMPA. [60] [61]

Part 5: Impacts on Māori

Mixture risk from multiple herbicides including glyphosate is severely underestimated.[62] In order to adequately consider the impact on Māori, the NZEPA must consider the joint effect of herbicide mixtures used to try to combat herbicide resistance, and the effects on taonga species.

While glyphosate by itself can reduce the fertility of many species,[63] the total herbicides used over a year produce ongoing stresses, particularly to juvenile trophic species. Endocrine disruptors harm vertebrates similarly, so chemical contaminants which mimic and disrupt hormone function are likely to impact the juveniles of species – including humans – similarly.[64] It is very clear that if juveniles are harmed, this can impact predator–prey relationships, intergenerational health and the resilience of trophic ecosystems.[65] [66] Chemicals including glyphosate may not directly damage genes but alter genetic (epigenetic) function intergenerationally, making exposed organisms more vulnerable to disease.[67] Scientists have found that exposures to grandparents may not harm the grandparents, but set in place epigenetic harms which are experienced by future generations.[68]

This speaks to the Māori proverb: *Te tōrino haere whakamua, whakamuri.* At the same time as the spiral is going forward, it is returning. The protection of our children and juvenile species is dependent on a safe healthy environment. This must be in place before they exist, in order for these individuals to reach maturity and in turn, produce healthy future generations

There is evidence that pollution may disrupt food webs more than climate change.[69] This will negatively impact the health of food webs and foraging sites, and this is likely to impact Māori, their culture, traditions and relationships with their ancestral lands, water, sites, waahi tapu, valued flora and fauna, and other taonga.

Aerial sprays over forestry, Department of Conservation lands, roadsides and sprays over freshwater either prevent Māori from foraging, or expose them to health risks.

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[60] Soil & Health Association. Glyphosate 2020 No Public Exposures [3]. https://soilandhealth.org.nz/wp-content/uploads/2019/10/3-Glyphosate-free-streets-parks-roads-2.pdf

[61] EFSA. (2013). Glyphosate Renewal Assessment Report of 18 December 2013. Rapporteur Member State (RMS): Germany, Co-RMS: Slovakia. European Food Safety Authority. http://dar.efsa.europa.eu/darweb/provision

[62] Gustavsson et al 2017. Pesticide mixtures in the Swedish streams: environmental risks, contributions of individual compounds and consequences of single-substance oriented risk mitigation. *Sci Total Environ*. 15;598:973-983

[63] Ingaramo et al 2020 Are glyphosate and glyphosate-based herbicides endocrine disruptors that alter female fertility?

[64] Demeneix 2017. Toxic Cocktail. How chemical pollution is poisoning our brains. Oxford University Press.

[65] Scott D. Application of the Precautionary Principle During Consenting Processes in New Zealand: Addressing Past Errors, Obtaining a Normative Fix and Developing a Structured and Operationalised Approach (LLM Thesis, Victoria University of Wellington, 2016).

[66] Brooks 2009. The Adverse Effects Of Contaminants On Predator-Prey Interactions: Implications For Ecological Risk Assessment. Submitted for the degree of Doctor of Philosophy Department of Animal and Plant Sciences University of Sheffield

[67] Kubsad et al. 2019). Assessment of Glyphosate Induced epigenetic transgenerational Inheritance of pathologies and sperm epimutations: Generational toxicology. *Nature Scientific Reports*, 9, 6372.

[68] Skinner 2016. Epigenetic transgenerational inheritance. *Endocrinology*. 12 http://dx.doi.org/10.1038/nrendo.2015.206

[69] Moore et al 2021. Laboratory-Based Comparison for the Effects of Environmental Stressors Supports Field Evidence for the Relative Importance of Pollution on Life History and Behavior of the Pond Snail, Lymnaea stagnalis. *Environ. Sci. Technol*. 2021, 55, 8806−8816

NZEPA does not request data on the potential of herbicides including glyphosate to accumulate in aquatic species such as tuna and koura.

NZEPA does not look at the cumulative exposures of herbicides including glyphosate used in rotation, and the cumulative effect on endemic freshwater species customarily fished by Māori.

The capacity for new technologies to help us understand how contaminants alter metabolic health in ecosystems has greatly increased. Environmental metabolomics is a promising new discipline that, by revealing biomarkers from contaminant exposures, can be applied to provide evidence of how endemic species traditionally relied upon as food sources by Māori can be harmed. These harms may occur at sub-lethal levels, not evident in regulatory analysis, but which are sufficient to harm intergenerational health of taonga species.[70] [71] [72]

Part 6: Technical information

Technical data relating to the content of GBHs are kept secret by commercial in-confidence agreements. A recent court case in Europe found that there is an overriding public interest in disclosing the full contents of formulations, as these contents are emitted into the environment along with the active ingredient glyphosate.[73]

The NZEPA's risk assessment processes need to keep up with scientific progress. The IARC, as an authority on cancer, considers a broader range of peer-reviewed data and more widely considers the multiple mechanisms through which exposures to toxic substances cause cancer. In a recent review, New Zealand was found to have a greater number of suspected carcinogens approved and released into the environment than the U.S.A. and Europe.[74]

Requirement to consider formulation, mixture risk and hormone level effects

Glyphosate is more harmful at levels lower than that declared safe by regulators,[75] the commercial formulation is more toxic than the active ingredient glyphosate,[76] and exposure to glyphosate not only harms the exposed individual, but can increase disease risk for future generations.[77] Studies are showing the pathways to disease. For example, immunosuppression, endocrine disruption and genetic alterations are commonly associated with non-Hodgkin's lymphoma.[78] [79]

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[70] Mesnage, et al. 2015 Potential toxic effects of glyphosate and its commercial formulations below regulatory limits, *Food Chem. Toxicol*. 84 (2015) 133–153.

[71] Zhang et al 2021. Ecological and toxicological assessments of anthropogenic contaminants based on environmental metabolomics. *Environmental Science and Ecotechnology*. 5:100081

[72] 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* 4:471

[73] Morvillo 2019. The General Court Orders Disclosure of Glyphosate-related Scientific Studies: Tweedale, Hautala, and the Concept of Environmental Information in the Context of Plant Protection Products. *European Journal of Risk Regulation*, 10:419–427

[74] 't Mannetje 2020 The carcinogenicity of pesticides used in New Zealand. *NZ Medical Journal*. 133:1526;76-88

[75] Myers et al 2016. Concerns over use of glyphosate-based herbicides and risks associated with exposures: a consensus statement. *Environmental Health* 15(19). DOI 10.1186/s12940-016-0117-0.

[76] Mesnage et al 2014. Major Pesticides Are More Toxic to Human Cells Than Their Declared Active Principles. *BioMed Research International* doi: 10.1155/2014/179691.

[77] Maamar et al 2020. Epigenome-wide association study for glyphosate induced transgenerational sperm DNA methylation and histone retention epigenetic biomarkers for disease. *Epigenetics*, DOI: 10.1080/15592294.2020.1853319

[78] Zhang,et al 2019. Exposure to Glyphosate-Based Herbicides and Risk for Non-Hodgkin Lymphoma: A Meta-Analysis and Supporting Evidence. Mutation Research.

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

Regulators assume there is a threshold of exposure, below which there is no effect of a toxic substance. However, this has been shown to be incorrect, and low dose harm at endocrinologically (hormone) relevant levels may occur.

Studies are outdated because they do not consider gender-based (sex-specific) hormone differences.[80] Glyphosate exhibits the key characteristics of a hormone disruptor, impacting genders differently.[81] [82] [83] A recent study looked at maternal urinary levels of glyphosate, and identified females had effects associated with excess androgen exposure. Androgen is a masculinization hormone that adversely impacts sexual development.[84] Studies have drawn attention to the potential harm to sperm for nearly 30 years.[85] [86] [87] Recent papers have deepened knowledge relating to how glyphosate damages sperm quality.[88] [89]

Toxic exposures can lead to cascading harm. For example, in fish, glyphosate induces oxidative stress, producing an inflammatory response leading to lipid accumulation and liver damage.[90] GBHs are found to be toxic at environmentally relevant levels – levels commonly detected in the environment.[91]

Requirement to consider frequency of spills and court information relating to dermal exposure

Question 4.2, asked by the NZEPA, assumes adverse effects occur from use of GBHs, as spills and inadvertent poisoning of PCUs is common.[92] [93] However, serum testing of farmers to understand exposures is rare and difficult for the public to access. The U.S. court cases demonstrated dermal exposure could be more than assumed in regulatory science – and that this knowledge was understood by Monsanto.

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[80] Vom Saal & Vandenberg. Update on the health effects of bisphenol A: Overwhelming evidence of harm. *Endocrinology* 1:162:3:bqaa171. DOI: 10.1210/endocr/bqaa171

[81] Munoz et al 2020. Glyphosate and the key characteristics of an endocrine disruptor: A review. Chemosphere 270:128619

[82] Ganesan & Keating 2020. Ovarian mitochondrial and oxidative stress proteins are altered by glyphosate exposure in mice. 402:115116

[83] Séralini, et al 2014. Republished study: long-term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize. RESEARCH Open Access Springer. *Environmental Sciences Europe* 2014, 26:14.

[84] Lesseur et al 2021. Maternal urinary levels of glyphosate during pregnancy and anogenital distance in newborns in a US multicenter pregnancy cohort. *Env Pollution*. 280:117002

[85] Yousef et al 1995. Toxic effects of carbofuran and glyphosate on semen characteristics in rabbits. *Environ Sci Health* B. 1995 Jul;30(4):513-34.

[86] Romano et al 2010 Prepubertal exposure to commercial formulation of the herbicide glyphosate alters testosterone levels and testicular morphology. *Arch. Toxicol*., 84:309–317

[87] Romano et al 2011Glyphosate impairs male offspring reproductive development by disrupting gonadotropin expression. *Arch Toxicol*. 2012 Apr;86(4):663-73. doi: 10.1007/s00204-011-0788-9. Epub 2011 Nov 26.

[88] Akça et al 2021. Glyphosate disrupts sperm quality and induced DNA damage of rainbow trout (Oncorhynchus mykiss) sperm. *J. Environ. Sci and Health*.

[89] Epigenome-wide association study for glyphosate induced transgenerational sperm DNA methylation and histone retention epigenetic biomarkers for disease

[90] Liu et al 2021 Glyphosate-induced lipid metabolism disorder contributes to hepatotoxicity in juvenile common carp. *Environmental Pollution*. 269:116186

[91] Faria et al 2021. Glyphosate targets fish monoaminergic systems leading to oxidative stress and anxiety. 146:106253

[92] Connolly et al 2019. Evaluating Glyphosate Exposure Routes and Their Contribution to Total Body Burden.

[93] Boedeker et al 2020. The global distribution of acute unintentional pesticide poisoning.

Dermal exposure is the greatest risk for PCUs. Court transcripts from the Pilliod trial[94] revealed how moisture and sweating improved the uptake of glyphosate through clothing into human cells and that the GBH formulation increased penetration into skin. The trial transcripts outlined that washing off the GBH formulation was difficult as glyphosate bound to the skin. The transcript discusses how the dermal absorption studies used by regulators have historically underestimated the percentage of glyphosate that was absorbed and resided, or pooled in the epidermis layer of skin. The transcript outlined how exudation from the epidermis increased the length of exposure and therefore absorption, from the epidermis into the body did not occur for a couple of hours, but could continue for days.

By convention, hazardous substance regulators consider that dermal exposure is only 3% of total exposures when PCUs use glyphosate.[95] The Monsanto trials revealed that 5–20% of glyphosate could be stored in the skin. Finally, after absorption of glyphosate, the tests of operators assumed that testing urine was sufficient to indicate exposure levels, however the U.S. court cases revealed that faeces contain much higher levels of glyphosate than urine. In dermal exposure tests, faeces were not tested, and when farming families were tested, only urine was tested, not faeces. Trial evidence revealed how low levels (rather than high doses which would go direct into urine) of glyphosate would be processed by the liver, and travel through the bile duct.[96]

Cancer is an occupational disease for users of herbicides.[97]

Crucial herbicide has been developed for much greater adhesion and absorption to ensure better penetration into plant leaves.[98] The formulation has not been tested on human skin to understand the risk to humans. The formulation is always mixed, as it is a concentrated formulation, and must be mixed if it is to be applied at the standard rate, thus increasing the exposure humans have to it.

Glyphosate and GBHs disrupt the immune system, increasing inflammation in fish and mammals, and metabolic damage from oxidative stress (the IARC demonstrated this occurs from exposure to GBHs). Oxidative stress can encourage chronic inflammatory conditions which can set in place conditions for cancer. While GBHs increase oxidative stress, mixtures of herbicides increase risk for oxidative stress more than single-use herbicides.[99]

Requirement to consider mental health from usage of herbicide mixtures

Farmers commonly use mixtures in order to manage herbicide resistance, and this appears to increase their risk of developing conditions associated with oxidative stress, including cancer and neurological impairment and delay. The brain is particularly vulnerable to oxidative damage. Recently glyphosate has been shown to target fish neuron networks, leading to oxidative stress and anxiety.[100]

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

[95] Benbrook 2020. Shining a Light on Glyphosate-Based Herbicide Hazard, Exposures and Risk. P.500

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

[97] Stoop 2018. Pesticides and cancer among farmers: the rush towards irrefutability. https://www.europeanscientist.com/en/features/pesticides-and-cancer-among-farmers-the-rush-towards-irrefutability/

[98] https://cdn.nufarm.com/wp-content/uploads/sites/17/2019/07/07144835/204790-Nufarm-CRUCIAL-Brochure-Update-A5-WEB.pdf

[99] Intayoung et al. 2021. Effect of Occupational Exposure to Herbicides on Oxidative Stress in Sprayers. *Safety and Health at Work*. 12:1;127-132

[100] Faria et al 2021. Glyphosate targets fish monoaminergic systems leading to oxidative stress and anxiety. 146:106253

PCUs commonly use a mixture of different herbicides, and long-term exposure is associated with poor mental health. Mental illness and disabling neurological conditions – including depression, Parkinson's[101] [102] and Alzheimer's disease – are increasingly recognised as occupational diseases for PCUs.[103] [104] [105] [106] [107] [108] [109] [110]

Glyphosate formulations are more toxic to the nervous system than the active ingredient glyphosate.[111] [112] Neurotransmitters affected by glyphosate include serotonin, dopamine and norepinephrine.[113] [114] GBHs inhibit acetylcholinesterase (AChE) and induce stress, inducing learning and memory impairment.[115] There is increasing evidence that glyphosate exposures may contribute to autism spectrum disorder risk.[116]

Communities and children living in agricultural regions have higher pesticide residues in their bodies than groups not living near agricultural regions. The absence of monitoring, including biomarker testing and soil testing to identify aggregate herbicide pressure fails rural families. The brain and nervous system are not fully developed until age 10–12 and neurotoxic chemicals can produce permanent damage.[117]

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[101] Pouchieu et al 2018. Pesticide use in agriculture and Parkinson's disease in the AGRICAN cohort study. International *Journal of Epidemiology*, 47;1:299–310

[102] Baltazar et al 2014. Pesticides exposure as etiological factors of Parkinson's disease and other neurodegenerative diseases— A mechanistic approach. *Toxicology Letters* 230:85-103

[103] Corral et al 2017. Cognitive impairment in agricultural workers and nearby residents exposed to pesticides in the Coquimbo Region of Chile. *Neurotoxicology and Teratology* 62:13-19

[104] Kori et al 2018. Neurochemical and Behavioral Dysfunctions in Pesticide Exposed Farm Workers: A Clinical Outcome. *Ind J Clin Biochem* 33;4:372–381

[105] Dardiotis et al 2019. Pesticide exposure and cognitive function: Results from the Hellenic Longitudinal Investigation of Aging and Diet (HELIAD). *Environmental Research*. 177:108632

[106] Khan et al 2019. A Pest to Mental Health? Exploring the Link between Exposure to Agrichemicals in Farmers and Mental Health. *Int. J. Environ. Res. Public Health* 16;1327. DOI:10.3390/ijerph16081327

[107] Tsai et al 2019. Fine particulate matter is a potential determinant of Alzheimer's disease: A systemic review and meta-analysis. *Environmental Research* 177:108638

[108] Medehouenou et al 2019. Exposure to polychlorinated biphenyls and organochlorine pesticides and risk of dementia, Alzheimer's disease and cognitive decline in an older population: a prospective analysis from the Canadian Study of Health and Aging. Environmental Health. 18:57.

79 Yan et al 2016. Pesticide exposure and risk of Alzheimer's disease: a systematic review and meta-analysis. *Nature*. 6:32222

[109] Freire & Koifman 2013. Pesticides, depression and suicide: A systematic review of the epidemiological evidence. *International Journal of Hygiene and Environmental Health*. 216:445-460

[110] Weisskopf et al 2013 Pesticide Exposure and Depression Among Agricultural Workers in France. *American Journal of Epidemiology*, doi: 10.1093/aje/kwt089

[111] Aitbali, et al. 2018 Glyphosate based-herbicide exposure affects gut microbiota, anxiety and depression-like behaviors in mice, *Neurotoxicol. Teratol*. 67: 44–49.

[112] Gallegos, et al. 2016. Exposure to a glyphosate-based herbicide during pregnancy and lactation induces neurobehavioral alterations in rat offspring, *Neurotoxicology* 53:20–28.

[113] Pu et al 2020. Glyphosate Exposure Exacerbates the Dopaminergic Neurotoxicity in the Mouse Brain After Repeated Administration of MPTP. *Neurosci Lett*., doi: 10.1016/j.neulet.2020.135032

[114] Martínez et al. 2018. Neurotransmitter changes in rat brain regions following glyphosate exposure. *Environmental Research*, 161, 212-219.

[115] Ait Bali et al 2019. Learning and memory impairments associated to acetylcholinesterase inhibition and oxidative stress following glyphosate based-herbicide exposure in mice. *Toxicology*. 415:18-25

[116] Ongono et al 2020. Pesticides used in Europe and autism spectrum disorder risk: can novel exposure hypotheses be formulated beyond organophosphates, organochlorines, pyrethroids and carbamates? - A systematic review. *Environmental Research*, 187:109646

[117] Watts 2013. Poisoning our Future: Children and Pesticides. Auckland: Pesticide Action Network Asia and the Pacific. https://www.panna.org/resources/poisoning-our-future-children-and-pesticides

Long-term exposure to glyphosate is a risk factor for depression. Rodent studies, used by regulatory agencies to identify risk factors for human health, demonstrate that 'both prenatal and postnatal periods cause oxidative stress, affects cholinergic and glutamatergic neurotransmission in offspring hippocampus'.[118] These effects change how the brain functions, increasing depression risk. This study also revealed how GBH exposures reduced acetylcholinesterase (AChE), an enzyme that aids neurotransmitter function.

Teenagers in agricultural communities are also at greater risk of depression and there is evidence that exposure to GBHs play a role.[119] Pesticide exposed people have lower levels of AChE in their blood and AChE activity is a biomarker of pesticide exposure. The teenagers who had lower levels of depression also had lower acetylcholinesterase (AChE) in the blood.

Studies on mental health and herbicide use in Aotearoa have not been undertaken, despite farmers being at high risk for depression, suicide, Parkinson's and dementia.

Requirement to assess exposure levels in humans and the environment and analyse hazard.

Prior exposure to herbicides and nutrients alter the capacity of ecosystems to safely degrade GBH, and increase potential for bioaccumulation, and favour GBH tolerant species.[120] Annual applications of GBHs and runoff into sediment can result in permanent GBH contamination and metabolite accumulation in the sediment.[121]

Runoff from agriculture can contaminate groundwater wells, and long-lived metabolites can travel considerable distances away from the site where spraying occurred.[122] The formulation, which contains petroleum by-products and heavy metals,[123] can be toxic at levels below the levels considered by regulators to be safe.[124]

Requirement to adopt 21st century technology in risk assessment

Current regulatory risk assessment is outdated[125] [126] [127] and New Zealand's recently released risk assessment methodology[128] is muddled and lacking a clear line of sight between toxicity and

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[118] Cattani et al.2017. Developmental exposure to glyphosate-based herbicide and depressive-like behavior in adult offspring: Implication of glutamate excitotoxicity and oxidative stress. *Toxicology*. 387:67-80

[119] Suarez-Lopez 2020. Associations of acetylcholinesterase activity with depression and anxiety symptoms among adolescents growing up near pesticide spray sites. *Int J Hyg Environ Health*. DOI:10.1016/j.ijheh.2019.06.001

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

[121] Robichaud & Rooney 2021. Low concentrations of glyphosate in water and sediment after direct over-water application to control an invasive aquatic plant. *Water Research* 188:116573

[122] Hintze et al. (2020). Influence of surface water–groundwater interactions on the spatial distribution of pesticide metabolites in groundwater. *Science of the Total Environment*. 733:139109

[123] Defarge et al.2018.Toxicity of formulants and heavy metals in glyphosate-based herbicides. *Toxicology Reports*, 156-163.

[124] Mesnage, et al. 2015 Potential toxic effects of glyphosate and its commercial formulations below regulatory limits, *Food Chem. Toxicol*. 84 (2015) 133–153.

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

[126] Myers et al. Concerns over use of glyphosate-based herbicides and risks associated with exposures: A consensus statement. Environ. Health 2016, 15, 19–32

[127] Vandenberg et al 2017. Is it time to reassess current safety standards for glyphosate-based herbicides? J. Epidemiol. Community Health 71, 613–618. https://doi.org/10.1136/jech-2016-208463.

[128] Request for feedback on our risk assessment guide https://www.epa.govt.nz/public-consultations/decided/request-for-feedback-on-our-risk-assessment-guide/

regulatory action. In a recent consultation to alter the methodology, the NZEPA did not include the issues of concern to the public, such as the outdated approach to risk assessment and the problem of identifying hormonally relevant toxicity within the scope for consultation.

In the response to feedback on the development of the methodology, the regulator commonly responded to public concerns with the comment 'the use of chemicals is an emotive issue'.[129] Issues of concern to the public were largely outside the consultation – the reliance on industry data, absence of precaution, overweighting on cost-benefit rather than human health, the failure to monitor chemicals and their metabolites, and transparently feedback data to the public and regulators, were outside the scope.

The resultant methodology paper does not mention precaution; it continues to heavily rely on applicant (industry) data – encouraging applicants to submit their own risk assessments with their applications. The methodology paper prioritises linear individual chemical modelling rather than feedback from environmental and human health biomonitoring to understand aggregate health risk, which is required in order to protect human and environmental health, as is required by its directive legislation. [130] The outdated guidelines that were outside the scope,[131] for example, meant that the current methodology avoided issues relating to how regulators grapple with the scientific knowledge that oxidative stress and endocrine disruption set the conditions for many of the diseases that PCUs and rural families are particularly at risk of, including cancer and mental illness. Also outside the scope was the increased risk following exposure to the stronger full GBH formulation.

New technologies can be applied to more sensitively understand the impact to human and environmental health.[132] [133] Regulators must take account of formulation and mixture risk [134] and new omics technologies can reveal how formulations produce a range of biological harms in the body.[135] Shifting from a reliance on industry supplied studies, placing more weight on mechanistic data and low dose effects like oxidative stress, integrating high throughput technologies that can identify multiple biomarkers, can shift regulatory science into the 21st century. [136]

Part 7: Benefits and alternatives to glyphosate products

Public awareness of the human and environmental health harm of GBHs and substitute herbicidal products is high. The scientific literature indicates that novel technologies, such as gene drive technologies[137] are being explored as potential replacement technologies for synthetic herbicides,

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[129] NZEPA 2020. Response to feedback on EPA's risk assessment methodology for hazardous substances: Summary of submissions received on the May 2018 consultation

[130] 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

[131] NZEPA 2012, Thresholds and Classifications under the Hazardous Substances and New Organisms Act 1996: User Guide, https://www.epa.govt.nz/assets/Uploads/Documents/Hazardous-Substances/Guidance/Manufactured-articles-info-sheet.pdf, accessed 25/01/2018

[132] Olesti et al 2021. Approaches in metabolomics for regulatory toxicology applications. *Analyst*, 2021, 146, 1820

[133] Rodriguez et al 2020. Omics Approaches to Pesticide Biodegradation. *Current Microbiology* 77:545-563

[134] Kortenkamp, A., & Faust, M. (2018). Regulate to reduce chemical mixture risk. *Science*, 224- 226.

[135] 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

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

[137] Sustainability Council 2018. A Constitutional Moment: Gene Drive and International Governance. http://www.sustainabilitynz.org/a-constitutional-moment-gene-drive-and-international-governance/

such as GBHs.[138] [139] [140] There is continued evidence that public scepticism about the safety of organisms released into the environment are well founded. Genetic modification and gene editing technologies continue to carry with them substantial uncertain risk of off-target harm[141] [142] [143] and New Zealand has not been good at stewarding these technologies.[144] There is potential for horizontal gene transfer across species[145] and the funding to advance these technologies vastly outweighs research to examine risk. This is why precautionary legislation to prevent emission into the environment of GMO/GE technology is in place in Europe and New Zealand. High level commentaries position novel technologies, including synthetic chemicals and genetic engineering, as a threat to earth system boundaries.[146]

Mechanical and robotic technologies have turned a corner in the last three years, but still represent a risk to farmers who invest in these technologies. In New Zealand an increasing range of contractors provide remote-control weed mowing and mulching which can manage steep inclines safely. However, at this stage they are more likely to be taken up by lifestyle block owners, who are more likely to recognise GBH and associated herbicide toxicity, than farmers who have depended on GBHs for years.

Farmers and PCUs may be reluctant to acknowledge GBH risk. For decades, farmers have faced an impossible double-bind situation where they have been required to apply highly toxic cocktails of environmental herbicides in order to achieve productivity and pay mortgages. This dilemma is a function of the necessity of long-term weed management where there is an absence of viable options. Farmers had to navigate the psychological quandary 'the ends justify the means' in order to justify their exposures which carry substantial health risks. Due to the development and start-up costs and time to market, private industries have been unwilling to step into this arena in New Zealand, a classic case of market failure that would traditionally be viewed as an opportunity for state intervention. For farmers, the problem has been firstly, exacerbated by herbicide resistance, which has resulted increased exposures to herbicide formulation; secondly, upheld by the severing of public good extension services that could act to reduce chemical dependency and thirdly, reinforced by an agricultural media historically highly dependent on advertising revenue.

Transition from herbicide dependent farming is required due to the problem of herbicide resistance which requires an integrated weed management approach. The state has a role in reintroducing extension services in agriculture, and providing information and education to the public sector –

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[138] Kumaran et al 2020. Gene technologies in weed management: a technical feasibility analysis. Current Opinion in Insect Science 38: 6-14

[139] Legros et al 2021. Gene drive strategies of pest control in agricultural systems: Challenges and opportunities. Evolutionary Applications 00:1-17

[140] Perotti et al 2020. Herbicide resistant weeds: A call to integrate conventional agricultural practices, molecular biology knowledge and new technologies. Plant Science 290:110255

[141] ENSSNER 2019. Gene Drives: A report on their science, applications, social aspects, ethics and regulations. 2019. Critical Scientists Switzerland, European Network of Scientists for Social and Environmental Responsibility and Vereinigung Deutscher Wissenschaftler (VDW). ISBN: 978-3-00-062389-9

[142] Murugan K. et al 2020. CRISPR-Cas12a has widespread off-target and dsDNA-nicking effects. *Journal of Biological Chemistry*. doi: 10.1074/jbc.RA120.012933

[143] Von Gleich A & Schröder, W. 2020. Gene Drives at Tipping Points. Precautionary Technology Assessment and Governance of New Approaches to Genetically Modify Animal and Plant Populations. Springer. DOI https://doi.org/10.1007/978-3-030-38934-5

[144] McGuiness W., Versteed S., White W. Review of the Forty-Nine Recommendations of the Royal Commission on Genetic Modification. Sustainable Future Limited, April 2008

[145] Hayes et al 2018. Identifying and Detecting Potentially Adverse Ecological Outcomes Associated with the Release of Gene-Drive Modified Organisms. Journal of Responsible Innovation5 (Suppl. 1): S139–S158.

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

including NZTA, territorial and local authorities and the Department of Conservation to support a shift to integrated weed management.[147]

For urban, industrial and asset management in the public sector, research funding is required to identify operating units, and public-good resourcing is required to source and support transition to safe, operator assisted and/or remote-controlled mechanical non-chemical weeding (mowing and mulching) services.[148] [149]

Robotic weeding systems range from small bots used in turf management, to small portable automated robots that can operate alone or in a fleet, to autonomous interrow cultivators that cultivate multiple rows in a single pass.[150] Electrochemical and robotics technologies are disruptive technologies that can pivot growers and applicators out of the treadmill of herbicide use with its associated and persistent health harms. New technologies can be applied for urban[151] and to protect industrial areas including railways.[152]

Specialty growers employ hand-weeding technologies, however price, competition and labour shortages have encouraged the development of robotic weeding technologies.

The barriers to development of robust agriculture robots include high capital investment, a lack of standardisation and concerns about safety of field workers. Farmer concerns include the dependability and durability of the products. However, the benefits include reduced labour costs,[153] lower development costs for robots, and less complex regulations, as robots can travel between crop types without fear of contamination by herbicides that are suitable for one crop type but not another.[154]

Machine-detectable differentiation of crop species using labels or topic markers can identify and remove non-crop species. For example, identifying markers on lettuce and tomato plants, which helped robotic technologies avoid the desired species (tomatoes and lettuce), but cultivate the weed species, found that 90% more weeds from tomato and 66% more weeds from lettuce than standard cultivators without reducing yields.[155] Markers could be applied to *Pinus radiata* seedlings before aerial distribution of seedlings. A fluorescent marker compound applied to crop roots and translocated to leaves, could potentially by engaged for automated crop signalling systems.[156]

[147] Merfield 2019. Integrated weed management in arable crop systems. Foundation for Arable Research.
[148] E.g. BOSCH Corporate Research and DeepField Robotics
[149] E.g. Grazor.co.nz. https://www.irus.de/produkte.php?p_id=11&lang=EN
2021 Promotional literature https://www.irus.de/files/Prospekt_Funkgesteuert_EN_2021-05_WEB.pdf
E.g. Roadside Dücker, Gerhard, GmbH & Co. KGLSM 740 guiding post mower https://www.youtube.com/watch?v=7-pXAv0W2-I&t=54s
[150] Pandey et al 2020. A Literature Review of Non-Herbicide, Robotic Weeding: A Decade of Progress. White Paper prepared for Cotton Incorporated.
[151] E.g. Urban use https://zasso.com/portfolio/xpu/
[152] E.g. Vitirover mower-robots https://www.vitirover.fr/en-home
[153] Lowenberg-DeBoer et al 2020. Economics of robots and automation in field crop production. *Precision Agriculture* 21:278–299. https://doi.org/10.1007/s11119-019-09667-5
[154] Fennimore & Tourte 2019. Regulatory Burdens on Development of Automated Weeding Machines and Herbicides are Different. *Outlooks on Pest Management*. August 2019. DOI: 10.1564/v30_aug_02
[155] Kennedy et al. 2019. Crop signal markers facilitate crop detection and weed removal from lettuce and tomato by an intelligent cultivator. *Weed Technol*. doi: 10.1017/ wet.2019.120
[156] Su et al 2020. Development of a systemic crop signalling system for automated real-time plant care in vegetable crops. *Biosystems Engineering*.193:62-74

Marker systems have been applied to control robotic weed knives to uproot most weeds in close proximity to lettuce and tomato crops, containing varying densities of weeds.[157]

The integration of multiple technologies overlaps with other fields of robotic development as components integrated into the product include systems for vision, navigation, control and communications, robotics, and safety. AI adaptive learning systems can be integrated for terrain management, to improve machine-farmer interface, robotics and co-ordination and for weed identification. Hardware can be tractor-mounted or unmanned ground-based and aerial drone technologies, weed-sensor technologies.[158] [159] [160]

Sensor technologies include machine vision, global navigation satellite positioning systems and laser and ultrasonic (or distance) sensors which can classify plants or detect weed infestation.[161] Complex algorithms can be deployed, using a neural network approach, much as is applied to classify objects in pictures, to differentiate crop from non-crop seedlings.[162] Small agbots can mow between rows once crops are too high for larger vehicles, and mowing can reduce pressure from weed-seed banks.[163]

The interdisciplinary nature of robotics development may create uncertainties that result in challenges in achieving funding in New Zealand's highly competitive science funding system.

Integrated technologies developed for weed control have potential to be adapted for other applications.

Robotics technologies serve specialty crop markets, such as delicate lettuce varieties and the organics sector, are expanding quickly. These niche providers are expanding into larger crops.

Development of robotic weeding technologies include machine vision technologies which detect crop and non-crop plants. Weed control actuators (destroyers) include abrasives, cultivators, high-pressure water, lasers and propane flaming.[164] Field robots can scout for insect pests and foliar diseases, in addition to weeding. See also APPENDIX.[165]

> 'Because barriers to the transfer of physical weed control devices among crops are lower than for herbicides, the potential for their use in many specialty crops is high... robotic weeders are less regulated than herbicides and do not require the consent of so many parties, they will be cheaper and easier to adapt for a large number of crops.'[166]

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[157] Raja et al 2020. Real-time robotic weed knife control system for tomato and lettuce based on geometric appearance of plant labels. *Biosystems Engineering* 194:152-164. https://doi.org/10.1016/j.biosystemseng.2020.03.022

[158] Esposito et al.2021. Drone and sensor technology for sustainable weed management: a review. *Chem. Biol. Technol. Agric*. 8:18

[159] Fountas et al 2020. Agricultural Robotics for Field Operations. *Sensors* 2020, 20, 2672; doi:10.3390/s20092672

[160] Lam et al.2021. An open source workflow for weed mapping in native grassland using unmanned aerial vehicle: using Rumex obtusifolius as a case study. *European Journal of Remote Sensing*. 54:S1;71-88

[161] Machleb et al 2020. Sensor-based mechanical weed control: Present state and prospects. *Computers and Electronics in Agriculture*. 176:105638

[162] Knoll et al 2019. Real-time classification of weeds in organic carrot production using deep learning algorithms. *Computers and Electronics in Agriculture* 167: 105097

[163] McAllister et al 2020. Agbots 2.0: Weeding Denser Fields with Fewer Robots. Conference Paper. Robotics: Science and Systems 2020 Corvalis, Oregon, USA, July 12-16, 2020

[164] Fennimore et al 2016 Technology for automation of weed control in specialty crops. *Weed Technol* 30:823–837.

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The robustness and efficiency of robots are expected to continually improve, and future research is expected to focus on improvement of locomotion systems, sensors, computer vision algorithms and IoT-based smart agriculture which converge and embeds multiple technologies for maximum user benefit.[167] [168] Forestry robotics are challenged by rough terrain traversability, but benefits of robots engaged to act as mulcher weeders during the early growth stages include reduction of fire risk,[169] reduce invasive volunteer species and limit runoff into local waters.

Transitioning away from herbicide reliance to mechanical technologies which reduce pollution in soil and water is an environmental and social health-based public good and can be supported through external funding, in the same way as financial support might be granted for wetland restoration or riparian planting.

The organic sector is an early adopter of mechanical technologies, however adoption can differ by use scenario, for example market gardeners such as lettuce growers have been early adopters. Mechanical weed management not only reduces exposure to herbicides, but appears to have potential during workload peaks, when seasonal workers are difficult to source.[170]

European funding has enabled researchers to harness funding streams and work with startup industries to deepen knowledge of robotics and mechanical weeding.[171] The French Farm competitiveness plan, which is co-financed by the European Agricultural Fund for Rural Development (EAFRD), the French state and regional authorities supports up to 40% of machinery purchased.[172] Robs4Crops is a four-year project focussed on mainstreaming robotics in agriculture. Cofunded by the European Commission, the Netherlands based project aims to shift towards large-scale implementation of robotics technologies and is focussed on reducing repetitive manual tasks and implementing mechanical weed control technologies.[173] The AgROBOfarm project is a Business-Oriented Support to the European Robotics and Agri-food Sector, towards a network of Digital Innovation Hubs in Robotics.[174] In 2017, Europe initiated ROMI – Robotics for MIcrofarms, a strategy aimed to develop lightweight precision robots for the market (vegetable) farms sector.[175]

The EU1.5 million GALIRUMI project has been developed to deliver robot weeding to remove herbicide use in dairy farming, to remove barriers to transition for dairy farmers to organics. The project integrates weed detection, weed kill, autonomous vehicles and precision navigation. Laser defoliation and electricidal technologies are the predominant technologies under research to destroy weeds.[176] [177] [178]

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[167] Oliviera et al 2021. Advances in Agriculture Robotics: A State-of-the-Art Review and Challenges Ahead. *Robotics* 2021, 10, 52. https://doi.org/10.3390/robotics10020052

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[170] Spykman et al 2021 Farmers' perspectives on field crop robots – Evidence from Bavaria, Germany. *Computers and Electronics in Agriculture*. 186:10676

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[173] Robs4Crops. Four year project co-funded under Horizon2020. https://robs4crops.eu/about/

[174] Grant Contract number 825395 https://agrobofood.eu/.

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[176] GALIRUMI. Project Call: H2020 - Galileo 4th Call Contract Number: 870258 https://www.euspa.europa.eu/galileo-assisted-robot-tackle-weed-rumex-obtusifolius-and-increase-profitability-and-sustainability#tab-details

[177] E.g. Naïo Technologies (France) Dino https://www.naio-technologies.com/en/dino/
Oz https://www.naio-technologies.com/en/agricultural-equipment/weeding-robot-oz/

[178] E.g. Carrington April 29 2021 Killer farm robot dispatches weeds with electric bolts. *The Guardian*

Part 8: Hearing your views

New Zealand's agriculture focus for research and development has been disproportionately tilted to genetic improvement for productivity, and export-led innovation rather than to addressing soil health, herbicide tolerance, food quality, chemical hygiene (absence of contaminants) sustainability and labour shortages.

Weed management focuses tend to revert to technological measures that carry unknown risks to PCUs and the environment, such as new product development that is not declared to the public.[179] Herbicide resistance can be countered with the introduction of extension services and education for integrated weed management to PCUs in the private and public sector.[180] New remote control mowing and mulching services can contract out to the private and public sector, but state support is required to integrate these services with weed management and ensure the transition is effective.

8.2 Do you think the rules and controls are enough to manage the risks?

No. Self-reported exposures to herbicides are common.[181] As a result comments and claims that state GBHs are safe when applied correctly, or when applied according to label directions, underestimate the likelihood of risk of unintended dermal exposure.[182]

Spills are common.

The commercial formulation is more toxic.

Mixtures are more toxic.

GBHs absorb into skin longer than regulators assume, and persist in the environment for longer than regulators assume.

Sequential court cases found that GBHs cause cancer in commercial and professional users. The risks are far greater than narrowly framed cost-benefit analyses portray, and commence at very low-level exposures.

Recently, an Italian review which recognised the problem of the toxicity of the formulation, and the different environmental conditions, considered that controlling the use of GBH to limit exposures was required, concluding that 'it is the abuse of a product, even the most harmless, which determines its dangerousness'.[183]

8.3 Do you have any concerns that the use of glyphosate products impacts people's health?

Yes, we refer to Part 6 and 7.

Exposure to GBHs drives oxidative stress and inflammation, and is neurotoxic. These harms occur over the long term and at lower levels than outdated guidelines portray and predict. For regularly exposed individuals or vulnerable individuals such as children, these harms lead to cascading and interrelated illnesses, such as depression and cancer.

[179] APP204104 Decision Document https://www.epa.govt.nz/database-search/hsno-application-register/view/APP204104
[180] Merfield 2019. Integrated weed management in arable crop systems. Foundation for Arable Research.
[181] Firth HM, Rothstein DS, Herbison GP, McBride DI. Chemical Exposure among NZ Farmers. Int J Environ Health Res. 2007; 17(1):33-43. P.119
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[183] Leoci & Ruberti 2020. Glyphosate in Agriculture: Environmental Persistence and Effects on Animals. A Review. JAEID 114:1;99-122

8.4 Do you have any concerns that the use of glyphosate products impacts the environment?

Yes, we refer to Part 6 and 7.

GBHs persist much longer than regulators predict and New Zealand remains ignorant of the potential adverse effects across our varying environments.

8.5 Do you have any concerns that the use of glyphosate products impacts on public spaces?

Yes, we refer to Part 6 and 7.

Glyphosate is harmful, and the risk is particularly acute to children. Due to the persistence of GBHs, children playing or walking in public spaces could be exposed at low levels that cause neurological harm and oxidative stress, for weeks. The failure to identify these risks means that local authorities have ignored new herbicidal technologies.[184]

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

We refer to Parts 5, 6 and 7.

Transitioning away from GBH and herbicide dependency (which drives herbicide resistance and harms human and environmental health) carries substantial benefits to future generations. See Parts 5, 6, 7.

8.7 Do you think glyphosate products should be available and easy to buy for everyone, or available to professional users only?

1. Glyphosate should only be available to professional users in heavily regulated agricultural environments which limit the frequency of exposure to the user in order to ensure that GBHs do not persist on skin, in urine and in faeces. Restrictions on GBHs and herbicidal use can be aligned with rolling out of free extension services to farmers in order to transition to integrated weed management.
2. State assistance can provide start-up financing for mechanical technologies that do not carry risks from release into the environment that many biological agents (such as introduced weed predator species and gene edited organisms) carry with them.
3. There is a wide variety of mulching and mowing systems that can help the Department of Conservation move away from chemical use in national parks to support native forest regeneration.

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

Positively. Restrictions should reduce the risk of:

- Conventional PCUs being diagnosed with prostate cancer and multiple myeloma – recognised risk factors in farmers related to herbicide use.
- Children and families being poisoned from roadside spraying, as well as cyclists and joggers who use roadsides regularly for sport and exercise and are also at risk from multiple

[184] E.g. https://zasso.com/portfolio/xpu/

myeloma if they exercise regularly along roadsides in the weeks following a spray application.

- Offshore detections in more stringent regulatory jurisdictions, where governments act more quickly to ban the use of pesticides when human and environmental health are at risk.
- Organic growers and producers inadvertently being contaminated from glyphosate exposures through air, water or from drift from neighbouring properties.

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