Human and Environmental Risks of Glyphosate and Triclopyr for invasive weed control in natural areas:

Annotated partial bibliography
21 October 2020

Submitted to Sudbury Valley Trustees by Tim Simmons
This bibliography is a companion to the report, "A review of the potential human health and environmental risks of two commonly used herbicides (Glyphosate and Triclopyr) in natural areas management"

Acquavella, John, et al 2016. "Glyphosate Epidemiology Expert Panel Review: a Weight of Evidence Systematic Review of the Relationship between Glyphosate Exposure and Non-Hodgkin's Lymphoma or Multiple Myeloma." *Critical Reviews in Toxicology*, vol. 46, no. sup1, pp. 28–43., doi:10.1080/10408444.2016.1214681.

"this study found no evidence of an association between glyphosate and NHL. For MM, the case control studies shared the same limitations as noted for the NHL case-control studies and, in aggregate, the data were too sparse to enable an informed causal judgment. Overall, our review did not find support in the epidemiologic literature for a causal association between glyphosate and NHL or MM."

Aguilar-Dorantes ,K. Glyphosate Susceptibility of Different Life Stages of Three Fern Species American Fern Journal Vol. 105, Issue 3 (Sep 2015), pg(s) 131-144

"At the lowest concentration (0.33 g a.i. L-1), however, 50–69% of the plants of all three species and life stages survived after 90 days post-treatment… "We conclude that even glyphosate concentrations of 0.33 g a.i. L-1 may negatively impact natural spore banks of ferns and result in mortality of 31–50% of all green life stages. Such negative effects may also eliminate at least the most susceptible fern species in habitats that are frequently exposed to such glyphosate concentrations."

Alcock, John, et al. "Monarch Butterflies Use Regenerating Milkweeds for Reproduction in Mowed Hayfields in Northern Virginia." *Journal of the Lepidopterists' Society*, vol. 70, no. 3, 2016, pp. 177–181., doi:10.18473/107.070.0302.

American Cancer Society 2020. Lists of potential carcinogens: https://www.cancer.org/cancer/cancer-causes/general-info/known-and-probable-human-carcinogens.html

"Classification 2A (includes the following but this list is not complete)

Acrylamide Androgenic (anabolic) steroids
Art glass, glass containers, and press ware (manufacture of)
Biomass fuel (primarily wood), emissions from household combustion
Bitumens, occupational exposure to oxidized bitumens and their emissions during roofing
Bischloroethyl nitrosourea (BCNU), also known as carmustine
Captafol
Carbon electrode manufacture
Cobalt metal with tungsten carbide
Creosotes
DDT (4,4'-Dichlorodiphenyltrichloroethane)
Frying, emissions from high-temperature
Glycidol
Glyphosate
Hairdresser or barber (workplace exposure as)
Human papillomavirus (HPV) type 68 (infection with)
Hydrazine

Lead compounds, inorganic
Malaria (caused by infection with Plasmodium falciparum)
Malathion Nitrate or nitrite (ingested) under conditions that result in endogenous nitrosation
Non-arsenical insecticides (workplace exposures in spraying and application of)
Petroleum refining (workplace exposures in)
Polybrominated biphenyls (PBBs)
Red meat (consumption of)
Shiftwork that involves circadian disruption
Styrene
Styrene-7,8-oxide
3,3′,4,4′-Tetrachloroazobenzene
Tetrachloroethylene (perchloroethylene)
Very hot beverages (above 65 degrees Celsius)
Vinyl bromide (Note: For practical purposes, vinyl bromide should be considered to act similarly to the human carcinogen vinyl chloride.)
Vinyl fluoride (Note: For practical purposes, vinyl fluoride should be considered to act similarly to the human carcinogen vinyl chloride.)"

Antunes-Kenyon, S., and G. Kennedy 2004. A Review of the Toxicity and Environmental Fate of Triclopyr. Submitted to the Massachusetts Pesticide Board Subcommittee.

"In summary, strict adherence to Renovate 3 labeling, will result in minimal acute and negligible chronic risks to most fish, waterfowl, amphibians and aquatic invertebrates from triclopyr TEA and its metabolites. However, use of Renovate 3 in wetlands may result in significant risks to threatened and endangered aquatic plant species. Strict adherence to product labeling with oversight via the State's wetlands protection laws, permit requirements for nuisance aquatic vegetation, and endangered species program requirements, are adequate to manage these risks in sensitive areas."

Arora, S. "Techniques for Pesticide Risk Assessment." *Pesticide Risk Assessment*, 2019, pp. 181–205., doi:10.1079/9781780646336.0181. Accessed on-line: https://books.google.com/books?hl=en&lr=&id=FS-hDwAAQBAJ&oi=fnd&pg=PR1&dq=Arora,+S.+%E2%80%9CTechniques+for+Pesticide+Risk+Assessment.%E2%80%9D+Pesticide+Risk+Assessment,+&ots=ir6eTwkkPP&sig=LYumAuLxGFTmJ_I-n5xdZV3lOOw#v=onepage&q=Arora%2C%20S.%20%E2%80%9CTechniques%20for%20Pesticide%20Risk%20Assessment.%E2%80%9D%20Pesticide%20Risk%20Assessment%2C&f=false

"A risk to human health is always present when handling pesticides and their formulated products"

Auberson-Huang, Lillian. "The Dialogue between Precaution and Risk." *Nature Biotechnology*, vol. 20, no. 11, 2002, pp. 1076–1078., doi:10.1038/nbt1102-1076.

"The 'precautionary approach' or 'precautionary principle' is based on the premise that activities threatening harm to human health or the environment require precautionary measures, even if some cause-and effect relationships are not fully established scientifically."

Austin, A. P., Harris, G. E., and Lucey, W. P., Impact of an organophosphate herbicide (Glyphosate®) on periphyton communities developed in experimental streams, *Bull. Environ. Contam. Toxicol.*, 47, 29, 1991.

"The paucity of published research on action of glyphosate on periphyton architecture, species composition, bio-accumulation, trophic transport (especially through secondary and tertiary consumer species preyed upon by juvenile salmonids) further recommends caution in the application of this herbicide."

Balbuena, M. S., et al. 2015. "Effects of Sublethal Doses of Glyphosate on Honeybee Navigation." *Journal of Experimental Biology*, vol. 218, no. 17, pp. 2799–2805., doi:10.1242/jeb.117291.

"These results suggest that, in honeybees, exposure to levels of GLY commonly found in agricultural settings impairs the cognitive capacities needed to retrieve and integrate spatial information for a successful return to the hive. Therefore, honeybee navigation is affected by ingesting traces of the most widely used herbicide worldwide, with potential long-term negative consequences for colony foraging success."

Barukčić, Ilija. "Glyphosate and Non-Hodgkin Lymphoma: No Causal Relationship." *Journal of Drug Delivery and Therapeutics*, vol. 10, no. 1-s, 2020, pp. 6–29., doi:10.22270/jddt.v10i1-s.3856.

"In this re-analysis, no causal relationship was apparent between Glyphosate and NHL and its subtypes"

Bates, Nicola, and Nick Edwards. "Glyphosate Toxicity in Animals." *Clinical Toxicology*, vol. 51, no. 10, 2013, pp. 1243–1243., doi:10.3109/15563650.2013.851390.

Very high concentrations were used.

Battaglin, W.A., et al. "Glyphosate and Its Degradation Product AMPA Occur Frequently and Widely in U.S. Soils, Surface Water, Groundwater, and Precipitation." *JAWRA Journal of the American Water Resources Association*, vol. 50, no. 2, 2014, pp. 275–290., doi:10.1111/jawr.12159.Chromatography revealed widespread low levels of degradation products though well below drinking water quality standards.

Beane, N.R. et al. "Integrated Assessment of vegetation and Soil Conditions Following Herbicide Application" 2017. ERDC/EL TR-17-9.

Vegetation and soil conditions were evaluated prior to, and following cut-stump herbicide (Remedy Ultra) application implemented to control woody vegetation and maintain open grassland areas at Fort Hood, TX. Field monitoring assessed herbicide concentrations in soil and water. Herbicides were not observed in creeks and ponds adjacent to treatment areas. In soils, herbicide concentrations decreased by 72% over one month, likely due to microbial degradation, and with distance from the point of application. Monitoring results suggest that limited lateral and/or vertical transport occurred under field conditions.

Belbin, Fiona E., et al. "Plant Circadian Rhythms Regulate the Effectiveness of a Glyphosate-Based Herbicide." *Nature Communications*, vol. 10, no. 1, 2019, doi:10.1038/s41467-019-11709-5.

"We identify a daily and circadian rhythm in the inhibition of plant development by glyphosate, due to interaction between glyphosate activity, the circadian oscillator and potentially auxin signaling. We identify that the circadian clock controls the timing and extent of glyphosate-induced plant cell death. Furthermore, the clock controls a rhythm in the minimum effective dose of glyphosate. We propose the concept of agricultural chronotherapy, similar in principle to chronotherapy in medical practice. Our findings provide a platform to refine agrochemical use and development, conferring future economic and environmental benefits."

Bell, James R., et al. "Do Incremental Increases Of The Herbicide Glyphosate Have Indirect Consequences For Spider Communities?" *Journal of Arachnology*, vol. 30, no. 2, 2002, pp. 288–297., doi:10.1636/0161-8202(2002)030[0288:diioth]2.0.co;2.

"We attribute the lack of any effect to a large number of common agricultural species which are never eliminated from a habitat, but are instead significantly reduced…"

Belsky, Joseph, and Neelendra K. Joshi. "Assessing Role of Major Drivers in Recent Decline of Monarch Butterfly Population in North America." *Frontiers in Environmental Science*, vol. 6, 2018, doi:10.3389/fenvs.2018.00086.
"However, the non-target effects of these commonly used herbicides to the monarch host-plant, milkweed (Asclepias spp. L.), which commonly grows within GM planted agricultural fields has also been hypothesized to explain reduced breeding habitats in the midwestern United States. Currently, significant uncertainty regarding the dynamics of these multiple hypotheses and how their interaction may impact the eastern monarch butterfly population remains."

Benbrook, Charles M. "How Did the US EPA and IARC Reach Diametrically Opposed Conclusions onthe Genotoxicity of Glyphosate-Based Herbicides?" *Environmental Sciences Europe*, vol. 31, no. 1, 2019, doi:10.1186/s12302-018-0184-7.
"EPA and IARC reached diametrically opposed conclusions on glyphosate genotoxicity for three primary reasons: (1) in the core tables compiled by EPA and IARC, the EPA relied mostly on registrant-commissioned, unpublished regulatory studies, 99% of which were negative, while IARC relied mostly on peer-reviewed studies of which 70% were positive (83 of 118); (2) EPA's evaluation was largely based on data from studies on technical glyphosate, whereas IARC's review placed heavy weight on the results of formulated GBH and AMPA assays; (3) EPA's evaluation was focused on typical, general population dietary exposures assuming legal, food-crop uses, and did not take into account, nor address generally higher occupational exposures and risks. IARC's assessment encompassed data from typical dietary, occupational, and elevated exposure scenarios. More research is needed on real-world exposures to the chemicals within formulated GBHs and the biological fate and consequences of such exposures.

Benbrook, Charles M. "Trends in Glyphosate Herbicide Use in the United States and Globally." *Environmental Sciences Europe*, vol. 28, no. 1, 2016, doi:10.1186/s12302-016-0070-0.
Use is increasing worldwide

Borenstein, M. et al. 2009. An introduction to meta-analysis. John Wiley and Sons. ISBN: 978-0-470-05724-7
"If the entire review is performed properly, so that the search strategy matches the research question, and yields a reasonably complete and unbiased collection of the relevant studies, then (providing that the included studies are themselves valid) the meta-analysis will also be addressing the intended question. On the other hand, if the search strategy is flawed in concept or execution, or if the studies are providing biased results, then problems exist in the review that the meta-analysis cannot correct."

Carreiro, Margaret M., et al. "Efficacy and Nontarget Effects of Glyphosate and Two Organic Herbicides for Invasive Woody Vine Control." *Natural Areas Journal*, vol. 40, no. 2, 2020, p. 129., doi:10.3375/043.040.0204.
Did not target typical invasives in our area. "We found that glyphosate killed these vines after two spray treatments, but that a third treatment was needed the next year for the organic herbicides to kill or reduce vines. This reduction lasted into a third summer. We detected no herbicide effects on nematode densities and functional feeding groups, nor on abundance and species richness of moss and fern germinants. Although these organic herbicides cost 5–6.5 times more than glyphosate at dosages used, they greatly reduced these woody vines and can expand choices for chemical plant control for natural areas managers."

Carter, Evin T., et al. "Invasive Plant Management Creates Ecological Traps for Snakes." *Biological Invasions*, vol. 19, no. 1, 2016, pp. 443–453., doi:10.1007/s10530-016-1289-9.
"Of those fatal injuries that were a result of management operations, four were the result of being crushed during mowing or brush cutting operations, three were crushed by heavy machinery during cut brush manipulations, and two were crushed following herbicide treatment by off-road vehicle. Nonfatal injuries included two snakes cut by mowers and two suffering bone fractures during cut brush manipulations"

Cessna, Allan J., et al. "Environmental Fate of Triclopyr." *Reviews of Environmental Contamination and Toxicology*, 2002, pp. 19–48., doi:10.1007/978-1-4757-4260-2_2.
"At rates of 1-10 kg acid equivalent (a.e.) ha-I, tric10pyr can be applied to control woody plants and many broad-Ieaved weeds in noncropland areas such as rights-of-way, industrial areas, coniferous forests, rangeland, and permanent pastures"

Chakravarty, P. and S.S. Sidu. 1987. "Effect of glyphosate, hexazinone, and triclopyr on in vitro growth of five species of ectomycorrhizal fungi." *European Journal of Forest Pathology*. 17: 204-210.
"*In vitro* growth tests with glyphosate (Roundup[R]), hexazinone (liquid Velpar L.[R] and granular Pronone™5G[R]) and trichlopyr (Garlon[R]) on five species of ectomycorrhizal fungi (*Hebcloma crustuliniforme, Laccaria laccata, Thelophora amcrieana, T. terrestris and Suillus tomentosus*) showed varied species sensitivity to different concentrations of herbicides. Fungal growth was significantly (P = 0.05) reduced particularly at concentrations above 10 ppm. Garlon with tricloopyr as a. i. was the most toxic of the four herbieide formulations." Garlon reduced growth in five species of fungi at concentrations of 0.1 ppm and above.

Chang, Ellen T., and Elizabeth Delzell. 2016. "Systematic Review and Meta-Analysis of Glyphosate Exposure and Risk of Lymphohematopoietic Cancers." *Journal of Environmental Science and Health, Part B*, vol. 51, no. 6, 2016, pp. 402–434., doi:10.1080/03601234.2016.1142748.
"Bias and confounding may account for observed associations. Meta-analysis is constrained by few studies and a crude exposure metric, while the overall body of literature is methodologically limited and findings are not strong or consistent. Thus, a causal relationship has not been established between glyphosate exposure and risk of any type of LHC."

EFSA 2017. Peer review of the pesticide risk assessment of the potential endocrine disrupting properties of glyphosate "Conclusion on the Peer Review of the Pesticide Risk Assessment of the Active Substance Glyphosate." *EFSA Journal,* vol. 13, no. 11, 2015, doi:10.2903/j.efsa.2015.4302.
"The current assessment concluded that the weight of evidence indicates that glyphosate does not have endocrine disrupting properties through oestrogen, androgen, thyroid or steroidogenesis mode of action based on a comprehensive database available in the toxicology area. The available ecotox studies did not contradict this conclusion."

Cornish, P., and S. Bergen. 2005. Residual effects of glyphosate herbicide in ecological restoration. Restoration Ecology 13:695-702.
Greenhouse experiments. In practice, these conditions will not coincide very often, so widespread failure due to glyphosate residues would not be expected and have not been reported. Davoren, Michael J, and Robert H Schiestl. 2018. "Glyphosate-Based Herbicides and Cancer Risk: a Post-IARC Decision Review of Potential Mechanisms, Policy and Avenues of Research." *Carcinogenesis*, vol. 39, no. 10, 2018, pp. 1207–1215., doi:10.1093/carcin/bgy105.
"The IARC has classified glyphosate as a probable human carcinogen, but its status as one is far from decided in the eyes of the international scientific community."

Druille, M. et al 2013. Glyphosate reduces spore viability and root colonization of arbuscular mycorrhizal fungi. Applied Soil Ecology Volume 64, February 2013, Pages 99-103
"One month after sowing, total root colonization and percentage of arbuscules and vesicles were determined. The spore viability in herbicide untreated soils was between 5.8- and 7.7-fold higher than in treated soils. This reduction was detected even when the lower rate was applied. Root colonization was significantly lower in plants grown in glyphosate treated soil than in untreated ones."

Duke, Stephen O, and Stephen B Powles. "Glyphosate: a Once-in-a-Century Herbicide." *Pest Management Science*, vol. 64, no. 4, 2008, pp. 319–325., doi:10.1002/ps.1518.
Glyphosate resistance in crops

Duke, Stephen O. 2018. "Glyphosate: The World's Most Successful Herbicide under Intense Scientific Scrutiny." *Pest Management Science*, vol. 74, no. 5, 2018, pp. 1025–1026., doi:10.1002/ps.4902.
Glyphosate resistant crops discussion.

Durkin 2002. Neurotoxicity, Immunotoxicity, and Endocrine Disruption with Specific Commentary on Glyphosate, Triclopyr, and Hexazinone: Final Report to the US Forest Service.
"Based on these risk assessments and the review of the more recent literature conducted in the preparation of this paper, there is no scientific basis for asserting that glyphosate, triclopyr, or hexazinone cause specific toxic effects on the nervous system, immune system, or endocrine function. Based on this review, no significant changes are needed in the current risk assessments for glyphosate, triclopyr, or hexazinone prepared by the U.S. EPA or currently being used by the USDA Forest Service with respect to conclusions about risks of endocrine disruption, immunotoxicity, or neurotoxicity."

Gregory, et al. 2013 "Herbicides for Natural Area Weed Management." *Herbicides - Current Research and Case Studies in Use*, , doi:10.5772/56183.
"Currently there are over 400 invasive non-native plants impacting approximately 133 million acres in the U.S. alone and it is estimated that invasive species are spreading at the rate of 1.7 million acres annually"

Frans, Lonna M., 2004, Pesticides detected in urban streams in King County, Washington, 1998–2003: U.S. Geological Survey Scientific Investigations Report 2004–5194, 19 p.
"The most frequently detected herbicides were prometon, trichlopyr, 2,4-D, and MCPP, and the most frequently detected insecticides were diazinon and carbaryl. All of the most frequently detected herbicides and insecticides were sold for homeowner use over the timeframe of this study."
"Residential use of pesticides by homeowners is a possible major source for the most frequently detected compounds in the urban streams. Four compounds that were detected only in samples from the site on an irrigation return are most often associated with agricultural applications rather than residential use."

Gillam, Carey. *Whitewash: The Story of a Weed Killer, Cancer, and the Corruption of Science*. Island Press, 2019.
Very weak on causal relationships, strong on corporate mal-practices.

Gillezeau,C. et al 2019. The evidence of human exposure to glyphosate: a review. Environmental Health 18:2https://doi.org/10.1186/s12940-018-0435-5

"[1]. Individuals may be exposed to glyphosate through various routes such as food and drinking water, both in the occupational and environmental settings [2]. Recent findings suggest glyphosate and its metabolites may also spread by wind and water erosion [3]. Glyphosate has also been found in dust within non-agricultural homes, suggesting that the exposure is not only occupational [4]. Glyphosate levels in human beings can be quantified by measuring levels of either glyphosate or its metabolite, AMPA."

Grimm, V., et al. "Ecological Modeling for Pesticide Risk Assessment for Honey Bees and Other Pollinators." *Pesticide Risk Assessment for Pollinators,* 2014, pp. 149–162., doi:10.1002/9781118852408.ch11. https://onlinelibrary.wiley.com/doi/book/10.1002/9781118852408

Examines the potential for multiple stressors as causes of bee declines.

Guilherme, Sofia, et al. "Genotoxicity Evaluation of the Herbicide Garlon®and Its Active Ingredient (Triclopyr) in Fish (Anguilla AnguillaL.) Using the Comet Assay." *Environmental Toxicology,* vol. 30, no. 9, 2014, pp. 1073–1081., doi:10.1002/tox.21980.

Toxicity in eels reported despite well-established regulatory requirements disallowing aquatic applications of Garlon.

Gyton, K.Z. et al. 2014. "Carcinogenicity of tetrachlorvinphos, parathion, malathion, diazinon, and glyphosate." *Lancet Oncol.* http://dx.doi.org/10.1016/S1470-2045(15)70134-8

"Case-control studies of occupational exposure in the USA, Canada, and Sweden reported increased risks for non-Hodgkin lymphoma that persisted after adjustment for other pesticides."

Hamann, Thorsten. "Faculty Opinions Recommendation of Glyphosate Perturbs the Gut Microbiota of Honey Bees." *Faculty Opinions – Post-Publication Peer Review of the Biomedical Literature*, 2018, doi:10.3410/f.734065498.793551167.

"Glyphosate concentrations were chosen to mimic environmental levels, which typically range between 1.4 and 7.6 mg/L and may be encountered by bees foraging at flowering weeds."

Industrial application.

Haughton, Alison J, et al. "The Effect of the Herbicide Glyphosate on Non-Target Spiders: Part I. Direct Effects On Lepthyphantes Tenuis under Laboratory Conditions." *Pest Management Science*, vol. 57, no. 11, 2001, pp. 1033–1036., doi:10.1002/ps.388.

"Mortality of L tenuis remained at less than 10% in all treatments at 24 and 48 h after spray application, and only increased marginally (to 13%) after 72 h. These results support other limited data which suggest that glyphosate is 'harmless' to non-target arthropods."

Haughton, Alison J, et al. "The Effect of the Herbicide Glyphosate on Non-Target Spiders: Part II. Indirect Effects On Lepthyphantes Tenuis in Field Margins." *Pest Management Science*, vol. 57, no. 11, 2001, pp. 1037–1042., doi:10.1002/ps.389.

"Glyphosate applications only had a within-season indirect habitat effect on L tenuis as field margins sprayed 16 months after an application of 360 g glyphosate ha−1 showed no detrimental effect."

Helander, M. et al. 2018. Glyphosate decreases mycorrhizal colonization and affects plant-soil feedback. Science of The Total Environment Volume 642, 15 November 2018, Pages 285-291
Industrial forestry application. "These results demonstrate negative effects of glyphosate on non-target organisms in agricultural environments and grassland ecosystems."

Herbert, L. T., et al. "Effects of Field-Realistic Doses of Glyphosate on Honeybee Appetitive Behaviour." *Journal of Experimental Biology*, vol. 217, no. 19, 2014, pp. 3457–3464., doi:10.1242/jeb.109520.
Inconclusive but ". However, no effect on foraging related behaviour was found. Therefore, we speculate that successful forager bees could become a source of constant inflow of nectar with GLY traces that could then be distributed among nestmates, stored in the hive and have long-term negative consequences on colony performance."

Hoffman, David J. *Handbook of Ecotoxicology*. Lewis Publishers, 2nd edition 2003.

"Insects." *Pesticide Research Institute*, www.pesticideresearch.com/site/pri-resource-centers/weed-management-resource-center/herbicide-risk-comparisons/insects/.
"Assumptions: Terrestrial application of herbicide at half of the maximum rate on a representative product label (see Table 4-1); 50% of the bee's body surface is covered with herbicide; 100% of herbicide is absorbed; the distance between the bee and the sprayer is 0-10 feet.
"Likelihood: Most likely with spray-to-wet applications on blooming plants or those with extrafloral nectaries.
Mitigation: Do not apply to blooming plants. Apply early in the morning or close to sunset when insects are less active. Use low-volume applications and reduce the amount applied per acre.
Risk calculated as a function of: The inherent toxicity of the herbicide to honey bees; the amount of active ingredient sprayed; and the distance between bee and applicator. Risks in this chart do not account for potential toxicity of any surfactants that are part of the product formulation or added to spray mixtures."

Hooven, L. et al. 2013. How to reduce bee poisoning from pesticide use. A PACIFIC NORTHWEST EXTENSION PUBLICATION L PNW 591. Oregon State University n University of Idaho Washington State University."The mode of action of herbicides affects plants, not insects, and herbicides are unlikely to cause bee poisoning incidents under field conditions (Paraquat is a possible exception)."

Ingaramo, P. et al. 2020. "Are glyphosatge and glyphosate-based herbicides endocrine disruptors that alter female fertility?" *Molecular and Cellular Endocrinology*. Available on-line 10 July (preprint).
Review summarizes the endocrine disrupting effects of exposure to glyphosate at environmentally relevant doses. Data suggests that that low doses may have an adverse effect on female fertility.

Jimmo et al. 2018. "Linking Herbicide Dissapation to Soil Ecological Risk Along Transmission Rights-of-Way in the Yukon Territory, Canada. *Journal of Environmental Quality.* Vol 47: 1356-1364.
Soils from four sites were collected at 1, 30, and 365 d after treatment to determine persistence of herbicides (triclopyr and imazapyr) for each of three application methods (backpack spraying, cut stump, and point injection). Weight of evidence and toxic exposure ratios were used to characterize the risks associated with herbicide application to soil invertebrates. When the soil

mite *O. nitens* was exposed to triclopyr in lab studies, an effect at the EC25 level occured when the concentration was 1500 mg/kg.

Lebar et al. 2012. Investigating the Role of Herbicides in Controlling Invasive Grasses in Prairie Habitats: Effects on Non-Target Butterflies." *Natural Areas Journal*, vol. 32, no. 2, 2012, p. 177., doi:10.3375/043.032.0207.
"The results suggest that the herbicide had very little to no impact on larval performance, flower species, or Puget blue oviposition, while adult butterflies spent significantly less time in sprayed plots than in controls. Given the necessity of invasive grass control in natural areas, we recommend several strategies to minimize herbicide effects on butterflies."

Kier, Larry D., and David J. Kirkland. "Review of Genotoxicity Studies of Glyphosate and Glyphosate-Based Formulations." *Critical Reviews in Toxicology*, vol. 43, no. 4, 2013, pp. 283–315., doi:10.3109/10408444.2013.770820.
" Negative results for in vitro gene mutation and a majority of negative results for chromosomal effect assays in mammalian cells add to the weight of evidence that glyphosate is not typically genotoxic for these endpoints in mammalian systems."

Kissane, Zoe, and Jill M. Shephard. "The Rise of Glyphosate and New Opportunities for Biosentinel Early-Warning Studies." *Conservation Biology*, vol. 31, no. 6, 2017, pp. 1293–1300., doi:10.1111/cobi.12955.
Speculates potential contamination of birds and other species without any evidence.

Kreutzweiser, David P., et al. "Effects of the Herbicides Hexazinone and Triclopyr Ester on Aquatic Insects." *Ecotoxicology and Environmental Safety*, vol. 23, no. 3, 1992, pp. 364–374., doi:10.1016/0147-6513(92)90085-h.
Low effects were observed. "The risk to aquatic insects of these herbicides used in forest vegetation management is discussed."

Kumar, Sudhir, et al. "Glyphosate-Rich Air Samples Induce IL-33, TSLP and Generate IL-13 Dependent Airway Inflammation." *Toxicology*, vol. 325, 2014, pp. 42–51., doi:10.1016/j.tox.2014.08.008.
Industrial application. Unrealistic exposure rates.

La Cecilia, Daniele La, and Federico Maggi. "Analysis of Glyphosate Degradation in a Soil Microcosm." *Environmental Pollution*, vol. 233, 2018, pp. 201–207., doi:10.1016/j.envpol.2017.10.017.
"GLP degradation to its end products was assessed under various environmental conditions. GLP can be a recalcitrant pollutant every time the activity of GLP biodegraders is substantially slowed down, such as in 02(aq) -depleted environments, in poorly available C conditions, and in extreme acidic and basic environments. GLP predominant byproduct was the phytotoxic molecule AMPA

Lavoie, C. "The Impact of Invasive Knotweed Species (Reynoutria Spp.) on the Environment: Review and Research Perspectives." *Biological Invasions*, vol. 19, no. 8, 2017, pp. 2319–2337., doi:10.1007/s10530-017-1444-y.
"Invasive knotweeds have major negative impacts on native plants, while the abundant litter produced and the deep rhizome system alter soil chemistry to the benefit of the invaders."

Maderthaner, et al. 2020. “Commercial glyphosate-based herbicides effects on springtails (Collembola) differ from those of their respective active ingredients and vary with soil organic matter content.” *Environmental Science and Pollution Research* (2020) 27: 17280–17289
Greenhosue experiments found Glyphosate-based herbicides increased the surface activity of springtails compared to control pots.

Mance, D. 2012. “The Great Glyphosate Debate”. *Northern Woodlands*. Spring 2012.
Gyphosate use in forest management.

Mann, Reinier M., et al. “Amphibians and Agricultural Chemicals: Review of the Risks in a Complex Environment.” *Environmental Pollution*, vol. 157, no. 11, 2009, pp. 2903–2927., doi:10.1016/j.envpol.2009.05.015.
“However, demonstrating a link between population declines and the toxic effects of agricultural chemicals is difficult. In one case where there is strong evidence that pesticide exposure has directly impacted on amphibian populations (Davidson and Knapp, 2007), the actual mechanism of toxicity remains unknown, and the links between declines and pesticide usage are drawn from multivariate statistical treatments of data about the presence or absence of Rana muscosa in California’s Sierra Nevada. The authors still needed to speculate as to the mechanisms by which pesticides affect individual frogs…”

McMullin, R.T. et al 2011. The effects of triclopyr and glyphosate on lichens. Forest Ecology and Management 264 (2011) 90–97.
Mixed results over a two-year monitoring period. “Herbicide applications affected lichen abundance with high mortality in some species but no effect for other species. One year post-treatment, 15 lichen species showed no reduction in abundance at any concentration from triclopyr while six species (40%) were negatively affected.”

McPhail, Erica, 2018. Influences of vegetation management strategies on pollinator assemblages on powerline rights-of-way (2018). Dissertations and Theses. 60.
https://digitalcommons.esf.edu/etds/60
“Studies have shown that in the context of glyphosate used in operational areas (like powerline ROWs), there is a low risk of acute toxicity to bees.”

Massachusetts Dept. Agric. 2006. SURFACE WATER MONITORING OF GLYPHOSATE USED IN RIGHTS-OF-WAY RAILROAD VEGETATION MANAGEMENT (2005 – 2006).
“The monitoring program provides a sound basis for the Pesticide Board to finalize its decision making regarding the proposed changes to the Rights-of-Way regulations. The results, along with the DEP modeling analysis, indicate that a 10 foot buffer zone around a stream is likely to be sufficient for glyphosate to ensure adequate protection of the stream from Round-Up applications.”

Massachusetts Dept. Agric. 333 CMR: PESTICIDE BOARD 333 CMR 11.00: RIGHTS OF WAY MANAGEMENT
“The purpose of 333 CMR 11.00 is to establish a statewide and uniform regulatory process which will minimize the uses of, and potential impacts from herbicides in rights-of-way on human health and the environment while allowing for the benefits to public safety provided by the selective use of herbicides. Specific goals of 333 CMR 11.00 are to:
(1)Ensure that an Integrated Pest Management (IPM) approach to vegetation management isutilized on all rights-of-way covered by 333 CMR 11.00.

(2)Establish standards, requirements and procedures necessary to prevent unreasonable risksto humans or the environment, taking into account the economic, social and environmental costsand benefits of the use of any pesticide.
(3)Ensure ample opportunity for public and municipal agency input on potential impacts ofherbicide application to rights-of-way in environmentally sensitive areas."

Massachusetts Dept. Agricultural Resources 333 Mass. Reg. 11.04
Section 11.04 - Sensitive Area Restrictions
Massachusetts Dept. Agric. Glyphosate Fact Sheet

"Glyphosate when used as recommended by the manufacturer, is unlikely to enter watercourses through run-off or leaching following terrestrial application (117). Toxic levels are therefore unlikely to occur in water bodies with normal application rates and practices (118).
Glyphosate has oral LD5Os of 4,320 and 5,600 in male and female rats respectively. The elimination is rapid and very little of it is metabolized. The NOAEL in rats was 20,000 ppm and 500 mg/kg/d in dogs. No teratogenic effect was observed at doses up to 3,500 mg/kg/d and the fetotoxicity NOELS were 1,000 mg/kg/d in the rat and 175 mg/kg/d in the rabbit.
The evidence of oncogenicity in animals is judged as insufficient at this time to permit classification of the carcinogenic potential of glyphosate. The compound is not mutagenic."

Massachusetts Dept. Agric. 2011. Triclopyr Fact Sheet

Given that the higher application rates required for vegetation control in some areas have the potential to produce potentially lethal concentrations of the butoxyethyl ester of Triclopyr to fish in water as a result of runoff, a setback greater than the mandated 10 feet from standing or flowing waters (333 CMR 11.04: (1) and (4) (a)) will provide an additional level of protection when application rates exceed 0.5 pts/acre.
Triclopyr exhibits moderate mobility in most of the soils tested. Soils with higher organic carbon content would be expected to retard the mobility of Triclopyr. Trichloropyridinol, the major breakdown product, is less mobile than Triclopyr.

Mensah, Paul K., et al. 2015. "Ecotoxicology of Glyphosate and Glyphosate-Based Herbicides Toxicity to Wildlife and Humans." *Toxicity and Hazard of Agrochemicals*, doi:10.5772/60767.

"Our review reveals that glyphosate and its formulations may not only be considered as having genotoxic, cytotoxic or endocrine disrupting properties but they may also be causative agents of reproduction abnormalities in both wildlife and humans. Furthermore, the extensive use of glyphosate-based herbicides in genetically modified glyphosate-resistant plants grown for food and feed should be of grave concern since they can be sources of genotoxicity, cytotoxicity, and reproductive toxicity in wildlife and humans."

Mensah K., Paul, et al. "Lethal and Sublethal Effects of Pesticides on Aquatic Organisms: The Case of a Freshwater Shrimp Exposure to Roundup®." *Pesticides - Toxic Aspects*, 2014, doi:10.5772/57166.

"The case study, i.e. lethal and sublethal exposures of C. nilotica to varying environmentally relevant concentrations of Roundup®, showed that C. nilotica can be used as early detection system to assess glyphosate-based herbicides pollution effects on aquatic ecosystems."

Mertens, M. et al. 2018. "Glyphosate, a chelating agent. – relevant for ecological risk assessment?" *Environmental Science and Pollution Research* 25: 5298-5317.

"According to the results, it has not been fully elucidated whether the chelating activity of glyphosate contributes to the toxic effects on plants and potentially on plant–microorganism interactions, e.g., nitrogen fixation of leguminous plants. It is also still open whether the chelating property of glyphosate is involved in the toxic effects on organisms other than plants, described in many papers."

Mesnage, R., et al. "Potential Toxic Effects of Glyphosate and Its Commercial Formulations below Regulatory Limits." *Food and Chemical Toxicology*, vol. 84, 2015, pp. 133–153., doi:10.1016/j.fct.2015.08.012.
"Some effects were detected in the range of the recommended acceptable daily intake
Current evidence presented raises concerns and indicates the need for further studies"

Mesnage, Robin, and Michael N. Antoniou. "Facts and Fallacies in the Debate on Glyphosate Toxicity." *Frontiers in Public Health*, vol. 5, 2017, doi:10.3389/fpubh.2017.00316.
"The aim of this review is to examine the evidential basis for these claimed negative health effects and the mechanisms that are alleged to be at their basis. We found that these authors inappropriately employ a deductive reasoning approach based on syllogism. We found that their conclusions are not supported by the available scientific evidence."

Mills, Paul J., et al. "Glyphosate Excretion Is Associated With Steatohepatitis and Advanced Liver Fibrosis in Patients With Fatty Liver Disease." *Clinical Gastroenterology and Hepatology*, vol. 18, no. 3, 2020, pp. 741–743., doi:10.1016/j.cgh.2019.03.045.
Industrial strengths. Ingestion

Mink, Pamela J., et al. "Epidemiologic Studies of Glyphosate and Cancer: A Review." *Regulatory Toxicology and Pharmacology*, vol. 63, no. 3, 2012, pp. 440–452., doi:10.1016/j.yrtph.2012.05.012.
"Our review found no consistent pattern of positive associations indicating a causal relationship between total cancer (in adults or children) or any site-specific cancer and exposure to glyphosate."

Motta et al. 2018. Glyphosate perturbs the gut microbiota of honey bees. PNAS: https://www.pnas.org/content/pnas/115/41/10305.full.pdf
"Thus, exposure of bees to glyphosate can perturb their beneficial gut microbiota, potentially affecting bee health and their effectiveness as pollinators."

NAISMA. 2020. The Use of Pesticides in Invasive Species Management
A Position Statement of the North American Invasive Species Management Association
"NAISMA supports the following invasive species prevention, management, and policy actions to prevent and manage invasive species in North America that will help to minimize the use of pesticides over time:
1. Promote prevention tools, education, and awareness campaigns as a first line of defense against all invasive species introductions.
2. Support early detection technology and programs that can identify a species that will spread rapidly if it is not contained quickly.
3. Use integrated pest management (IPM) that uses knowledge of species' life history and strategic use of chemical, mechanical or biological controls as necessary at the most effective life stages for the type of control chosen.
4. Apply minimal amounts of pesticides when chemical control is required to achieve optimal management. Use direct application techniques to reduce damage to

non-target species.
5. Monitor invasive species to inform and target future management strategies, especially those that include the key elements of early detection, rapid response, containment of spread, and eradication where possible.
6. Increase the sharing of technical data and cooperation among agencies and other partners to manage invasive species.
7. Increase funding for scientific research that involves the input of managers by public and private agencies and organizations to control, minimize, or eliminate negative impacts of invasive species.
8. Enact, expand, and enforce laws and regulations focused on prevention and control of the spread of existing invasive species.
9. Reduce or eliminate the sale, distribution and propagation of known invasive species in livestock, horticultural, and agricultural industries to prevent their accidental escape into natural areas."

Newmaster, S.G. et al. 1999. The effects of glyphosate and triclopyr on common bryophytes and lichens in northwestern Ontario Canadian Journal of Forest Research; Jul 1999; 29, 7; pg. 110
A decrease was detected. "Herbicide application rate affected both bryophyte and lichen abundance and species richness."

Niemeyer, J.C. et al. 2018. "Do recommended doses of glyphosate-based herbicides affect soil invertebrates? Field and laboratory screening tests to risk assessment". 2018. *Chemosphere.* 18: 154-160.

Despite glyphosate-based herbicides are widely used in agriculture, forestry and gardens, little is known about its effects on non-target organisms. The study evaluated the ecotoxicity of four formulated products (Roundup® Original, Trop®, Zapp® Qi 620 and Crucial®) on soil invertebrates. Screening ecotoxicity tests were carried out with soil and oat straw collected in a field experiment, besides laboratory-spiked soils. Screening tests included avoidance behaviour of earthworms (*Eisenia andrei*), collembolans (*Folsomia candida*) and isopods (*Porcellio dilatatus*) in single and multispecies tests; reproduction of collembolans (*F. candida*), and bait lamina in field. Some formulations had an effect. The findings highlight the importance of considering different formulations for the same active ingredient in risk assessment of pesticides.

Nowak, C.A. and B.D. Ballard. 2005. "Off-target Herbicide Deposition Associated with Treating Individual Trees." *Environmental Management*. 2005. 36: 237-247.
The study quantified the amount of off-target deposition that resulted from four conventional herbicide application methods: 1) basal, 2) cut-stump, 3) high-volume, hydraulic foliar, and 4) low-volume, backpack foliar. On a per tree basis, basal and cut-stump treatments deposited nearly six times more total herbicide than highvolume foliar, and 68 times more than low-volume foliar. All of the herbicide deposited off-target landed within 0.6 m of the basal and cut-stump treatments, 3.7 m with the low-volume foliar, and 7.3 m with high-volume foliar methods. Off-target herbicide deposition resulted in affected areas with killed or damaged vegetation ranging in size from 0.36 m2 (cut stump) to 7.08 m2 (high-volume foliar).

Pahwa, Manisha, et al. “Glyphosate Use and Associations with Non-Hodgkin Lymphoma Major Histological Sub-Types: Findings from the North American Pooled Project.” *Scandinavian Journal of Work, Environment & Health*, vol. 45, no. 6, 2019, pp. 600–609., doi:10.5271/sjweh.3830.
“There was some limited evidence of an association between glyphosate use and NHL, but consistent patterns of association across different metrics and sub-types were not observed.”

Perez, Gonzalo, et al. “Effects of Herbicide Glyphosate and Glyphosate-Based Formulations on Aquatic Ecosystems.” *Herbicides and Environment*, 2011, doi:10.5772/12877.
“Commercial formulations and specially those containing the surfactant POEA, showed higher toxicity than the active ingredient itself for all the aquatic organisms studied.”
Wijnja (2010) reviewed and determined “In conclusion, this risk assessment indicates that the use of herbicides containing alkyl
ethoxylated surfactants POEA, NPE, AE, and PE in ROW sensitive areas managed according to the ROW regulations and adherence to protective buffer-zones and rate restrictions appear to provide adequate protection for sensitive aquatic systems. This is consistent with the mandate to protect and prevent unreasonable risk to these sensitive areas associated with ROW.”

Perkins, Peggy J., et al. “Toxicity Of Glyphosate And Triclopyr Using The Frog Embryo Teratogenesis Assay—Xenopus.” *Environmental Toxicology and Chemistry*, vol. 19, no. 4, 2000, p. 940., doi:10.1897/1551-5028(2000)0192.3.co;2.
“The higher toxicity of Roundup (with surfactant POEA) compared with Rodeo (no surfactant) to *X. laevis in this study can be attributed to the toxicity of the surfactant itself, which had a LC50 of 6.8 mg/L compared with an LC50 of 7,296.8 mg/L for Rodeo (glyphosate alone)”*Peterson, Hans G., et al. “Aquatic Phyto-Toxicity of 23 Pesticides Applied at Expected Environmental Concentrations.” *Aquatic Toxicology*, vol. 28, no. 3-4, 1994, pp. 275–292., doi:10.1016/0166-445x(94)90038-8.
Full text not available. “Through testing the phytotoxicity of a variety of agricultural pesticides to a wide range of algal taxa, it is evident that there are considerable differences in sensitivity among species and that the use of an uncertainty factor is necessary to provide an acceptable margin of safety in evaluating the hazard presented by these chemicals to the aquatic environment.”

Petty, D.G. et al. 2003. A Review of the Aquatic Environmental Fate of Triclopyr and its Major Metabolites. *J. Aquat. Plant Manage.* 41: 69-75.
Aquatic applications.
“Field studies indicate that triclopyr in natural waters degrades rather quickly, but at least partially independent of the action of direct photolysis.”
“Field studies clearly show that triclopyr and TCP are found in fish and shellfish tissues in direct proportion to the residues found in water, and depurate from these organisms at rates roughly equivalent to the dissipation from the water column (typical fish half-lives of 5 to 8 days), indicating a low bioconcentration potential.”

Pleasants, John M., and Karen S. Oberhauser. “Milkweed Loss in Agricultural Fields Because of Herbicide Use: Effect on the Monarch Butterfly Population.” *Insect Conservation and Diversity*, vol. 6, no. 2, 2012, pp. 135–144., doi:10.1111/j.1752-4598.2012.00196.x.
“Taken together, these results strongly suggest that a loss of agricultural milkweeds (in the mid-west) is a major contributor to the decline in the monarch population.

Pleasants, John M., et al. “Conclusion of No Decline in Summer Monarch Population Not Supported.” *Annals of the Entomological Society of America*, vol. 109, no. 2, 2016, pp. 169–171., doi:10.1093/aesa/sav115.
“This would ignore the evidence that the key driver of population decline is the massive loss of milkweeds, the larval host plant, in agricultural fields due to the use of glyphosate herbicide in conjunction with the widespread adoption of glyphosate-tolerant corn and soybeans that began in 1996 (Pleasants and Oberhauser 2013).”

Pochron, S. et al. 2020. “Glyphosate but not Roundup harms earthworms (*Eisenia fetida*).” *Chemosphere*. 241: Article 125017.
‘Worms living in soil spiked with pure glyphosate lost 14.8–25.9% of their biomass and survived a stress test for 22.2–33.3% less time than worms living in uncontaminated soil. Worms living in soil spiked with Roundup Ready-to-Use III® and Roundup Super Concentrate® did not lose body mass and survived the stress test as well as worms living in uncontaminated soil. No contaminant affected soil microbial or fungal biomass over the 40-day period of this experiment.”

Porta, Miquel. “Faculty Opinions Recommendation of Differences in the Carcinogenic Evaluation of Glyphosate between the International Agency for Research on Cancer (IARC) and the European Food Safety Authority (EFSA).” *Faculty Opinions – Post-Publication Peer Review of the Biomedical Literature*, 2016, doi:10.3410/f.726267569.793516472.
“Serious flaws in the scientific evaluation in the RAR incorrectly characterise the potential for a carcinogenic hazard from exposure to glyphosate.”

Portier, Christopher J., and Peter Clausing. “Update to ‘Re: Tarazona Et Al. (2017): Glyphosate Toxicity and Carcinogenicity: a Review of the Scientific Basis of the European Union Assessment and Its Differences with IARC. Doi: 10.1007/s00204-017-1962-5.’” *Archives of Toxicology*, vol. 92, no. 3, 2017, pp. 1341–1341., doi:10.1007/s00204-017-2138-z.
“Two complementary exposure assessments, human-biomonitoring and food-residues-monitoring, suggests that actual exposure levels are below these reference values and do not represent a public concern.”

Relyea, Rick A. “New Effects of Roundup on Amphibians: Predators Reduce Herbicide Mortality; Herbicides Induce Antipredator Morphology.” *Ecological Applications*, vol. 22, no. 2, 2012, pp. 634–647., doi:10.1890/11-0189.1.

Relyea, Rick A. “The Impact Of Insecticides And Herbicides On The Biodiversity And Productivity Of Aquatic Communities: Response.” *Ecological Applications*, vol. 16, no. 5, 2006, pp. 2027–2034., doi:10.1890/1051-0761(2006)016[2027:tioiah]2.0.co;2.
“However, Roundup completely eliminated two species of tadpoles and nearly exterminated a third species, resulting in a 70% decline in the species richness of tadpoles. This study represents one of the most extensive experimental investigations of pesticide effects on aquatic communities and offers a comprehensive perspective on the impacts of pesticides when nontarget organisms are examined under ecologically relevant conditions.”

Relyea, Rick A. “The Lethal Impact Of Roundup On Aquatic And Terrestrial Amphibians.” *Ecological Applications*, vol. 15, no. 4, 2005, pp. 1118–1124., doi:10.1890/04-1291.
Poor designs, poor understanding of application rates, types and content. Used illegal concentrations and surfactants.

Wijnja 2010 stated "The dramatic effects observed in Relyea's studies (Relyea, 2005abc) attracted significant media attention and were also discussed in the context of global amphibian decline. As was pointed out, however, the direct applications of the glyphosate-based herbicides containing POEA surfactant to aquatic systems, as was done in the mesocosms studies by Relyea, was in violation with label instructions (Langeveld, 2006; Thompson et al., 2006). In addition, the applied rates were 3-10 times higher than the label rates for uses in non-cropland, forestry, or agriculture. These studies have therefore limited relevance to typical field terrestrial applications. However, these studies do have value as a worst-case scenario of inadvertent overspray of a water body by aerial spraying as may occur in forest management (Thompson et al., 2006; Relyea, 2006)."

Rittel, Horst W. J., and Melvin M. Webber. "Dilemmas in a General Theory of Planning." *Policy Sciences*, vol. 4, no. 2, 1973, pp. 155–169., doi:10.1007/bf01405730.
Science and "wicked" social problems.

Robichaud, C. and Rooney 2020. Preprint. Glyphosate used to control invasive Phragmites australis in standing water poses little risk to aquatic biota. BioRxiv. 20 June 2020.
A Phragmites control project.
"In sediment, glyphosate residue persisted above detection limits (>0.005 ppm) for over one year but less than two years. Concentrations of alcohol ethoxylates were variable in space and time, following a pattern that could not be attributed to Aquasurf® application. The direct, over-water application of Roundup Custom® with Aquasurf® to control invasive P. australis does not pose a toxicological risk to aquatic biota."

Rooney, R. 2018. Fate and effects of glyphosate used in Phragmites control. Great Lakes Phragmites collaborative. https://www.youtube.com/watch?v=pvB3ntiFAOQ

Rothstein et al. 2005. Publication Bias in Meta-Analysis: Prevention, Assessment and Adjustments. John Wiley and sons
"Simply put, when the research that is readily available differs in its results from the results of all the research that has been done in an area, readers and reviewers of that research are in danger of drawing the wrong conclusion about what that body of research shows.

Samanta, Palas, et al. "Evaluation of Metabolic Enzymes in Response to Excel Mera 71, a Glyphosate-Based Herbicide, and Recovery Pattern in Freshwater Teleostean Fishes." *BioMed Research International*, vol. 2014, 2014, pp. 1–6., doi:10.1155/2014/425159.
Comment -30 days exceeds all likely concentrations when used according to label specifications

Schinasi, Leah, and Maria Leon. "Non-Hodgkin Lymphoma and Occupational Exposure to Agricultural Pesticide Chemical Groups and Active Ingredients: A Systematic Review and Meta-Analysis." *International Journal of Environmental Research and Public Health*, vol. 11, no. 4, 2014, pp. 4449–4527., doi:10.3390/ijerph110404449.
"Despite compelling evidence that NHL is associated with certain chemicals, this review indicates the need for investigations of a larger variety of pesticides in more geographic areas, …"

Schmidt, F. (2017) "Statistical and measurement pitfalls in the use of meta-regression in metaanalysis", Career Development International, Vol. 22 Issue: 5, pp.469-476, https://doi.org/10.1108/CDI-08-2017-0136

“Findings – The analysis in this paper demonstrates that many of the nine statistical and measurement pitfalls in the use of meta-regression are nearly universal in applications in the literature, leading to the conclusion that few meta-regressions in the literature today are trustworthy. A second conclusion is that in
almost all cases, hierarchical subgrouping of studies is superior to meta-regression as a method of identifying and calibrating moderators. Finally, a third conclusion is that, contrary to popular belief among researchers, the process of accurately identifying and calibrating moderators, even with the best available methods, is complex, difficult, and data demanding.”

Schmolke, Amelie, et al. “Ecological Models and Pesticide Risk Assessment: Current Modeling Practice.” *Environmental Toxicology and Chemistry*, vol. 29, no. 4, 2010, pp. 1006–1012., doi:10.1002/etc.120.
“The results of the present review provide a preliminary checklist of what needs to be improved if models are to be used for decision support in ecological risk assessments. The nine characteristics (model type, model complexity, toxicity measure, exposure pattern of chemical, inclusion of other factors, taxonomic group modeled, endpoint of risk assessment, model parameterization, and model evaluation) that were used for reviewing the models should be checked explicitly, and model assumptions should be described clearly by model developers. Risk managers can also use this list to check how a model, its documentation, and its analysis deal with these nine characteristics.”

Seide, Vanessa Eler, et al. “Glyphosate Is Lethal and Cry Toxins Alter the Development of the Stingless Bee Melipona Quadrifasciata.” *Environmental Pollution*, vol. 243, 2018, pp. 1854–1860., doi:10.1016/j.envpol.2018.10.020.
A species of native bee was negatively affected by glyphosate in GMO agricultural setting.

Senapati, T. et al. 2009. Observations on the effect of glyphosate based herbicide on ultra structure (SEM) and enzymatic activity in different regions of alimentary canal and gill of Channa punctatus (Bloch). Journal of Crop and Weed, 5(1): 233-242
Unrealistically high dosages for extended periods of time.

Shaw, David R. “The ‘Wicked’ Nature of the Herbicide Resistance Problem.” *Weed Science*, vol. 64, no. SP1, 2016, pp. 552–558., doi:10.1614/ws-d-15-00035.1.
Weed resistance to glyphosate.

Sheppard, Lianne, and Rachel M Shaffer. “Re: Glyphosate Use and Cancer Incidence in the Agricultural Health Study.” *JNCI: Journal of the National Cancer Institute*, vol. 111, no. 2, 2018, pp. 214–215., doi:10.1093/jnci/djy200.
“We encourage the AHS investigators to refine their approach and improve our ability to understand the true impacts of pesticide exposures, which—particularly for glyphosate—could have tangible consequences for public health policy.”

Stark, John D., et al. “Effects of Herbicides on Behr's Metalmark Butterfly, a Surrogate Species for the Endangered Butterfly, Lange's Metalmark.” *Environmental Pollution*, vol. 164, 2012, pp. 24–27., doi:10.1016/j.envpol.2012.01.011.
“These herbicides reduced the number of adults that emerged from pupation (24e36%). Each herbicide has a different mode of action. Therefore, we speculate that effects are due to inert ingredients or indirect effects on food plant quality.”
Applications selecting target invasives would limit exposure.

State of California Environmental Protection Agency Office Of Environmental Health Hazard Assessment Safe Drinking Water And Toxic Enforcement Act Of 1986 Chemicals Known To The State To Cause Cancer Or Reproductive Toxicity January 3, 2020.
Added glyphosate as a probable cause of cancer in 2017.

Stark, John D, et al 2012. Effects of herbicides on Behr's metalmark butterfly, a surrogate species for the endangered butterfly, Lange's metalmark. Environmental Pollution 164 (2012) 24e27

Sutherland, William J., et al. *What Works in Conservation: 2018*. Open Book Publishers, 2018.
Reduce herbicide, pesticide use generally but use them to achieve ecological goals.

Sviridov, A. V., et al. "Microbial Degradation of Glyphosate Herbicides (Review)." *Прикладная Биохимия и Микробиология*, vol. 51, no. 2, 2015, pp. 183–190., doi:10.7868/s0555109915020221.
"This review analyzes the issues associated with biodegradation of glyphosate (N-(phosphonomethyl)glycine), one of the most widespread herbicides. Glyphosate can accumulate in natural environments and can be toxic not only for plants but also for animals and bacteria. Microbial transformation and mineralization of glyphosate, as the only means of its rapid degradation, are discussed in detail. The different pathways of glyphosate catabolism employed by the known destructing bacteria representing different taxonomic groups are described. The potential existence of alternative glyphosate degradation pathways, apart from those mediated by C-P lyase and glyphosate oxidoreductase, is considered. Since the problem of purifying glyphosate-contaminated soils and water bodies is a topical issue, the possibilities of applying glyphosate-degrading bacteria for their bioremediation are discussed."

Tarazona, Jose V., et al. "Glyphosate Toxicity and Carcinogenicity: a Review of the Scientific Basis of the European Union Assessment and Its Differences with IARC." *Archives of Toxicology*, vol. 91, no. 8, 2017, pp. 2723–2743., doi:10.1007/s00204-017-1962-5.
"Two complementary exposure assessments, human-biomonitoring and food-residues-monitoring, suggests that actual exposure levels are below these reference values and do not represent a public concern."

Thompson D.2011Ecological Impacts of Major Forest-Use Pesticides, in *Ecological Impacts of Toxic Chemicals*, 2011, 88-110
Specifically, assessment of the cases for glyphosate and Btk support their continued judicious use as environmentally acceptable components of integrated vegetation and insect pest management strategies. In contrast, higher level studies confirm risk postulates associated with typical forest-sector use patterns for triclopyr ester and diflubenzuron. Mitigation measures are required to ensure that use of these latter compounds do not pose undue risk to sensitive non-target organisms. In a broader context, the ecological implications of pesticide use in the forest sector must be considered in light of the fact that any management action, including the "no intervention" option, carries both economic and ecological risk. Strict adherence to the weight of scientific evidence principle, incorporation of knowledge gained from all levels of investigation, and a balanced assessment of relative risks of all potential options are considered primary requisites of comprehensive risk analysis and effective decision making."

Thompson, H. M., S. L. Levine, J. Doering, S. Norman, P. Manson, P. Sutton, and G. von Mérey. 2014. Evaluating exposure and potential effects on honeybee brood (Apis mellifera) development using glyphosate as an example. *Integrated Environmental Assessment and Management* 10(3):463–470.

"There were no significant effects from glyphosate observed in brood survival, development, and mean pupal weight. Additionally, there were no biologically significant levels of adult mortality observed in any glyphosate treatment group. Significant effects were observed only in the fenoxycarb toxic reference group and included increased brood mortality and a decline in the…"

Thogmartin, Wayne E., et al. "Monarch Butterfly Population Decline in North America: Identifying the Threatening Processes." *Royal Society Open Science*, vol. 4, no. 9, 2017, p. 170760., doi:10.1098/rsos.170760.

"A structural equation model implicates the loss of milkweed as the mechanism by which glyphosate application influences monarch butterfly population size. To offset this loss of milkweed,

The Nature Conservancy 2011. Herbicide Use in Natural Areas: A Guide for Volunteers. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5386111.pdf

"Use of herbicides on Illinois nature preserves should be limited to situations in which managers or decision makers determine that no other reasonable means of control are available."

Trumbo, J. and Waligora. 2009. The impact of the herbicides imazapyr and triclopyr Triethylamine on bullfrog Tadpoles. California Fish and Game 95(3):122-127.

"The results of this study indicate that the direct application of imazapyr IPA and triclopyr TEA herbicides to water do not pose a significant acute toxicity hazard to bullfrog tadpoles."

Tu, M., Hurd, C. & J.M. Randall. 2001. Weed Control Methods Handbook, The Nature Conservancy, http://tncweeds.ucdavis.edu, version: April 2001

"Manual and mechanical techniques are generally favored against small infestations and/or where a large pool of volunteer labor is available. They are often used in combination with other techniques, for example, when shrubs are pulled and cut, and re-sprouts and seedlings are treated with herbicides or fire several weeks or months later.

See also chapter 7 for summary Triclopyr toxic effects (dated literature review).

U.S. Environmental Protection Agency. 2015. Preliminary Ecological Risk Assessment in Support of the Registration Review of Glyphosate and Its Salts. Washington. September 8.

Assessed risk to aquatic and terrestrial receptors, including Common Milkweed and the Monarch Butterfly.

U.S. Environmental Protection Agency. 2020. Interim Registration Review Decision (ID) for glyphosate acid (PC Code 417300) and its various salt forms (PC Codes 103601, 103604, 103605, 103607, 103608, and 103613; case 0178) https://www.epa.gov/ingredients-used-pesticide-products/proposed-interim-registration-review-decision-and-responses-0

"None of the open literature studies identified for the agency's consideration were found to have an impact on the glyphosate hazard characterization, cancer assessment, or human health risk assessment. The agency will continue to monitor the open literature for studies that use scientifically sound and appropriate methodology and relevant routes of exposure that have the potential to impact the risk evaluation of glyphosate."

"The agency concluded that there are no dietary risks of concern for any segment of the population, even with the most conservative assumptions applied in its assessments (e.g., tolerance-level residues, direct application to water, and 100% crop treated). The agency also

concluded that there are no residential, non-occupational bystander, aggregate, or occupational risks of concern. The EPA has not made a common mechanism of toxicity to humans finding as to glyphosate and any other substance and it does not appear to produce a toxic metabolite produced by other substances. Therefore, it was not appropriate for EPA to assess cumulative risks."
"The EPA found there was insufficient evidence to conclude that glyphosate plays a role in any human diseases."

Valavanidas, A. 2018. Glyphosate, the Most Widely Used Herbicide. Health and safety issues. Why scientists differ in their evaluation of its adverse health effects. Scientific Reviews: http://chem-tox-ecotox.org/?s=glyphosate
"In the last decade experimental and epidemiological evidence was accumulated that glyphosate has no significant toxicity in acute, subchronic, and chronic studies. The genotoxicity and carcinogenicity studies for glyphosate and its commercial products (Roundup) were assessed. There was no convincing evidence for direct DNA damage in vitro or in vivo, and it was concluded that Roundup and its components do not pose a risk for various types of cancer in humans."
"Why the frenzy? Agencies that find low risk of regulated products are often accused of undue industry influence. We at EFSA believe that some campaigners are unwilling to accept any evidence that certain regulated substances are safe, and will tout weak scientific studies showing the opposite."

Vandenberg, Laura N, et al. 2017. "Is It Time to Reassess Current Safety Standards for Glyphosate-Based Herbicides?" *Journal of Epidemiology and Community Health*, vol. 71, no. 6, 2017, pp. 613–618., doi:10.1136/jech-2016-208463.
"We are concerned that the assays used to assess glyphosate safety, including the toxicity studies requested by the US Environmental Protection Agency (EPA) in 2009, may be insufficient to address the full complement of health effects that could be induced by exposure to glyphosate-based herbicides (GBHs)."

Wagner, Norman, et al. "Questions Concerning the Potential Impact of Glyphosate-Based Herbicides on Amphibians." *Environmental Toxicology and Chemistry*, vol. 32, no. 8, 2013, pp. 1688–1700., doi:10.1002/etc.2268.
"If and how glyphosate-based herbicides and other pesticides contribute to amphibian decline is not answerable yet due to missing data on how natural populations are affected. Amphibian risk assessment can only be conducted case specifically, with consideration of the particular herbicide formulation."

Ward, Jeffrey S., et al. "Controlling Japanese Barberry (Berberis Thunbergii DC) in Southern New England, USA." *Forest Ecology and Management*, vol. 257, no. 2, 2009, pp. 561–566., doi:10.1016/j.foreco.2008.09.032.
"A two-step process can effectively control Japanese barberry in areas where herbicide use is restricted and in areas where management objectives include minimizing herbicide applications."
What is the 2-step process?

Warren R. Scott *, Paul E. Fell, Jonna L. Grimsby, Erika L. Buck, G. Chris Rilling,And Rachel A. Fertik. 2001. Rates, Patterns, and Impacts of PHRAGMITES AUSTRALIS Expansion and Effects of Experimental PHRAGMITES Control on Vegetation, Macroinvertebrates, and Fish within Tidelands of the Lower Connecticut River. Estuaries Vol. 24, No. 1, p. 90–107.

No change in macroinvertebrates or fish after applications.

Washington State Department of Ecology, Water Quality Program 2004. Final Environmental Impact Statement for the use of Triclopyr.
Aquatic applications only
"In soils, factors that affect persistence of triclopyr include temperature, pH, higher organic matter content, higher microbial numbers, and the presence of triclopyr due to previous applications. Half-life persistence can range from less than one day to nearly a year"

Weed, D.L. 2000. Interpreting epidemiological evidence: how meta-analysis and causal inference are related. International Jour. Epidem. 29: 387-390
"Meta analysis has a real but limited role in causal inference adding to an understanding of some causal criteria. Meta-analysis may also point to sources of confounding or bias…"Wijnja, H. 2010. Risk assessment of surfactants associated with herbicide applications in rights-of-way areas.
"The following document describes a risk assessment of herbicide surfactants in ROW areas taking into account the restrictions provided in the ROW management regulations. Federal regulations allow only limited information regarding the identity and nature of the inert ingredients. Consequently, the evaluation of these ingredients relies mainly on review of the open literature on the toxicity and environmental fate."

Wijnja, H. 2019. Note to L. Mattei.
"….may not be that familiar with the regulatory data and assessments that support the registration and legal uses of these products. While the open literature studies provide useful information and broaden the scope of data on these herbicides, the studies may not always be useful for risk assessment purposes. Regulatory system is based on a robust set of studies and risk assessments that have to meet strict standards."

Woźniak, E., Sicińska, P., Michałowicz, J., Woźniak, K., Reszka, E., Huras, Bogumił., Zakrzewski, J., Bukowska, Boż., The mechanism of DNA damage induced by Roundup 360 PLUS, glyphosate and AMPA in human peripheral blood mononuclear cells - genotoxic risk assessment, Food and Chemical Toxicology (2018), doi: 10.1016/j.fct.2018.07.035
"Summing up, Roundup 360 PLUS caused much stronger damage to DNA of human PBMCs in comparison to glyphosate, and AMPA in particular. DNA damage in human PBMCs was induced by Roundup at low concentrations (even at 5 μM), while glyphosate and AMPA were capable of inducing DNA lesions at much higher dosages of 250 μM and 500 μM, respectively.
We may conclude that observed DNA damage was not due to direct interaction of glyphosate, Roundup 360 PLUS or AMPA with DNA as no DNA adducts formation has been observed, while this damage was associated with ROS-mediated effects , e.g. DSBs formation and an increase in •OH level were observed in cells exposed to the same Roundup 360 PLUS (10 μM) and glyphosate (1000 μM) concentration."

Yahnke, Amy E., et al. "Effects of the Herbicide Triclopyr on Metamorphic Northern Red-Legged Frogs." *Environmental Toxicology and Chemistry*, vol. 36, no. 9, 2017, pp. 2316–2326., doi:10.1002/etc.3767.
"Metamorphs were exposed to the tank mix and a clean-water control for 96 h, and then reared in clean water for 60 d. Exposure to the tank mix resulted in no treatment-related mortalities, no effects on behavior immediately post exposure, and no effects on body or liver condition indices.

Exposure to the tank mix resulted in lethargy during exposure and a 1-d delay in completion of metamorphosis. Deformities present in the rearing population confounded results for some endpoints. Observed effects were minimal, especially compared with the potential for ecological impacts from unmanaged invasive plants."

Zaller, J. et al. 2014. Glyphosate herbicide affects belowground interactions between earthworms and symbiotic mycorrhizal fungi in a model ecosystem . SCIENTIFIC REPORTS | 4 : 5634 | DOI: 10.1038/srep05634.
"We found a 40% reduction of mycorrhization after Roundup application in soils amended with the mycorrhizal fungi G. mosseae. This is in contrast to what we hypothesized, based on the allegedly fast biodegradation of the herbicide and the very plant-specific mode of action. We explain this mainly by direct and indirect influences. Roundup could have directly affected active metabolite productionin the plant with detrimental effects on root AMF colonization."

Zhang L, Rana I, Shaffer RM, Taioli E, Sheppard L. 2019 Exposure to Glyphosate-Based Herbicides and Risk for Non-Hodgkin Lymphoma: A Meta- Analysis and Supporting Evidence, Mutation Research-Reviews in Mutation Research https://doi.org/10.1016/j.mrrev.2019.02.001
"Overall, in accordance with evidence from experimental animal and mechanistic studies, our current meta-analysis of human epidemiological studies suggests a compelling link between exposures to GBHs and increased risk for NHL."

Zhu, Y., J. Adamczyk, T. Rinderer, J. Yao, R. Danka, R. Luttrell, and J. Gore. 2015. Spray toxicity and risk potential of 42 commonly used formulations of row crop pesticides to adult honey bees (Hymenoptera: Apidae). Ecotoxicity 108: 2640-2647.
"From this study, it is clear that tetraconazole (a fungicide), etoxazole (miticide), and glyphosate (a popular herbicide) have very minor or no acute toxicity to honey bees based on 48-h mortality data, with the results being supported by an additional week-long observation."