

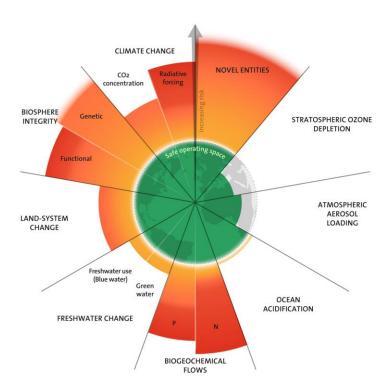
The indirect effects of historical and contemporary pesticides on forest ecosystems

Chris Edge - Canadian Forest Service Integrated Vegetation Management Forum 6 November 2025

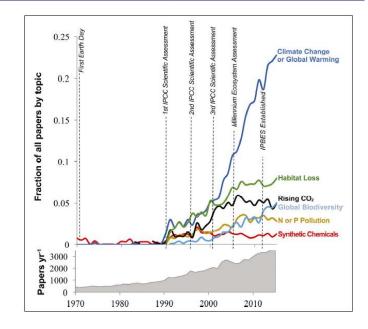
Canadä



Pesticides are a major, global issue

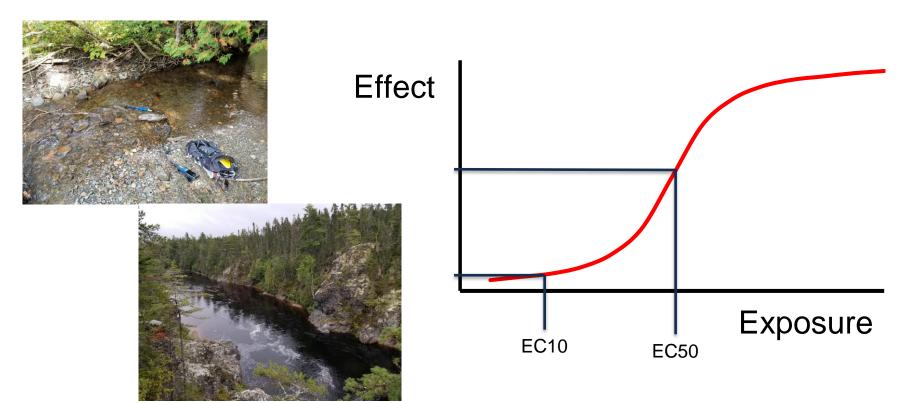


Synthetic chemicals and global change

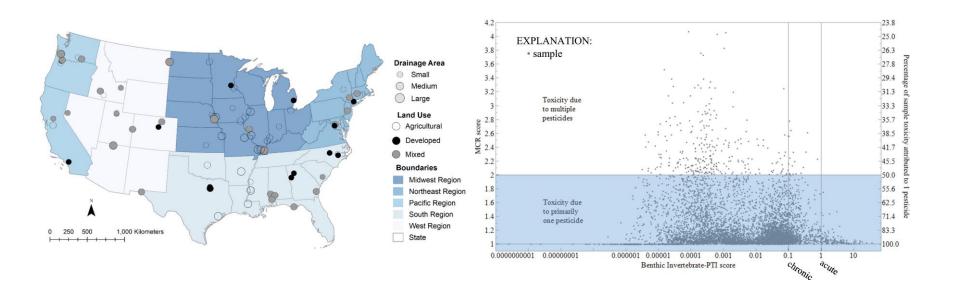


Bernhardt et al. 2017

Modern toxicology / Risk assessments Do measured concentrations exceed thresholds?

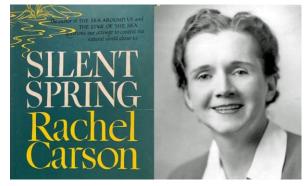


25% of sites exceed a toxicity threshold



Covert et al 2020

Chapter 9: Rivers of Death



FROM THE GREEN DEPTHS of the offshore Atlantic many paths lead back to the coast. They are paths followed by fish...the coastal rivers.

These events repeated a pattern that was age-old, a pattern that had made the **Miramichi** one of the finest salmon streams in North America.

Before the spraying there had been a rich assortment of the water life that forms the food of salmon and trout...But now the stream insects were dead, killed by the DDT, and there was nothing for a young salmon to eat.

Eastern Spruce Budworm (Choris

Targets Fir and Spruce trees

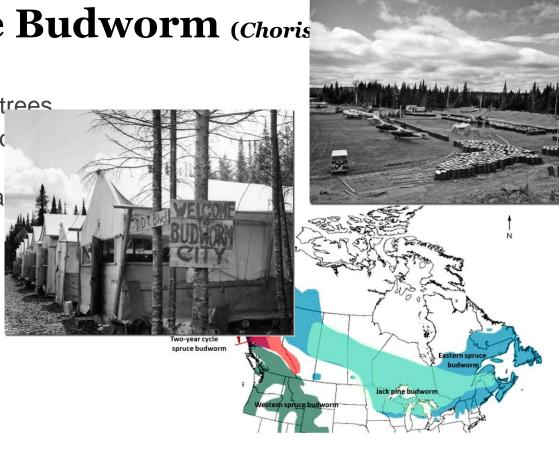
2019 defoliated 5.5 million

Total insect defoliation in

New Brunswick Outbrea

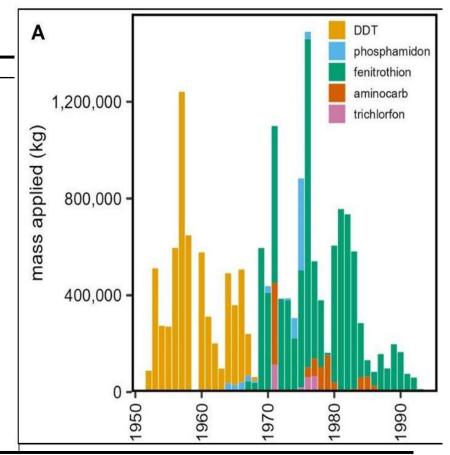
1940

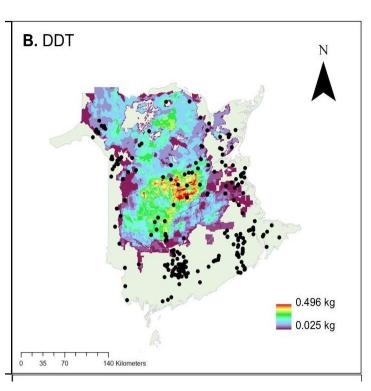


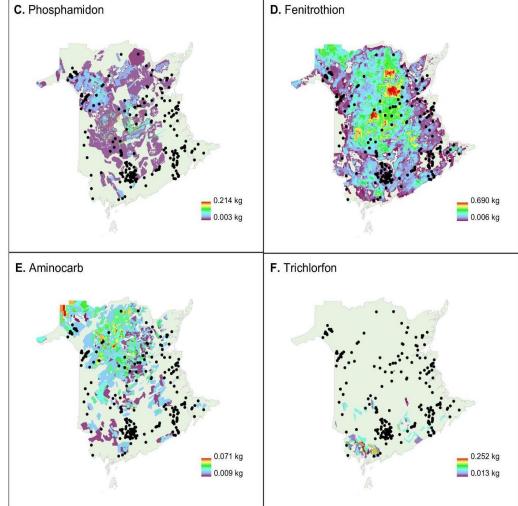


1952 - 1993

Active Ingredient	Class	Years
DDT	Organochloride	1952-1968
Phosphamidon	Organophosphate	1963-1977
Dimethoate	Organophosphate	1965
Malathion	Organophosphate	1965
Fenitrothion	Organophosphate	1966-1993
Methomyl	Carbamate	1970
Aminocarb	Carbamate	1970-1987
Pyrethrin	Carbamate	1970, 1973
Mexacarbate	Carbamate	1971
Methoprene		1973
Trichlorfon	Organophosphate	1973-1977
Bacillus thuringiensis kurstaki	Biopesticide	1975-1993







Historical pesticides

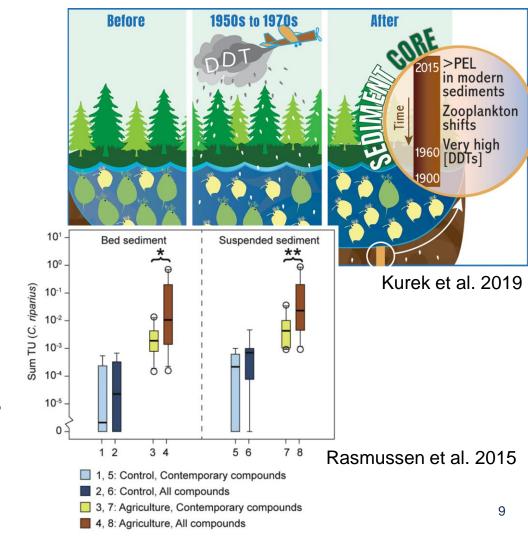
Higher toxicity

Longer persistence

Greater mobility

Less specificity

Still influence aquatic communities?



Living Data Project Working Group



canadian institute of ecology and evolution institut canadien d'écologie et d'évolution

Scott Sugden, McGill University Amy White, Waterloo University Ilya Dimitrovas, Mount Allison University Sandra Emry, University of British Columbia Xaiotian Hua, McGill University Moira Ijzerman, University of Guelph Karen Kidd, McMaster University Josh Kurek, Mount Allison University Jen Lento, University of New Brunswick Kaitlyn Morrow, Mount Allison University Jessica Ollinik, University of Regina Laura Schnell, University of Regina Marcus Thormeyer, University of British Columbia

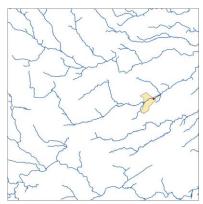




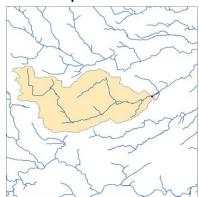


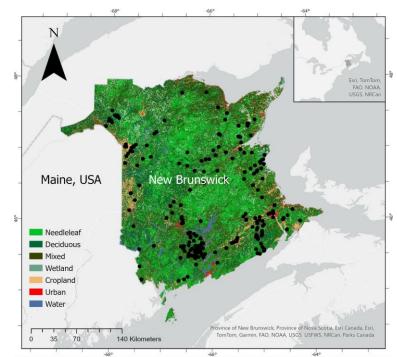
2000 - 2022 Standardized Benthic Invertebrate sampling 274 locations

RCA: Reach Contributing Area

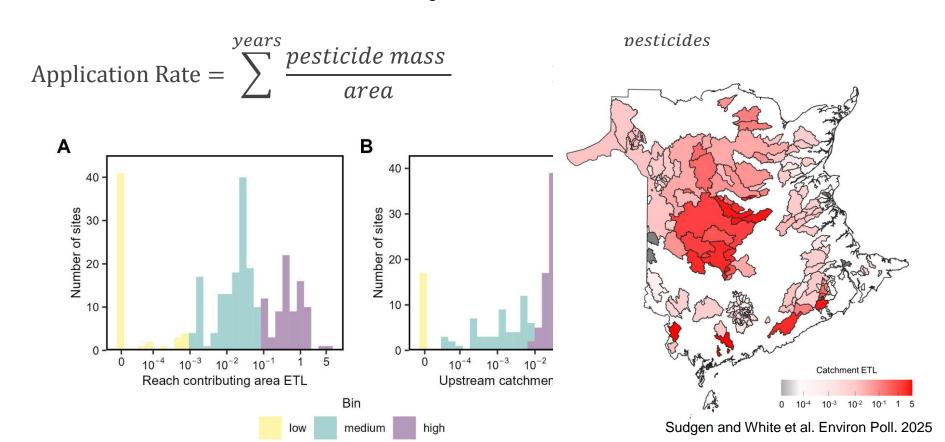


UCA: Upstream Catchment Area

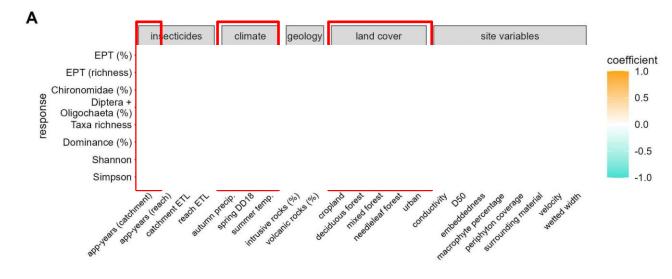




Estimated Toxicity Load (ETL)



Univariate



Application years

Climate

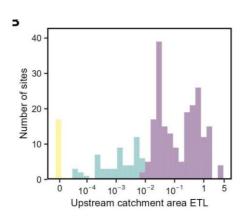
Land cover

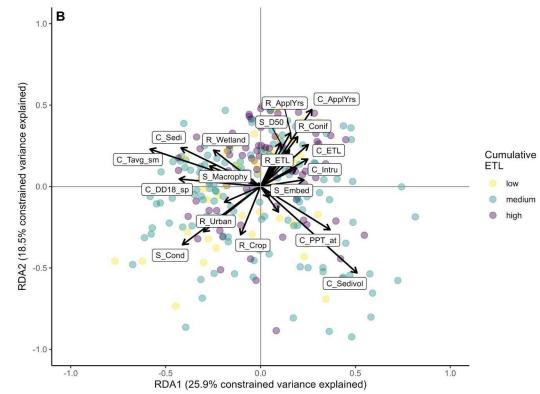
RDA: Environmental variables

Insecticides

Land Cover

Geology / Substrate



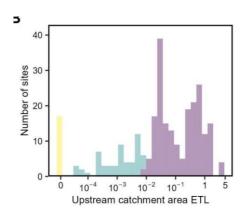


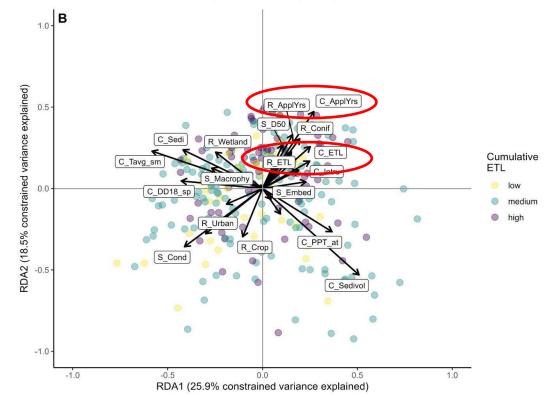
RDA: Environmental variables

Insecticides

Land Cover

Geology / Substrate



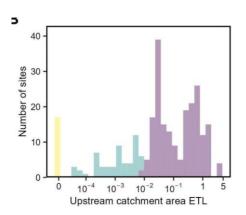


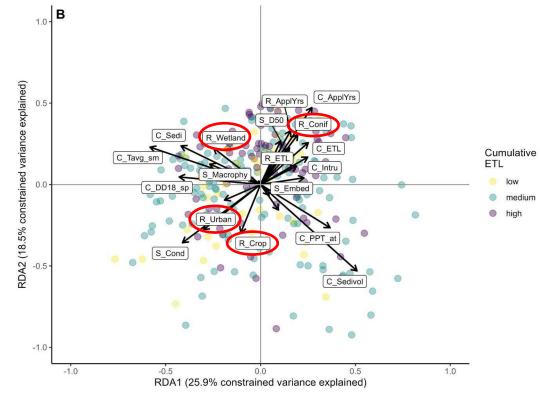
RDA: Environmental variables

Insecticides

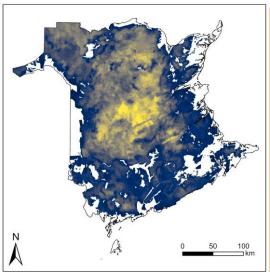
Land Cover

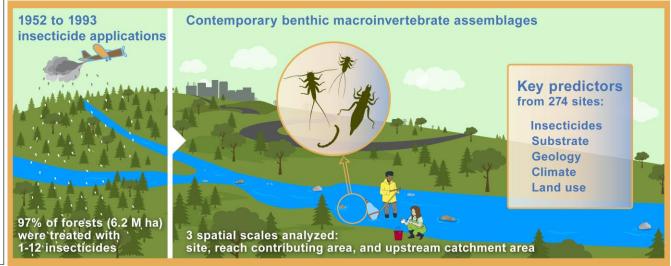
Geology / Substrate





Small, but important, legacy impact



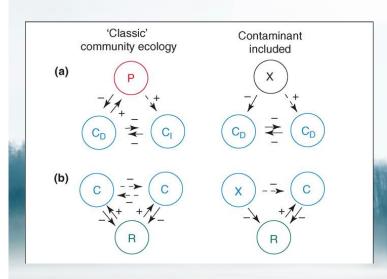


Goal of environmental toxicology

Trace effects on cellular targets to

- Populations
- Communities
- Ecosystems

Beketov and Liess 2012; Köhler and Triebskorn 2013



Community ecology to predict effects of pesticides

Rohr et al 2006; Halstead et al 2014

Herbicides in forestry

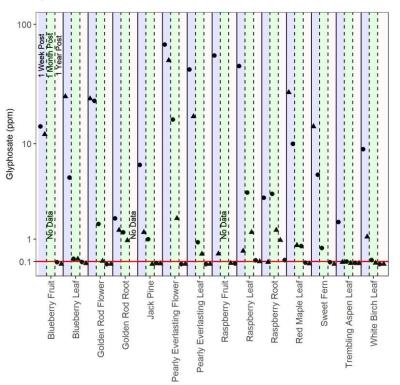
- Year 0: Clear cut harvest
- Year 1-2: Plant
- Year 2-4: Herbicide
- Year 50-70: Harvest



- Used to reduce competition between crop trees and other vegetation
- 95% is glyphosate

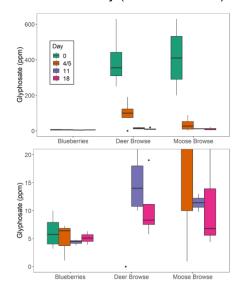


Long-Term study (Ontario)



Block 1Block 2

Short-Term study (New Brunswick)



Short term exposure to concentrations that predict negative effects

Aquatic monitoring

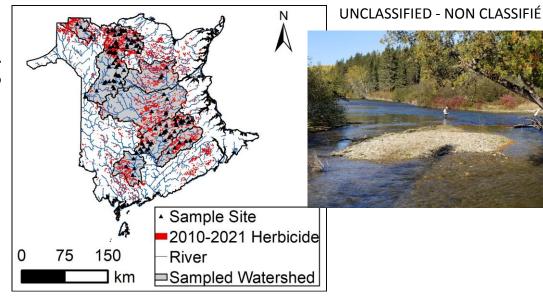
296 Total samples 1 detection, 17 ppb (µg/L)

Protection of aquatic health

Acute: 27,000 μg/L

Chronic: 800 µg/L

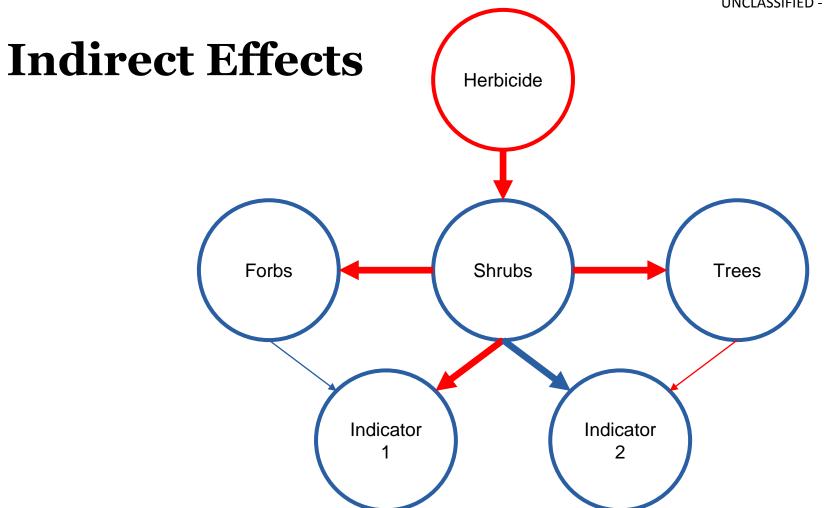


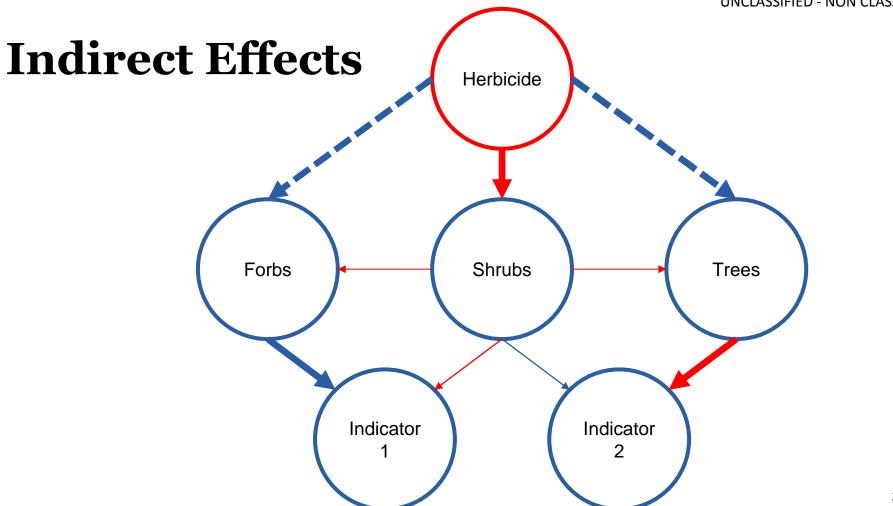




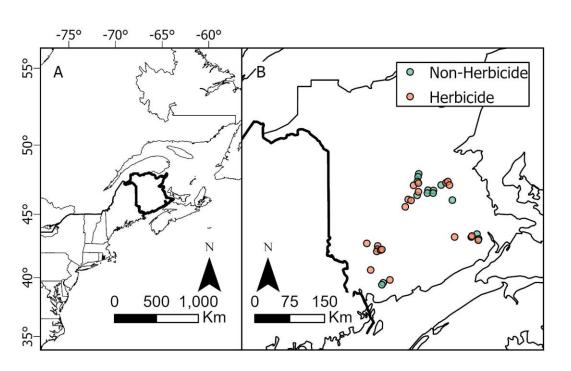


21





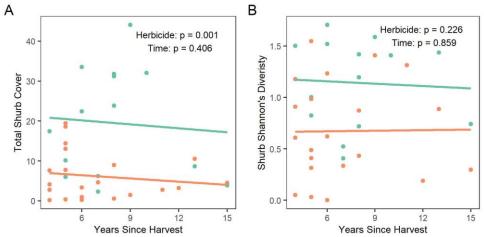
Vegetation change



35 blocks21 herbicide14 non-herbicide

4-15 years after harvest3-13 years after herbicide

Vegetation Change



Community shift Gr

Vaccinium myrtilloides

Kalmia angustifolia

Xiao et al. Forestry 2023

Comptonia peregrina Vaccinium angustifolium

Rhododendron canadense

llex mucronata

Majanthemum canadense Mitchella repens

0.5

Chamaenerion angustifolium

Prunus pensylvanica

Aralia hispida

Solidago L

-0.5

Cirsium Vulgare

Cornus canadensis

0.0

NMDS1

Aster

1.5 -

1.0 -

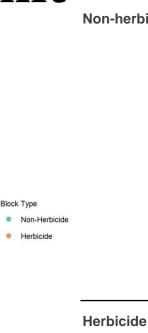
0.5

0.0

-0.5 -

-1.0

Rubus idaeus



Indicator species				
roup	Species			
on-herbicide	lowbush blueberry			
	velvet-leaved blueberry			
	sheep laurel			

bracken fern

sweet-fern

rhodora

Pine spp.

paper birch

bunchberry

wild lily-of-the-valley

pearly everlasting

mountain holly

three-leaved rattlesnakeroot

blueberry

% Non-Herbicide % Herbicide 100 % 93.3 %

UNCLASSIFIED - NON CLASSIFIÉ

54.5 % 40.9 %

63.6 %

59.1 %

80.0 % 86.7 %

> 53.3 % 22.7 % 18.2 %

60.0% 100 % 93.3 %

66.7 %

13.3 %

86.7 %

53.3 %

13.3 %

72.7 % 81.8 %

36.4 %

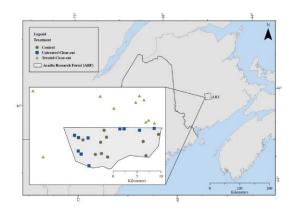
90.9 %

86.4%

54.57%

63.6 %

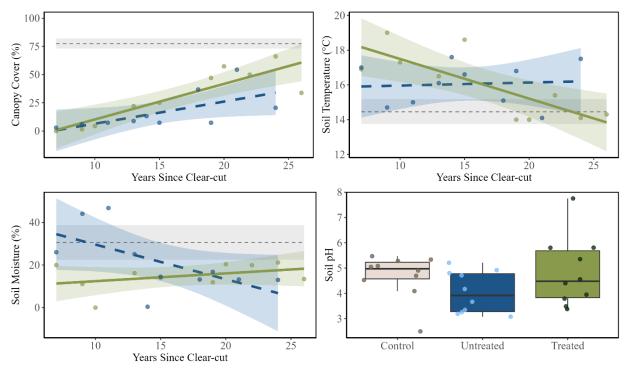
Abiotic environment



Faster canopy closure

Cooler soil

Lower, then higher, soil moisture

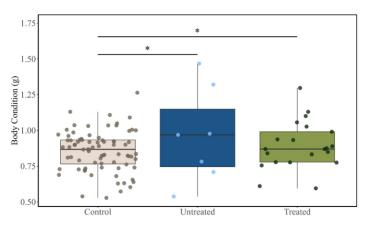


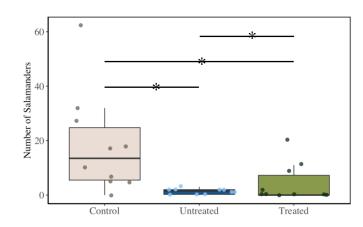
UNCLASSIFIED - NON CLASSIFIÉ

Salamanders









Indirect effects

- Glyphosate use in forestry unlikely to be directly toxic
 - Exposure
- Glyphosate use changes the vegetation community
 - Fewer shrubs, more flowering plants
 - Earlier canopy closure, lower temperature, and higher moisture
- Bumblebees respond to increased abundance of flowing plants
- Salamanders respond to environmental change







Invasive Species Management

Hemlock Woolly Adelgid



First detected in Virginia in the 1950's Detected in Nova Scotia in 2017 Once infested with HWA, usually die in 4-15 years



Imidacloprid

Non-selective

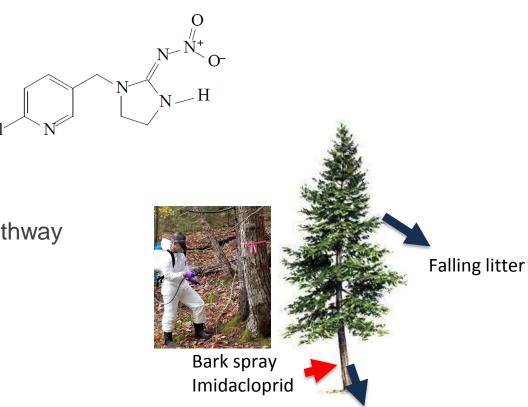
High water solubility

Low K_{ow}

Photolysis major breakdown pathway

Soil DT₅₀: 16-1200 days

Water DT_{50} : < 5 days



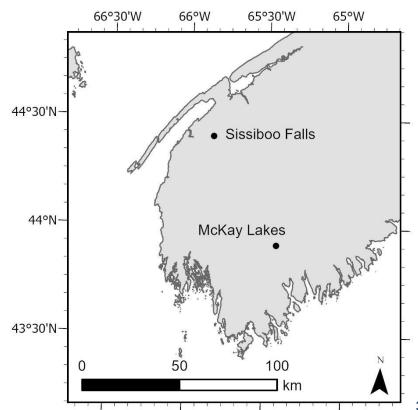
Run off

Field trials

Four 1 ha blocks per site

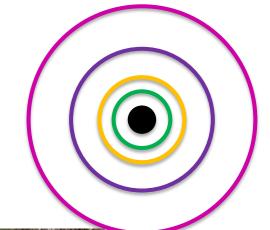
Xytect 2F applied to 40 to 60 hemlocks per year (1.89 L per ha limit)

Fall 2020 and Fall 2021 application



Soil samples

Matrix	6 months	12 months	18 Months	24 months
Soil 50cm	2020, 2021	2020, 2021	2020, 2021	2020, 2021
Soil 100cm	2021	2020, 2021	2020, 2021	2020, 2021
Soil 200cm	2021	2021	2020, 2021	2020, 2021
Soil 400cm	2021	2021	2020, 2021	2020, 2021



- 2 Applications
- 2 Sites
- 4 Blocks
- 3-6 Trees
- 4 Distances from tree
- 4 Time periods

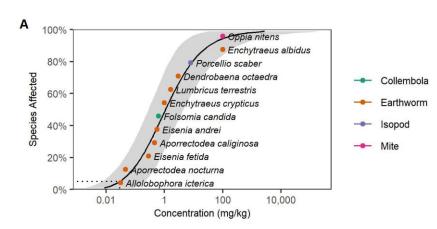
696 Soil samples





Threshold: Species Sensitivity Distribution

Conservative estimate NOEC HC5 = 0.0294 mg/kg



Environmental Risk

NOEC

Risk quotient = Environmental Concentration HC5

EC50

> 1 predicts risk

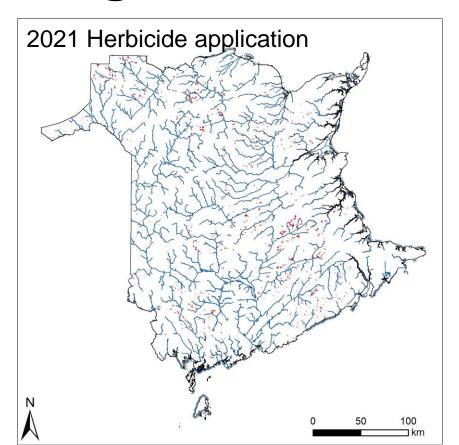
Hemlock

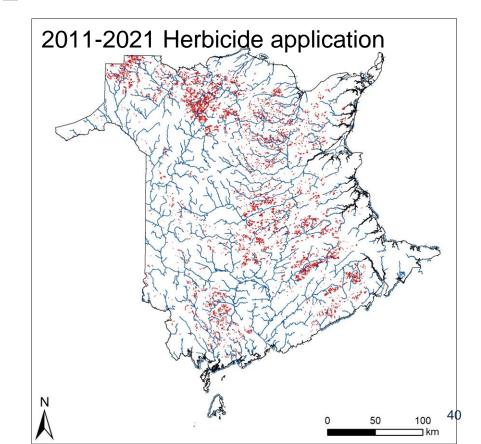




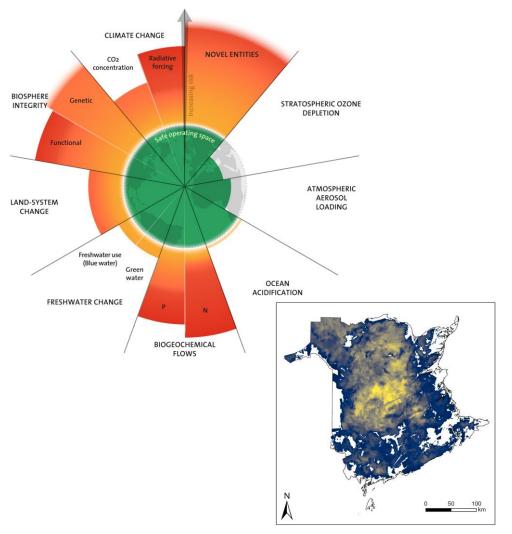


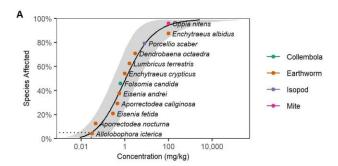
Large, cumulative, spatial extent





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Canadä