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Report

Managing the use of glyphosate-based herbicide in Nova Scotia's forestry sector

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Abstract

This report provides an overview of the use of glyphosate-based herbicides in Nova Scotia's forestry sector, including an analysis of the potential consequences of its use and recommendations for the future of forestry in the province. Potential impacts of glyphosate-based herbicides on ecosystems, human health, and Indigenous rights are considered. Corporate misconduct by manufacturers of glyphosate-based herbicides is investigated, and the responsibility of governments and regulatory bodies to govern the use of herbicides is examined. In light of the findings of this report, alternative vegetation management methods are considered, and recommendations are provided regarding the future use of glyphosate-based herbicides in Nova Scotia.

Our team recommends phasing out the use of glyphosate-based herbicides in Nova Scotia's forestry sector. Additional interim recommendations are outlined to provide immediate avenues for action. These recommendations include reversing provincial policies which permit herbicide use on Crown lands, protecting aquatic habitats by amending herbicide setback buffers, establishing meaningful partnerships with Mi'kmaq communities, and adopting a variety of silviculture practices. These recommendations will support Nova Scotia's forestry sector as it shifts away from the use of glyphosate-based herbicides and towards more sustainable and environmentally conscious vegetation management methods.

Keywords: glyphosate, herbicide, forestry, Nova Scotia, management, Monsanto, Bayer, genotoxicity

Introduction

Glyphosate-based herbicides (GBHs) have been the predominant method of vegetation control in Nova Scotia's high-production forestry sector for over four decades. Their effectiveness in suppressing deciduous species and promoting the growth of commercially valuable coniferous species such as spruce and pine have been critical to Nova Scotia's lumber, pulp, and paper industries (Lahey, 2018a; Department of Lands and Forestry, 2021). Although GBHs are widely used in agriculture and along linear features such as railways and utility corridors, this report focuses on their use in Nova Scotia's forestry sector, with attention to their application on public lands (Brookes et al., 2017; O'Reilly & Shrestha, 2013).

GBHs became the dominant herbicide in Canadian forestry following federal approval in 1984, driven by their demonstrated effectiveness, perceived low toxicity, and early scientific assessments suggesting minimal environmental risk (Lahey, 2018a). They are typically applied via on-the-ground spraying, or aerially, to suppress deciduous pioneer species such as aspen and alder, which often dominate clear-cut sites and compete with conifer seedlings for sunlight and nutrients (Canada, 2006; Thompson & Pitt, 2003). Most sites receive one to two applications of GBH per 40–80 year forest rotation (Lahey, 2018a).
Coniferous species ("softwoods") generally hold higher value in Nova Scotia than deciduous species ("hardwoods"), as they are more abundant, cost-effective to source, and central to lumber, pulp, and paper production (Duffield Timber, 2021). In 2022, Nova Scotia's forestry sector contributed approximately $1.8 billion in economic benefits, supported over 6,000 full-time jobs, and added $674 million to the provincial GDP, while generating significant export and tax revenues (Gardner Pinfold Consultants, 2023). These figures highlight the central role of forestry in the provincial economy and help explain why cost-effective vegetation management methods, such as GBHs, have been widely adopted within the sector.

As research on GBHs has continued to evolve, new insights into the potential impacts of GBHs on the environment and human health have emerged (Davoren & Schiestl, 2018; Lozano & Pizarro, 2024; Weisenburger, 2021). With increasing evidence of human health risks and growing public concern, the forestry industry has faced mounting pressure to reconsider its reliance on herbicides as a tool for vegetation management (Logan, 2022; Meftaul et al., 2020). This report examines the use of GBHs in Nova Scotia's forests, exploring its history of use, applications, and potential ecological and human health impacts, as well as related legal disputes and evidence of misconduct by a major manufacturer, Monsanto Inc. (now Bayer Crop Science Inc.).

Methods

A preliminary literature review was conducted to identify baseline knowledge essential to informed decision-making on the use of GBHs in Nova Scotia's forestry sector. This preliminary literature review was guided by a need to understand the chemical composition and mode of action of GBHs, as well as their fate in the environment. To understand the utility of GBHs as a tool within Nova Scotia's silviculture practices, provincial policies and reports were reviewed. These documents included economic reports related to Nova Scotia's forestry sector, as well as several provincial forestry policies, some of which are based on recommendations from William Lahey's *An Independent Review of Forest Practices in Nova Scotia* (2018a).

To understand the extent of pesticide use in Nova Scotia, a review was conducted of all available pesticide permits issued in the province. Details of pesticide approvals are publicly available on Nova Scotia's Department of Environment and Climate Change (ECC) website for a ten-year period (2014-2024)(ECC, n.d.). Each permit was reviewed to determine whether the permit was still in effect, the commercial product that had been approved for use, and the purpose of pesticide use. Parcel Identification Numbers of all areas approved for GBH spraying in Nova Scotia in 2024 were reviewed to determine whether herbicide application was occurring in proximity to residential communities and Mi'kmaq reserves (Tesar, 2018). Additionally, a list of all active pesticide permits in the province was compiled (Appendix A).

History of Glyphosate Use in Nova Scotia

GBH has played a significant role in Nova Scotia's forest management history, with patterns of use reflecting shifting policies, economic incentives, and evolving forestry practices. Figure 1 illustrates this fluctuation in reliance on GBH from 1990 to 2008. On average, nearly 10,000 hectares of Nova Scotia's forests were treated with herbicides each year, with the highest recorded use being in 2005, when 11,637 hectares about 0.44% of the province's managed forest land – were sprayed. By 2016, herbicide use had declined significantly to just 0.06% of the land base. Since herbicides were first introduced, nearly 200,000 hectares, or roughly 7% of Nova Scotia's managed forest land, have received at least one application (Lahey, 2018b).

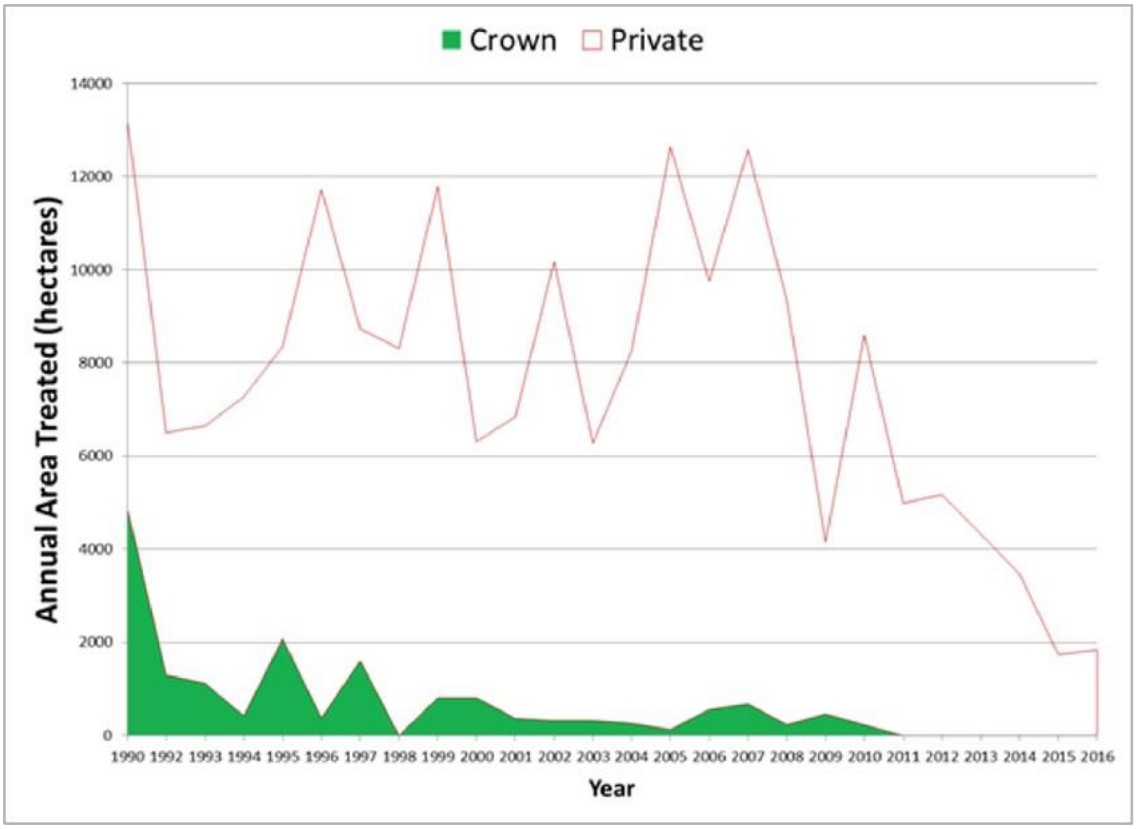

Figure 1. History of herbicide use on Crown and public lands in Nova Scotia since 1990 (Lahey, 2018b).

GBHs have also been widely used on private land in Nova Scotia. Between 2001 and 2010, approximately 34,400 hectares were treated—equivalent to spraying more than 64,000 football fields (Devet, 2016). Following the end of provincial subsidies for herbicide treatments in 2010, applications declined but continued, with 7,263 hectares of private woodlands sprayed between 2011 and 2014 (Devet, 2016). More recently, in 2024, ECC issued three new approvals for GBH spraying covering 1,837 hectares for forestry purposes (ECC, 2024). This figure does not reflect the full extent of pesticide applications in the province, as older permits that remain active continue to authorize current applications of various pesticides (Appendix A).

The continuance of herbicide spraying on Crown land was influenced by recommendations from *An Independent Review of Forest Practices in Nova Scotia* (Lahey, 2018a). The review recommended implementing a triad system on public land by dividing forests into three zones: (1) protected areas for biodiversity conservation, (2) high-production areas for intensive timber harvesting, and (3) an ecological matrix that balances conservation and resource use (McGrath et al., 2021). The triad approach reflects principles of ecosystem-based management (EBM), which emphasize maintaining ecological integrity while accommodating sustainable resource use (McGrath et al., 2021). In response, the province committed to establishing the triad model. As part of this commitment, herbicide application is permitted in Nova Scotia's high-production forestry zones on Crown land; however, unlike previous practices—and in alignment with Lahey's recommendations—public funding is no longer used to support herbicide applications (DNRR, 2023).

Glyphosate Products and their Governance

Trade names for GBH products include Roundup®, Vision®, VisionMax®, Forza®, Vantage®, and Timberline®, with VisionMax® commonly used in Nova Scotian forestry (Belchim Canada, 2025; Thompson & Pitt, 2011; Nova Scotia, 2024a). GBH products vary in their chemical formulation, but all contain glyphosate as the active ingredient (Thompson & Pitt, 2011). GBHs also contain a chemical surfactant which increases the permeability of glyphosate across the surface membranes of plants (Pérez et al., 2011). The surfactant included in the chemical formulation of VisionMax® and Roundup® is polyoxyethylene amine (POEA) (Thompson & Pitt, 2011). VisionMax® and Roundup® are both manufactured by Monsanto Inc., which was acquired by Bayer Crop Science Inc. in 2018 (Bayer, 2018).

GBH use in Nova Scotia's forests is regulated under the Pest Control Products Act (SC 2002, c 28) (PCPA), which is the primary federal legislation governing the regulation of pesticides to protect human health, safety, and the environment. GBHs fall within the PCPA's definition of a pesticide, which broadly includes substances used to control or destroy pests such as animals and plants (Pest Control Products Act, S.C. 2002, c. 28). Under this Act, Health Canada's Pest Management Regulatory Agency (PMRA) evaluates pesticide risks and re-assesses registered products on a 15-year cycle (Pest Control Products Act, S.C. 2002, c. 28). In Nova Scotia, herbicide applications in forestry are regulated by ECC, which enforces PMRA label requirements alongside additional provincial conditions, certifies applicators, and monitors compliance through reporting and inspections (NSEL, 2007).

The application of pesticides in Nova Scotia's forests requires approval from ECC. Pesticides may be applied to forested lands used for pulp, sawlogs, lumber, or firewood production, and are also permitted in other areas under specific conditions. For instance, herbicides may be used

for soil sterilization or as spot treatments (up to 100 m^2), and applications are permitted on utility corridors, road systems, and over watercourses (Activities Designation Regulations, N.S. Reg. 47/1995). Public notification is a key requirement: property owners within 500 meters of a spray zone must receive written notice at least 30 days before application, public signage must be posted at treatment sites for the same duration and remain throughout the growing season, and newspaper advertisements describing the spray program must be published at least 20 days prior to application (Province of Nova Scotia, 2025). All applicators must be certified by ECC, and approval holders are required to submit a contingency plan along with annual herbicide application reports (Province of Nova Scotia, 2025).

The following restrictions are included in the terms and conditions of pesticide approvals issued by ECC, which establish legal requirements for pesticide application, including limits and buffer zones, to reduce environmental and public health risks for herbicide use (Province of Nova Scotia, 2025). Restrictions vary by method of application, with spraying typically permitted between August and October. Wind speed is a key factor: spraying must stop when speeds exceed 10 km/h. Wind conditions must be monitored frequently—every 15 minutes for aerial spraying and every 30 minutes for ground spraying—and operations must cease if limits are exceeded twice consecutively.

Buffer zones in which pesticides may not be applied are required, ranging from 10 to 100 meters depending on the environmental feature and whether ground or aerial spraying is used (Province of Nova Scotia, 2025). In Nova Scotia, no-spray zones include 60m from wells, 30m from surface watercourses, 15m from wetlands, 10m from property boundaries, and between 30m and 100m from dwellings, businesses, schools, and public buildings. Additional restrictions apply in designated municipal or protected drinking water supply watersheds.

Potential Ecological and Community Impacts of Glyphosate-Based Herbicides

Mode of Action and Environmental Fate of Glyphosate-Based Herbicides

The effectiveness of GBHs as a vegetation management tool arises from their efficient mode of action. Following the application of GBH, deciduous trees, shrubs, herbs, and grasses absorb the herbicide through their leaf surfaces, which results in the disruption of amino acid synthesis and subsequent plant death (Comeau & Fraser, 2018). More specifically, glyphosate works by interfering with the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) in the shikimic acid pathway of plants (Bruggen et al., 2021). The shikimic acid pathway is a metabolic process by which specific amino acids are produced to contribute to the plant's growth and pathogen defense system (Duke, 2018; Gill et al., 2018). Disrupting the shikimic acid pathway increases plant vulnerability to pathogens and impedes growth, resulting in plant death over a period of 4 to 20 days (Gill et al., 2018; Henderson et al., 2019). Coniferous species are generally protected from the effects of glyphosate by the waxy cuticle which coats their needles and prevents absorption (Comeau & Fraser, 2018).

After GBH is applied to a harvested site, the product is either absorbed by plants, or binds with organic matter in the soil (Gill et al., 2018; Thompson & Pitt, 2011). Over time, glyphosate is broken down by microbes in the soil, which cleave the carbon-phosphorous bond of glyphosate molecules (Bruggen et al., 2021; Gill et al., 2018). Following the decomposition of glyphosate, a

decomposition product known as aminomethylphosphonic acid (AMPA), is produced (Gomes et al., 2014).

The strength with which glyphosate binds to soil and the speed with which it degrades can vary based on soil properties such as mineral composition, texture, pH, and microbial abundance (Bruggen et al., 2021; Chávez-Ortiz et al., 2022; Guijarro et al., 2018; Wood, 2019). Given this variability, reported half-life values for glyphosate range from approximately 2 to 215 days (Guijarro et al., 2018; Pérez et al., 2011; Tush et al., 2018). AMPA has been found to persist in soil for up to 153 days (Grunewald et al., 2001). Additionally, the surfactant POEA may persist in the environment for more than 2 years after application (Tush et al., 2018). Although glyphosate, POEA, and AMPA may impact target environments after the direct application of GBHs to a harvested stand, non-target environments may also be impacted as a result of surface run-off, ground leaching, and spray drift (Pérez et al., 2011; Thompson et al., 2010). In comparison to glyphosate and AMPA, POEA residues are considered to have a low potential to be mobilized through leaching or runoff (Pérez et al., 2011).

Impacts to Plant and Wildlife Communities

Plant mortality as a result of GBH application is expected, as these products are intended to remove plants that are considered to be competition for regenerating conifers (Thompson & Pitt, 2011). However, aerial applications of GBH can result in partial applications of herbicide to non-target understory plants, which are partially protected by overstory vegetation (Golt & Wood, 2021). Plants exposed to sub-lethal doses of GBH have been found to exhibit morphological changes, including producing higher proportions of abnormal (rolled, folded, asymmetrical) leaves, resulting in reductions in photosynthetic capacity (Golt & Wood, 2021; Timms & Wood, 2020). Prickly rose plants treated with GBH also showed changes in pollen size and shape two years after treatment, as well as a 66% reduction in pollen viability (Golt & Wood, 2021). Furthermore, glyphosate can be stored in plant tissues for a minimum of one year after treatment, and in some cases, residual glyphosate has been detected in plant tissues up to 12 years after treatment (Botten et al., 2021). Glyphosate appears to be stored in plant roots during the winter, and later translocated into new shoots, leaves, and fruit after growth is initiated in the following spring (Wood, 2019). AMPA has also been detected in root structures one year after application, although this finding was only true for non-woody plants (Wood, 2019).

The potential impacts of GBHs on wildlife health often stem from the toxicity of surfactants, such as POEA, and the metabolite AMPA, both of which appear to be more toxic to animals than glyphosate itself (Lozano & Pizarro, 2024; Pérez et al., 2011; Tresnakova et al., 2021). Aquatic organisms in particular demonstrate sensitivity to glyphosate and POEA, with impacts on growth, early development, antioxidative ability, and cell/tissue integrity (Tresnakova et al., 2021). This is acknowledged within the product label for VisionMax®, which specifically warns of toxicity to aquatic organisms (Bayer, 2020). Commercial formulas containing POEA have been found to be 42-fold more toxic than glyphosate in fish (Pérez et al., 2011). Pure glyphosate is also not without risk, as it has been linked to the inhibition of the enzyme acetylcholinesterase (AChE) in fish, which has the potential to cause a buildup of the neurotransmitter acetylcholine (ACh) and impact nerve signalling (Kissane & Shephard, 2017). Commercial formulas containing POEA have also been found to be 130-fold more toxic than glyphosate in frogs and toads, with tadpoles showing higher sensitivity to these products

compared to juvenile and adult amphibians (Pérez et al., 2011). For example, a 100% mortality rate for Northern leopard frog tadpoles has been reported for tadpoles treated with 0.75 mg a.e./L of Vision® (Chen et al., 2004).

Impacts of Spray Drift

Considering the health impacts on aquatic organisms, it is particularly important to consider the potential for GBHs to disrupt freshwater ecosystems in the event of spray drift during aerial application. In order to protect aquatic habitats from spray drift, "no-spray" buffer zones are established within pesticide product labels, and within pesticide approvals issued by the province (Belchim Canada, 2025; Bayer, 2020). For the 2024 season, VisionMax® and Timberline® were approved for use in Nova Scotia's forestry sector (Appendix A). Buffer zones established by the product labels for VisionMax® and Timberline® are relatively minimal, as these buffers range from 1-10m depending on the size of the area being sprayed, and the type of aircraft being used to apply the herbicide (Belchim Canada, 2025; Bayer, 2020). By comparison, the aquatic habitat buffers established by ECC for Nova Scotia offer slightly more protection for aquatic habitats, as pesticides may not be applied within 15m of a wetland or within 30m of a surface watercourse (Appendix B).

Studies on the deposition of spray drift as a result of aerial applications indicate that herbicides may drift 30-50m, even in optimal conditions (wind speed <6km/hr) (Thompson et al., 2010). Additionally, the glyphosate concentration of spray drift deposition at 30-50m is still high enough to induce plant death (Thompson et al., 2010). When comparing the aquatic habitat buffers that are currently established by product labels (1-10m) and the ECC (15-30m), against the observed travel distance of spray drift (30-50m), these buffers do not appear to be sufficient to protect aquatic ecosystems from spray drift. Other provinces, such as Ontario and New Brunswick, have instituted ≥60m buffers for aquatic habitats (Appendix B), and these buffer distances are verified and supported by scientific evidence on the deposition of spray drift (Riley et al., 1991; Thompson et al., 2010).

Human Health Concerns

Direct exposure to GBH has been linked as a risk factor for the development of cancer in several tissues, including the pancreas, kidney, breast, thyroid, liver, bladder, and bone marrow (Samsel & Seneff, 2015). One cancer which is the subject of increasing study in relation to GBHs is non-Hodgkin Lymphoma (NHL). Several case-control studies on the relationship between NHL and glyphosate have shown elevated odds ratios for NHL in individuals exposed to glyphosate (Pierce et al., 2020; Varona et al., 2009; Weisenburger, 2021). The average latency period for the development of NHL as a result of long-term exposure to carcinogenic chemicals is approximately 20 years, with a range of 10 to 30 years or more (Weisenburger, 2021). Studies that found no correlation between glyphosate exposure and NHL often had study periods of less than 10 years, which may be an insufficient timeframe for NHL to be detected (Weisenburger, 2021).

Although the risks of GBH exposure vary within agricultural and forestry settings, the greatest risk for herbicide applicators to be exposed to GBH typically occurs during the mixing stage, when the undiluted product is mixed with water prior to application (Gandini et al., 2020; Meftaul et al., 2020). With regard to the potential risk for members of the public to be

exposed to GBH at treated sites, provincial regulations attempt to limit this risk by mandating the provision of written notices to the public prior to herbicide application, and the posting of signage in treated areas (Government of Nova Scotia, 2009). However, there is a lack of publicly available data on the efficacy of these prevention methods. When considering potential impacts on human health, the cumulative effects of chronic exposure to low quantities of glyphosate should be considered for both humans and wildlife (Botten et al., 2021). Given the limited history of GBH use in Canada (<50 years), research continues to evolve on the topic of cumulative and long-term impacts to human health.

Challenges Against Decision-Makers on The Human Health Risks of Glyphosate

Regulatory agencies and government decision-makers at provincial, national, and international levels have shared conflicting views on the potential health risks of glyphosate. In 2015, the International Agency for Research on Cancer (IARC) reclassified glyphosate as a "probable carcinogen" (Davoren & Schiestl, 2018). In 2016, the U.S. Environmental Protection Agency (EPA) determined that glyphosate was "not likely" carcinogenic (EPA, 2016). In 2017, Health Canada stated that "glyphosate is not genotoxic and is unlikely to pose a human cancer risk" (Health Canada, 2017). Additionally, in 2018, *An Independent Review of Forest Practices in Nova Scotia*, which has informed Nova Scotia's policies on GBH in forestry, concluded that there is a "general lack of evidence of significant deleterious effect to humans, terrestrial and aquatic fauna" (Lahey, 2018a). However, the views of decision-makers on the health risks of glyphosate continue to evolve as new evidence on the safety of glyphosate arises. For example, the author of *An Independent Review of Forest Practices in Nova Scotia* has stated that new scientific evidence on the safety of glyphosate no longer supports his previous conclusion regarding a lack of evidence of significant harmful effects (W. Lahey, personal communication, March 12, 2025).

Decisions made by Canadian regulatory agencies regarding the safety of glyphosate are also being challenged in federal court, which is forcing decision-makers to reconcile with new evidence on the potential health risks of GBH. In February 2025, a federal court ruled that Health Canada's approval of a GBH (Mad Dog Plus®) was unreasonable, as Health Canada had failed to consider new scientific evidence during their product registration renewal process (Ecojustice, 2025). Mad Dog Plus® had been previously approved for use in forestry, agricultural and industrial applications (Loveland Products, 2020). During the renewal process, four environmental organizations presented Health Canada with 61 new scientific studies identifying new or increased risks associated with glyphosate (The Canadian Press, 2025). Although Health Canada is required to review new evidence if it pertains to health risks associated with a product's ingredients, an access to information request revealed that Health Canada proceeded to renew approvals without completing this review (Ecojustice, 2025). In February 2025, a Federal Court judge directed Health Canada to complete a review of the health risks associated with glyphosate and confirm its position on whether glyphosate poses an acceptable risk to human health (The Canadian Press, 2025). Following this review, Health Canada reaffirmed its decision to maintain existing reference values for glyphosate and asserted that the current risk assessment on file for glyphosate is valid (Flint, 2025). Notably, following this decision, Loveland Products Canada Inc. applied to discontinue its registration of Mad Dog Plus® (Fint, 2025). Health Canada's decision to maintain the registration of glyphosate has raised concerns that recent ecological and health studies—particularly those relevant to forestry—were not adequately assessed, and further litigation may follow this decision (SFM, 2025).

Potential Impacts to Indigenous Communities

The Government of Canada has a legal duty to consult and, where appropriate, accommodate Indigenous groups when proposed actions may adversely affect their Aboriginal treaty rights (Government of Canada, 2024). If GBHs are found to negatively impact traditional food sources, water quality, or culturally significant species, Indigenous groups could challenge the use of GBHs based on these constitutionally protected rights. Nova Scotia is part of the traditional territory of the Mi'kmaq people (Government of Canada, 2023). Mi'kmaq communities are known to harvest berries in the summer months as a source of food and medicine (Weber, 2022). Concerns regarding the safety of plants treated with GBH have been raised by this community, given that plants treated with a sub-lethal dose of GBH may contain glyphosate residues in their roots, fruits, and shoots for several years following treatment (Botten et al., 2021).

During the development of this report, Parcel Identification Numbers for all areas approved for GBH spraying in Nova Scotia in 2024 were reviewed to determine whether herbicide application was occurring in proximity to residential communities or Mi'kmaq reserves. No residential communities were identified within a minimum of 2km from any sites which were approved for GBH spraying in 2024 (Fig. 2). Considering the limited distance of off-site movement by herbicides through spray drift and runoff, these Mi'kmaq reserves are unlikely to be directly impacted by GBH that was applied in 2024. However, the application of GBH could pose a potential risk if Mi'kmaq communities use these sites for harvesting or other purposes.

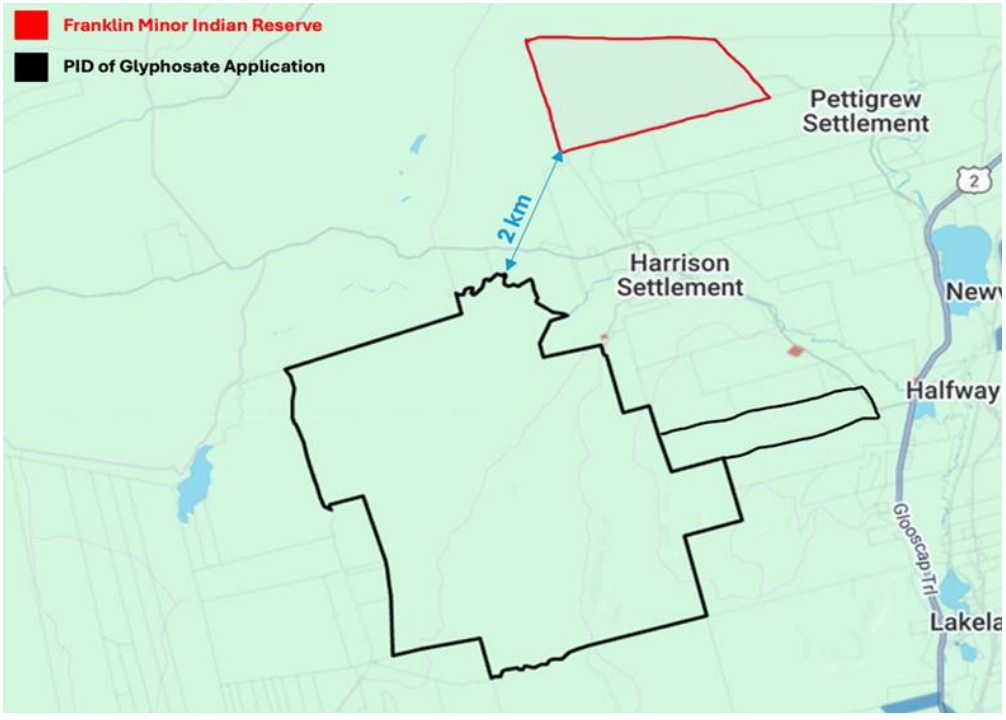

Figure 2. Proximity of Nearest Mi'kmaq Reserve to Site of Herbicide Application.

Discovery Documents and Corporate Malfeasance Related to Glyphosate

In conjunction with the growing public concern and pushback against GBH, legal action is also being taken against herbicide manufacturers in relation to the potential health impacts of their products. More specifically, several law firms in Canada and the United States are pursuing class action lawsuits against Monsanto/Bayer related to GBHs such as Roundup®, and the development of NHL in people who've faced significant exposure to the product (Koskie Minsky, n.d.; Miskin Law, n.d.; Wisner Baum, n.d.). As of March 2025, Monsanto/Bayer had reached settlement agreements in nearly 100,000 lawsuits and paid approximately $11 billion USD (Miller, Jr., 2025). An estimated 67,000 active lawsuits against Monsanto/Bayer remain (Miller, Jr., 2025).

Many of the lawsuits against Monsanto/Bayer have required the company to relinquish thousands of internal documents and emails to the courts as discovery documents. Several of these internal documents have become part of the public record, with some revealing unethical or unlawful acts committed by Monsanto/Bayer in relation to GBH (hereafter referred to as corporate malfeasance) (Krimsky & Gillam, 2018). These incidents include the ghostwriting of scientific articles by Monsanto employees and undue influence of federal regulatory agencies (Krimsky & Gillam, 2018; Malkan et al., 2022). Importantly, the actions perpetrated by Monsanto/Bayer appear to have impacted the scientific integrity of safety evaluations that have been conducted for glyphosate, which has implications for the potential risks that GBHs may pose to human health. For the purpose of this discussion, the company 'Bayer' will be referred to as 'Monsanto', as these accounts primarily refer to actions that were carried out by the company prior to its acquisition in 2018 (Bayer, 2018).

Hiding the Risks of Glyphosate and Ghostwriting Articles

Internal emails written by Monsanto scientist William Heydens reveal that he and other Monsanto employees understood that glyphosate presented a potential genotoxic risk, and that they worked to re-write scientific manuscripts to hide this risk. While discussing a draft scientific manuscript on the genotoxicity of glyphosate which was being prepared by former Monsanto scientist David Kier, Heydens wrote:

> After they got all the studies amassed into a draft manuscript, it unfortunately turned into such a large mess of studies reporting genetoxic effects, that the story as written stretched the limits of credibility among less sophisticated audiences. For most 'stories', the approach would have been fine. But even though we feel confident that glyphosate is not genotoxic, this became a very difficult story to tell given all the complicated 'noise' out there. So we (David, Larry, Bill H, Joel & Shawna) thought we needed to re-group & redesign the approach to the manuscript. As part of that re-tooling approach, it was suggested that one way to help enhance credibility is to have an additional author on the paper who is a heavyhitter in the area of genotoxicity. Larry did a search for possible co-authors and came up with 5. After internal discussion and some checking by David with fellow TWG tox folks, we landed on Kirkland as the best candidate. (Heydens, 2012).

Following this email, a review of genotoxicity studies was published by Dr. Kier and Dr. Kirkland (Kier & Kirkland, 2013). Its findings contradict the genotoxic risks of glyphosate that

Heydens had acknowledged in his email, and the article states that glyphosate does "not appear to present significant genotoxic risk under normal conditions of human or environmental exposures" (Kier & Kirkland, 2013). This review paper has been cited extensively and was cited by the U.S. EPA and Health Canada in their respective safety evaluations of glyphosate (EPA, 2016; Health Canada, 2017).

The public record also shows that Monsanto employees engaged in ghostwriting of scientific articles, meaning that these articles appeared to be written by academics, or consultants with academic credentials, when they were instead covertly authored by Monsanto's scientists (Krimsky & Gillam, 2018). A notable example of Monsanto's casual attitude toward ghostwriting is displayed in an email written by Heydens in 2015, which states:

> A less expensive/more palatable approach might be to involve experts only for the areas of contention, epidemiology and possibly MOA (depending on what comes out of the IARC meeting), and we ghost-write the Exposure Tox & Genetox sections. An option would be to add Greim and Kier or Kirkland to have their names on the publication, but we would be keeping the cost down by us doing the writing and they would just edit & sign their names so to speak. Recall that is how we handled Williams Kroes & Munro, 2000. (Heydens, 2015).

The "Williams Kroes & Munro" article[1] to which Heydens is referring was also cited by the U.S. EPA and Health Canada in their respective safety evaluations of glyphosate (EPA, 2016; Health Canada, 2017).

Monsanto's internal emails also suggest that they had connections within federal regulatory agencies which allowed them to exert undue influence on the handling of glyphosate by regulators (Krimsky & Gillam, 2018). In the case of an acute inhalation study in which three test subjects (rats) died following a glyphosate treatment, Heydens acknowledged Monsanto's relationship with regulators, writing:

> Do you feel confident that you can get the regulators to totally ignore the 3 deaths in the previous study if we get no deaths in a follow-up study? In the US, we have had a very difficult time getting EPA to ignore previous data no matter how good the subsequent study(ies) is (are). (Heydens, 2003).

Although this example demonstrates that Monsanto was interested in attempting to manipulate regulators, other internal discovery documents obtained from Monsanto support the conclusion that Monsanto has previously been successful at influencing regulators within both Health Canada and the U.S. EPA (Bacon et al., 2023; Krimsky & Gillam, 2018; Malkan et al., 2022).

Implications of Monsanto's Corporate Malfeasance

The potential implications of Monsanto's actions regarding glyphosate are concerning, as they indicate that the conclusions that have been made by Health Canada and the U.S. EPA about

[1] Author's note: This article was retracted by *Regulatory Toxicology and Pharmacology* in December 2025 (Kincaid, 2025).

the safety of GBHs are at least partially based on fraudulent science, and therefore the effective regulation of these products may be undermined. It also means that members of the public and industry may be using these products with a certain assumption of safety, when there may be a greater potential risk to their health than previously identified. Although Monsanto has withstood several years of class-action lawsuits related to glyphosate while continuing to produce GBH products, the company has recently stated that they may withdraw Roundup® from the market if litigation continues (Weiss & Burger, 2025).

Moving Towards Alternatives and Solutions

Alternative Vegetation Management Methods

In consideration of the environmental impacts of GBH, Health Canada's recent re-evaluation decision on glyphosate, and Monsanto's corporate malfeasance, it is critical to consider non-chemical vegetation management in forestry. Other provinces, most notably Quebec, have demonstrated that herbicide-free forestry is both feasible and economically viable. Since banning glyphosate in 2001, Quebec has relied on mechanical methods such as mowing, brush saws, soil cultivation, and pre-commercial thinning to support tree regeneration (Thiffault & Roy, 2011). Although these approaches can be more expensive, labour-intensive, and can pose safety risks to workers, the province's forestry sector continues to grow, contributing $6.4 billion to GDP in 2023 and supporting over 57,000 jobs (Thiffault, 2021; Quebec, 2024).

Building on this, the Herbicide Alternative Program (HAP), developed in northeastern Ontario and now in Quebec – further illustrates how non-chemical approaches can be scaled and adapted. HAP promotes non-chemical vegetation management by using ecological classification to predict how forest sites will respond to disturbance (Chapman et al., 2023). It integrates Indigenous knowledge, ecological science, and technologies such as laser-based mapping (LiDAR) to customize management strategies for different landscapes. Beyond reducing chemical inputs, the program provides social and economic benefits by creating jobs and training opportunities for Indigenous youth and increasing community engagement in forest stewardship (Chapman et al., 2023).

Although HAP was created for boreal forest conditions, its foundational principles are adaptable to Nova Scotia's Acadian Forest ecosystem (Chapman et al., 2023). Implementing a similar initiative in the province could align environmental goals with economic development, while supporting long-term forest sustainability and meaningful employment in rural and Indigenous communities. For this type of program to succeed in Nova Scotia, significant and sustained provincial funding will be essential.

Research also indicates that mechanical vegetation management can be optimized through timing, cutting height, soil preparation, and seedling size, with operations during full leaf growth often producing the strongest growth response (Bell et al., 1999; Thiffault et al., 2014; Thiffault, 2021). Other promising approaches include mulching, planting low-lying vegetation, controlled grazing, prescribed burns, and biological treatments such as organic herbicides or fungal stump applications, though further research is needed (Wiensczyk et al., 2011; Hamberg et al., 2021). In Nova Scotia, seedlings used in commercial planting typically range from 10cm to 25cm in height at planting and are grown in Jiffy® peat plugs (NSNRR, n.d.). To improve competitiveness, transitioning to taller stock (30–50 cm) with sturdier stems and well-

developed roots is recommended, particularly for slow-growing spruce, which are approximately the size of a coffee mug at planting (Noseworthy, 2018).

Despite these options, scaling up non-chemical approaches in Nova Scotia is constrained by workforce limitations. Notably, the physically demanding nature of mechanical vegetation management paired with low wages for workers has made it difficult to maintain a viable workforce (A. Westwood, personal communication, April 11, 2025). Addressing these challenges will be necessary if Nova Scotia is to successfully expand non-chemical vegetation management and adopt proven approaches from other provinces.

Recommendations for Policy and Practice

Considering the potential impacts of GBH to the environment and human health, as well as actions by GBH manufacturers to undermine government regulation and scientific inquiry of GBH products, we recommend that Nova Scotia should pursue precautionary, evidence-informed measures to support sustainable vegetation management. The following interim recommendations provide a responsible pathway until a long-term transition away from GBHs is achieved.

Interim Recommendation 1: Reverse the provincial policy permitting glyphosate use on Crown lands.
In alignment with growing public concern and successful herbicide-free practices in Ontario and Quebec, Nova Scotia should formally reverse its policy of permitting GBH use on Crown Lands. This change would solidify a long-term commitment to EBM and reinforce the importance of environmental and public health safeguards.

Interim Recommendation 2: Establish and fund a Nova Scotia HAP program with Indigenous partnerships.
Building on Ontario and Quebec's HAP, Nova Scotia should create a region-specific version for the Acadian Forest. The program would combine ecological classification, silvicultural research, Indigenous knowledge, and technologies like LiDAR to develop site-specific non-chemical strategies. Partnerships with Mi'kmaq communities should guide program design, with the duty to consult respected in all decisions, including pesticide notification.

Interim Recommendation 3: Invest in workforce training and fair compensation for mechanical vegetation management.
Mechanical vegetation management is limited by a shortage of trained brush-saw crews, driven by physically demanding labour and low wages. The province should fund training, safety certification, and competitive wages to build a reliable workforce for non-chemical vegetation management, with opportunities for cost-sharing or co-funding from private industry to strengthen workforce capacity.

Interim Recommendation 4: Amend aquatic habitat setbacks and move toward eliminating aerial spraying.
Current aquatic setback buffers for aerial applications of GBH that are established by the province are not supported by scientific evidence on the deposition of spray drift. The province should adopt an evidence-based approach and provide sufficient protection for aquatic habitats by amending these setbacks to a minimum of 60m. In addition, eliminating aerial applications

where feasible would further reduce the risks of drift to surrounding ecosystems and communities.

Interim Recommendation 5: Improve transparency in pesticide permitting.
Amend the Approval and Notification Procedures Regulations to require ECC to disclose key permit details online—including product used, concentration, area affected, contingency plans, annual reports, and justification for use as a last resort. Expand notification methods to include digital platforms and mandate a centralized online registry to ensure public access and re-build public trust.

Interim Recommendation 6: Improve silviculture practices with non-chemical vegetation management.
Forestry operations should prioritize planting larger, more robust seedlings (30–50 cm with strong roots and stems) and incorporating mixed, native tree species in production forests. Additional research should explore non-chemical management techniques such as prescribed burns and controlled grazing with sheep to enhance vegetation control. These measures enhance growth, resilience to competition, and biodiversity while reducing the need for herbicide or intensive mechanical vegetation management treatments.

Long-term Recommendation: Phase out the use of GBHs in Nova Scotia's forestry sector.
In the long term, the province should eliminate the use of GBHs for vegetation management in forestry in favour of more ecologically and socially responsible practices. This long-term vision will require sustained investment, adaptive management, and continued engagement with forestry workers, Indigenous communities, scientists, and the public.

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APPENDIX A: New and Ongoing Pesticide Approvals in Nova Scotia

Table A-1. New Pesticide Approvals Issued in 2024 and Ongoing Pesticide Approvals in Nova Scotia.

Approval No.	Start Date	Permit Expiry	Approval Holder	Pesticide	Available details
2024-3535010-00	15-Aug-24	31-Dec-2024	J.D. Irving, Limited	VisionMax®, Timberline®	Aerial application, forested land
2024-3555013-00	15-Aug-24	31-Dec-2024	ARF Enterprises Inc.	VisionMax®, Timberline®	Aerial application, forested land
2024-3556893-00	15-Aug-24	31-Dec-2024	ARF Enterprises Inc.	VisionMax®, Timberline®	Aerial application, forested land
2023-3314982-00	10-Aug-23	10-Aug-2033	Davey Tree Export Co. of Canada	Unknown	Utility corridor management
2023-3361233-00	10-Aug-23	10-Aug-2033	Asplundh Canada ULC	Unknown	Utility corridor management
2022-2956233-00	26-Aug-22	31-Dec-2025	Department of Fisheries and Aquaculture	Noxfish Fish Toxicant II®	Application to surface watercourses for the purpose of fish culls
2016-095804	24-Mar-16	31-Dec-2026	Highland Vegetation Management	21 approved pesticide products	Railway corridor management

Source: Nova Scotia, 2024a.

Permit approved for the 2024 season

Permit approved prior to 2024, permit ongoing

APPENDIX B: Aquatic Habitat Setbacks for Herbicide Application

Table B-1. Aquatic Habitat Setback Distances for Herbicide Application Prescribed by Provincial Regulations.

Province	Aquatic Habitat Buffer (m)	Setback Buffer Details

British Columbia	0-10	The following applies specifically to glyphosate-based herbicides:
		• 0m buffer around a body of water if the body of water is:
		  ○ Temporary free-standing body of water
		  ○ Is not a classified wetland or a wildlife habitat feature
		  ○ Not fish bearing and does not drain into a fish bearing body of water within 100m
		  ○ Either smaller than 25m² or not a wetland
		• 2m buffer around a body of water or a classified wetland if:
		  ○ The wetland/water body is not fish bearing
		  ○ Selective application methods are used between 2 and 10m above the high water mark
		• 10m for all other classified wetlands, bodies of water, and dry streams

Alberta	1-30	• Glyphosate-based herbicides may not be deposited closer than 1m from an open body of water (ground spraying only). • Herbicides may not be deposited within 30m of an open body of water if using non-ground (aerial) methods.
Nova Scotia	15-30	• Wetland: 15m • Surface watercourses (the bed and shore of every river, stream, lake, creek, pond, spring, lagoon or other natural body of water): 30m
New Brunswick	65	• 65m no-spray buffer zone around watercourses
Ontario	60-120	• Significant areas: 60m buffer. Includes lakes >10ha, lakes <10ha which possess significant fisheries values, and permanents streams on a topographic map of scale 1:50,000. • Sensitive areas: 120m. Includes critical fish habitat (spawning areas, wetlands, headwaters, migration areas, nursery areas, intermittent streams that provide spawning habitat for fish; fish sanctuaries; fish hatcheries; stocked lakes and rivers; endangered species habitat.

Sources: Environmental Code of Practice for Pesticides, 2025; Integrated Pest Management Regulation, 2024; Nova Scotia, 2024b; Ontario Ministry of Environment and Energy, 1992; Riley et al., 1991.