Environmental Fate & Potential Effects of Glyphosate (Vision) Herbicide in Canadian Forest Ecosystems

229 P ☐ NP ☐ DM6

Programme décennal d'épandage de phytocides par voie aérienne en milieu forestier sur des terrains privés de Smurfit-Stone inc. sur le territoire de La Tuque et de la MRC du Domaine-du-Roy

Mauricie **6211-13-011**

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Photo credit:
B. Richardson

Herbicides in Relation to Canadian Forest Service Goals

Sustainable Forestry

- Cost-effective, efficacious and environmentally acceptable technique for vegetation management on selected sites
- A critical component of Integrated Vegetation Management, particularly for conifer regeneration

Environmental Protection

- Minimum application rates to achieve silvicultural objective
- Minimize off-target deposit
- Environmental concentrations < biological effects thresholds
  - population, community level, most sensitive species

Extensive Management ⟷ Intensive Management

- Valuable crop trees lost in a sea of competing vegetation
- Mills, jobs and international competitiveness unsustainable

- Replace conifer on the landscape
- Reduce ecological footprint
- High quality fibre vol/ha
- International competitiveness

Integrated Vegetation Management

Shear blade

Mechanical

Bräcke scarifier

Brushsaw

Motor-Manual

Chainsaw

Alternative Harvesting

Silvicultural

Precommercial Thinning

Temporal/Spatial Integration

Glyphosate

Chemical

Triclopyr

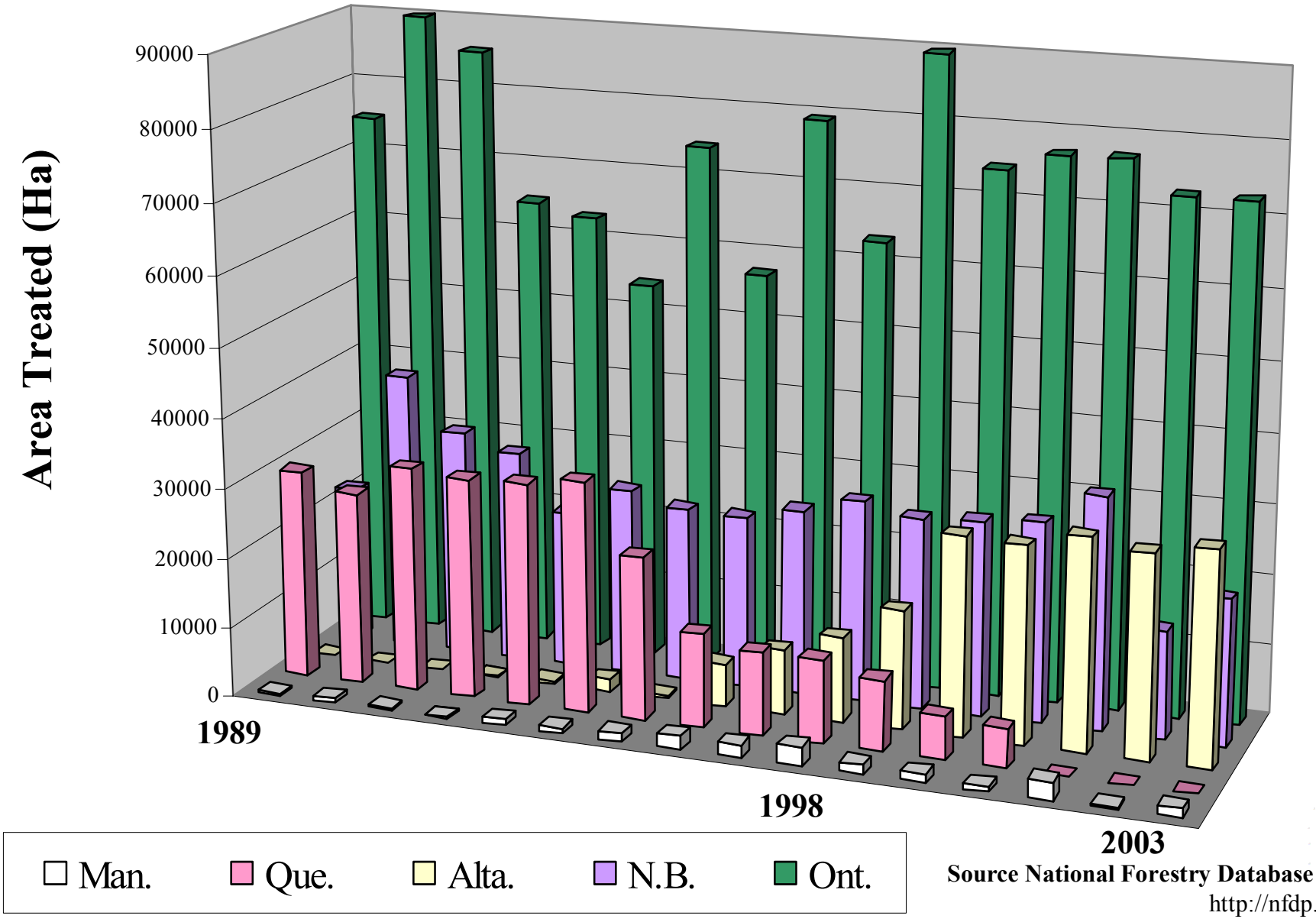
Prescribed Fire

Fungal pathogens

Biological

Insects

Glyphosate Use in Forest Sector of Key Canadian Provinces



Source National Forestry Database Program
http://nfdp.ccfm.org/

Pesticide Registration & Regulation in Canada

- New Pest Control Products Act (2002)
- Pest Management Regulatory Agency (PMRA)
- Widely considered the most rigorous environmental regulation process in the world
  - Specifically designed to ensure that registered products do not pose unacceptable risks to humans or the environment
- Additional regulations imposed by provincial ministries
  - e.g. buffer zones to protect aquatic systems
- Registration/regulation requires extensive scientific data

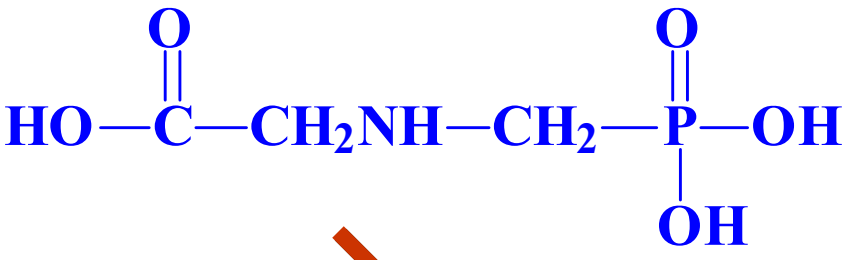
Major Scientific Reviews

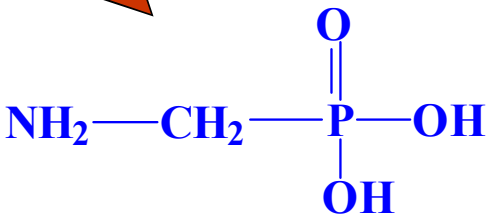
Fate and effects of Glyphosate in the Environment

1. Rueppel et al. 1977.
2. Ghassemi, M. et al. 1982.
3. USDA-FS. 1984.
4. Grossbard E. & D. Atkinson (Eds). 1985.
5. USDA 1984, 1989, 1992, 1996, 1997
6. Servizi et al. 1987.
7. Environment Canada. 1989.
8. USEPA. 1993.
9. Newton et al. 1994.
10. WHO - International Program on Chemical Safety. 1994.
11. Sullivan and Sullivan. 1997.
12. Roshon, R.D. et al. 1999.
13. Environment Canada 1999.
14. Giesy, J. P. et al. 2000.
15. Williams, G.M. et al. 2000.
16. Solomon, K.R. & D.G. Thompson. 2003.
17. Sullivan and Sullivan 2005 (in press) – soil organisms
18. Solomon, K.R. & D.G. Thompson 2006 (in prep) – amphibians

Glyphosate (Vision) Herbicide

Glyphosate



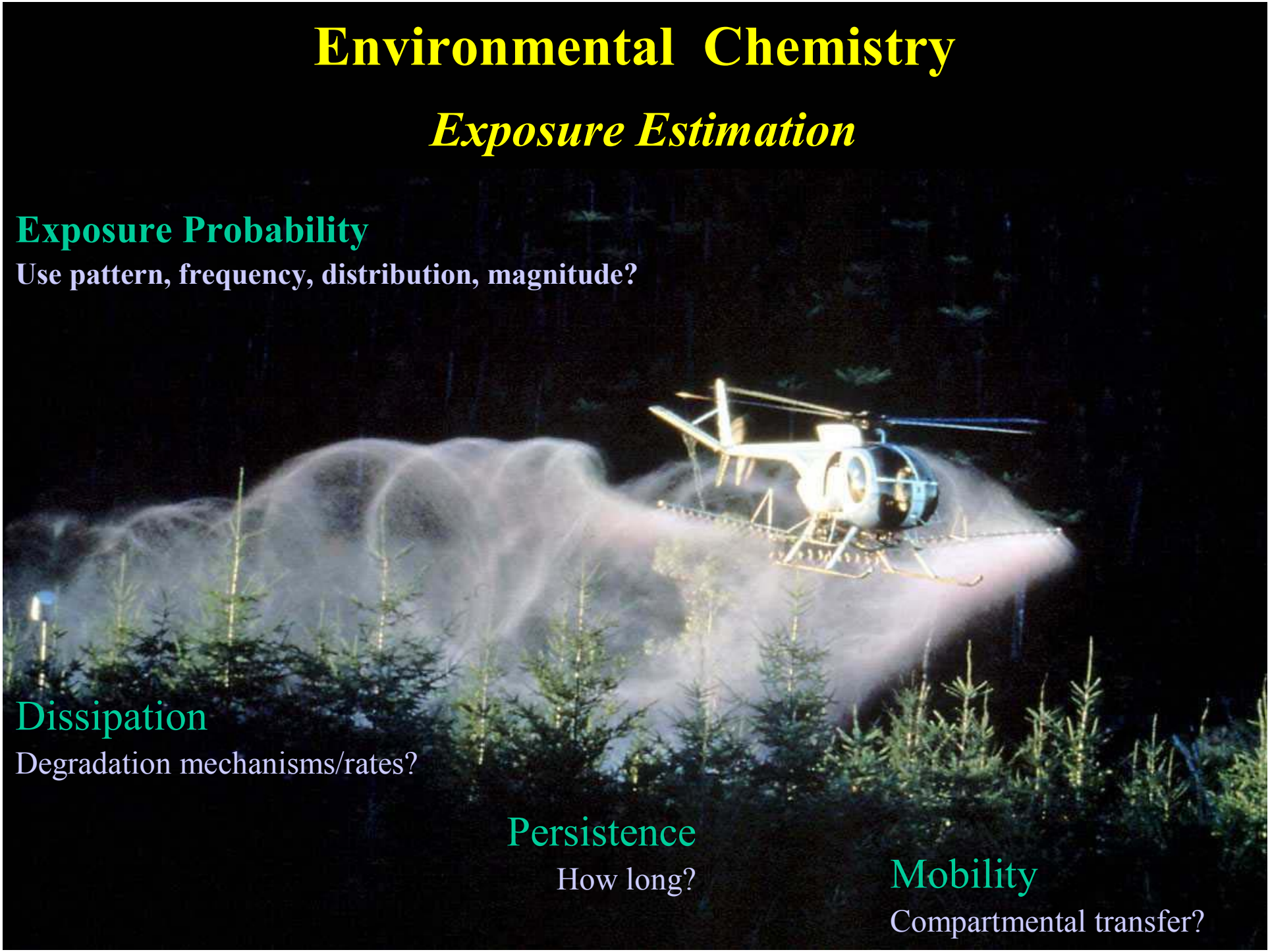


AMPA

- inhibits shikimic acid pathway of aromatic amino acid biosynthesis
- target pathway exists in plants, algae, bacteria, fungi and protoza but not in birds, insects, fish, mammals
- Organic acid, highly ionic
- Highly water soluble, non-bioaccumulatory
- Susceptible to microbial degradation
- Principal metabolite is AMPA
- Binds strongly to organic substrates
- non-persistent, non-leaching
- Primary toxicant in formulation is POEA surfactant
- POEA affects membranes and acts as a general narcotic

Environmental Chemistry

Exposure Estimation



Exposure Probability

Use pattern, frequency, distribution, magnitude?

Dissipation

Degradation mechanisms/rates?

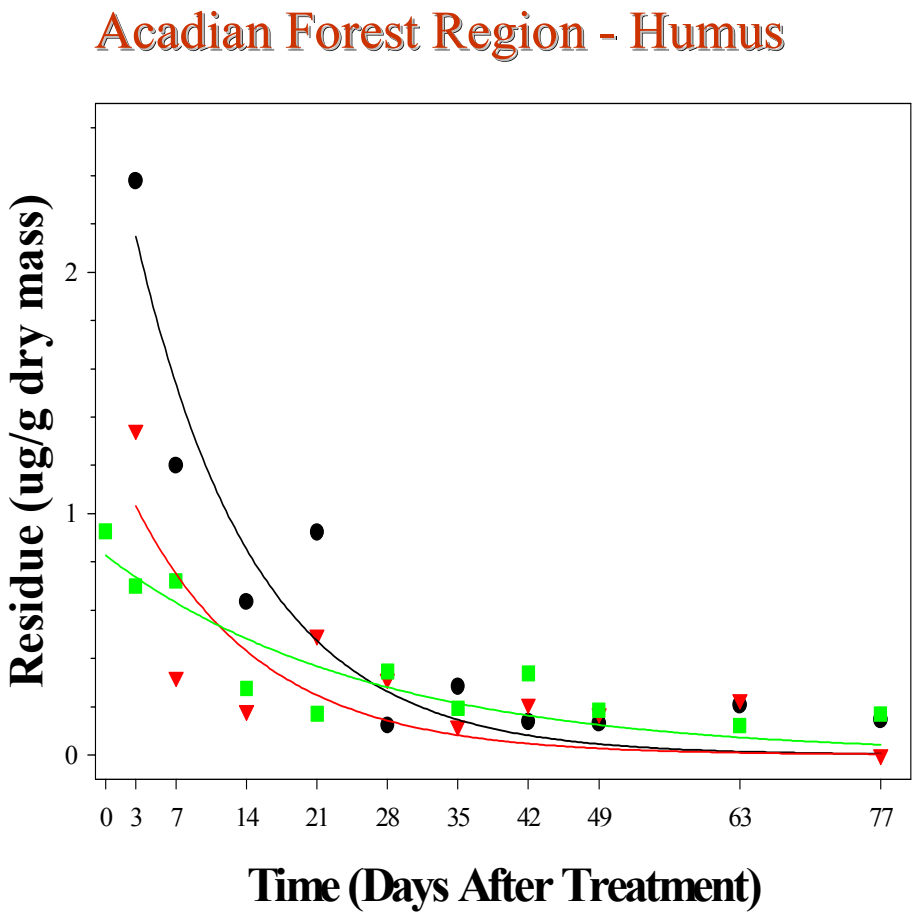
Persistence

How long?

Mobility

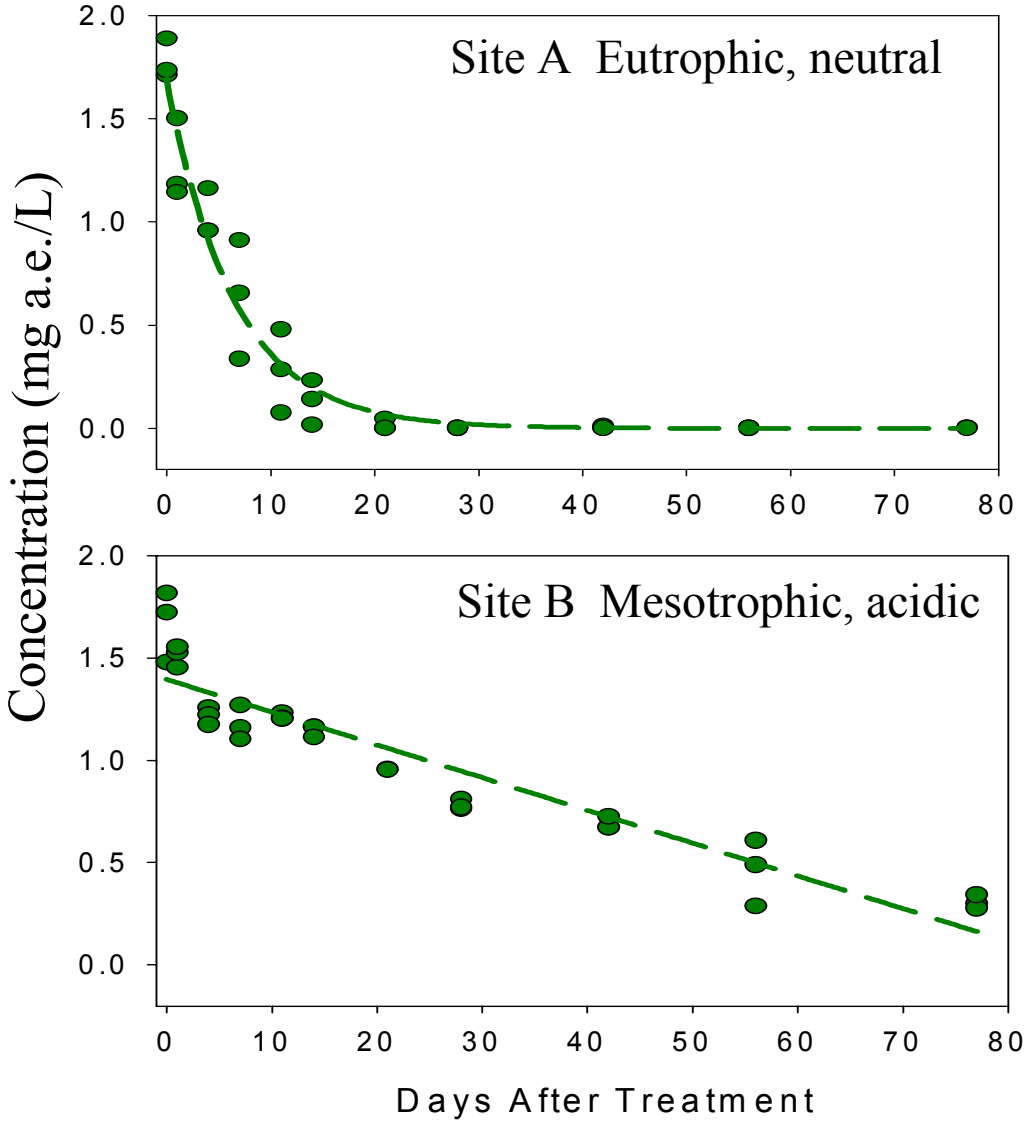
Compartmental transfer?

Glyphosate Persistence in Soils



- Roy et al. 1989
  - Matheson, Ont.
  - DT50 = 24 days, no lateral movement, no leaching
- Feng & Thompson, 1982
  - Carnation Creek, B.C.
  - DT50 < 14 days in litter
  - DT50 45-60 days in soil, no leaching
- Thompson et al. 2000
  - Fredericton, N.B.
  - DT50 12 days in litter
  - DT50 avg.10 says in soil, longer under high brush density

Glyphosate Dissipation in Forest Wetlands

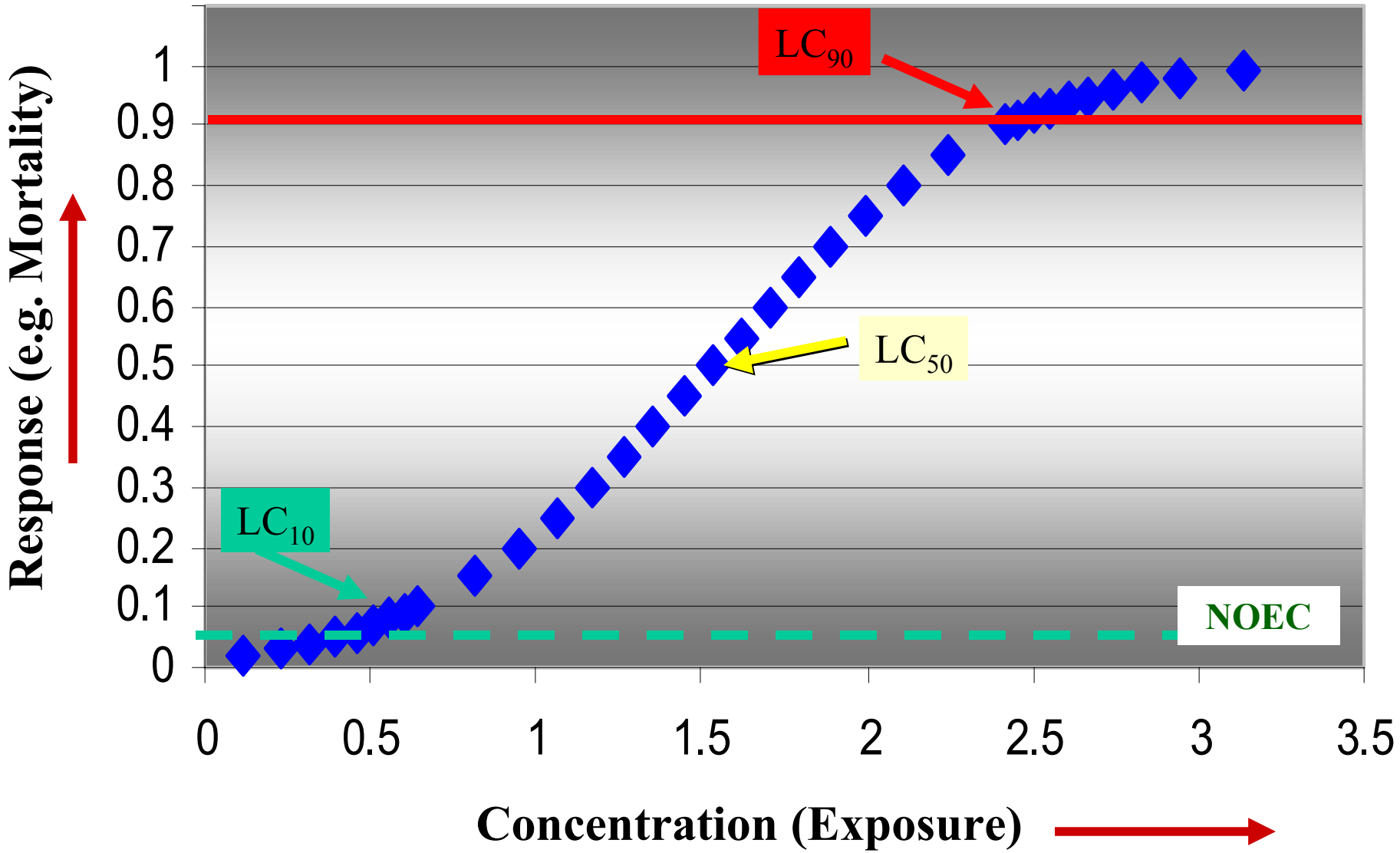


- DT50 = 4.2 d in shallow (< 1 m), eutrophic wetland with aquatic plants
- DT50 = 26.4 d in deeper (2 m), mesotrophic wetland

Glyphosate Fate & Persistence in Plants

- no uptake from soils & poor from foliage unless surfactant in formulation
- with surfactant, rapid uptake through leaves and rapid translocation to both shoots or roots
- Thompson et al. 1994
  - Fredericton, N.B.
  - DT50 of foliar residues < 2 days
- Roy et al. 1989
  - Matheson, Ont.
  - DT50 for berry resdues <13 and < 20 days for raspberry and blueberry respectively
  - levels consistently above 0.01 ppm max. permissible levels in food as established by Health Canada 1980
- Roshon et al. 1999
  - root growth of aquatic plants impaired by glyphosate but only at levels above expected environmental concentrations

Concentration-Response Relations



Glyphosate (Vision/Roundup) Acute Toxicity

As detailed in Giesy et al. 2000

Group	LD50 or EC50	NOEC
• Large mammals (Goat)	4860.0	2100.0
• Small mammals (Mouse)	>5000	2500.0
• Birds (*C. virginianus*)	>2250.0	1350.0
• Honeybees (*A. mellifera*)	100.0	----
• Earthworms (*E. foetida*)	---	3750.0
• Plant growth (*various*)	39.0	----
• Seed germination (*various*)	---	976.0
• Soil microbial function (*nitrification*)	300.0	5.0
• Fish (*O. mykiss*)	4.2	0.8
• Amphibians (*L. moorei*)	8.1	1.6
• Zooplankton (*D. magna*)	9.7	1.9
• Aquatic Plants (*M. sibiricum*)	3.9	0.78
• Algae (*S. capricornutum*)	2.1	0.73

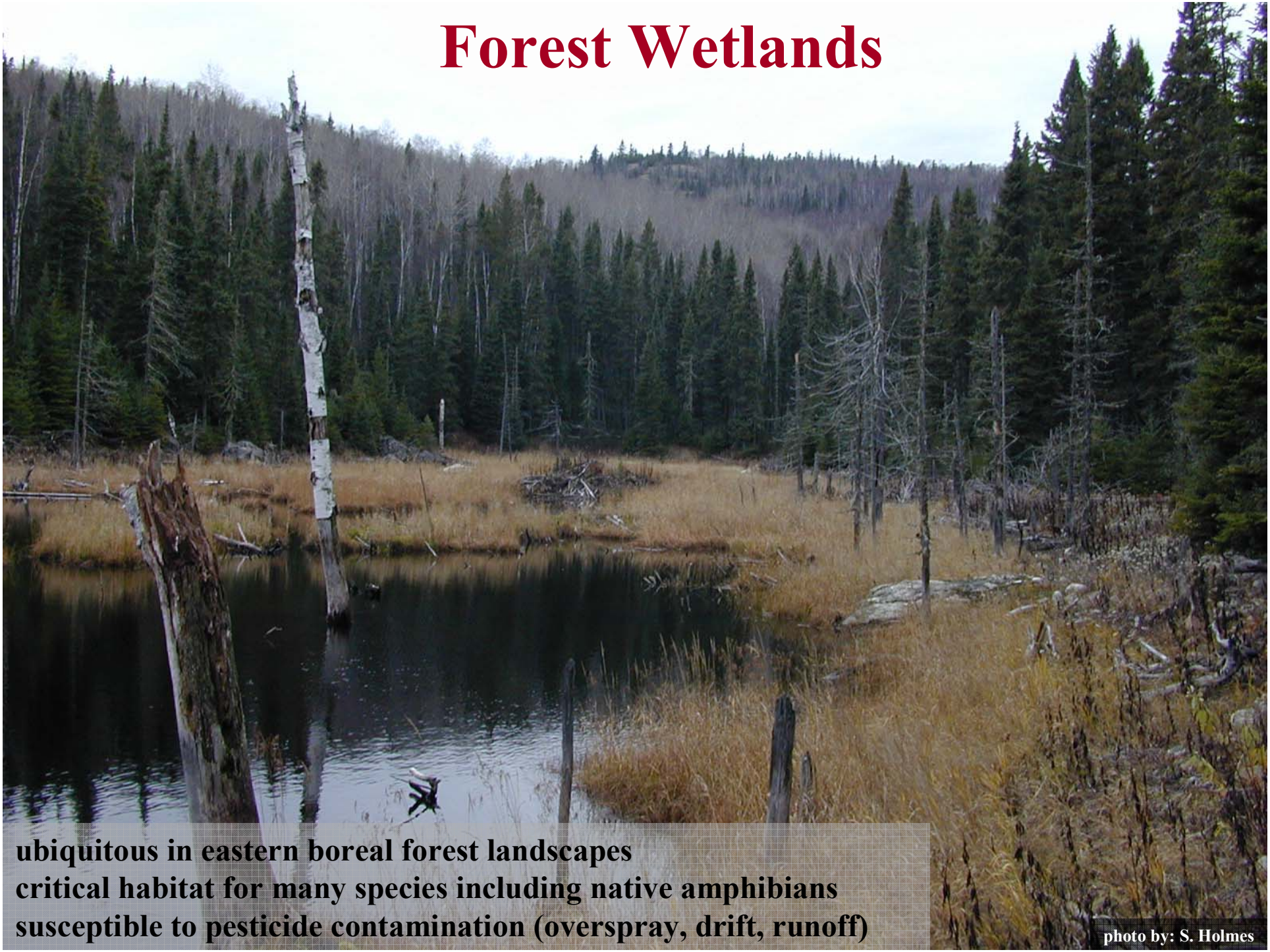
Units vary with endpoint

Most Sensitive Aquatic Species

Toxicity Threshold Values for glyphosate (Vision)

Toxicity Endpoint	Value (mg a.e./L)	Study Type	Reference
10^{th} centile lethality (all aquatic organisms)	3.2	PRA	Solomon & Thompson 2003
IC_{25} *M. sibiricum* (Plant)	0.6	Lab	Roshon et al. 1999
LC_{10} *R. pipiens* (amphibian larvae)	0.8	Lab	Edginton et al. 2003
LC_{10} *R. clamitans* (amphibian larvae)	1.2	Field	Wojtaszek et al 2003
NOEC *O. mykiss* (fish)	0.8	Lab	Solomon & Thompson 2003

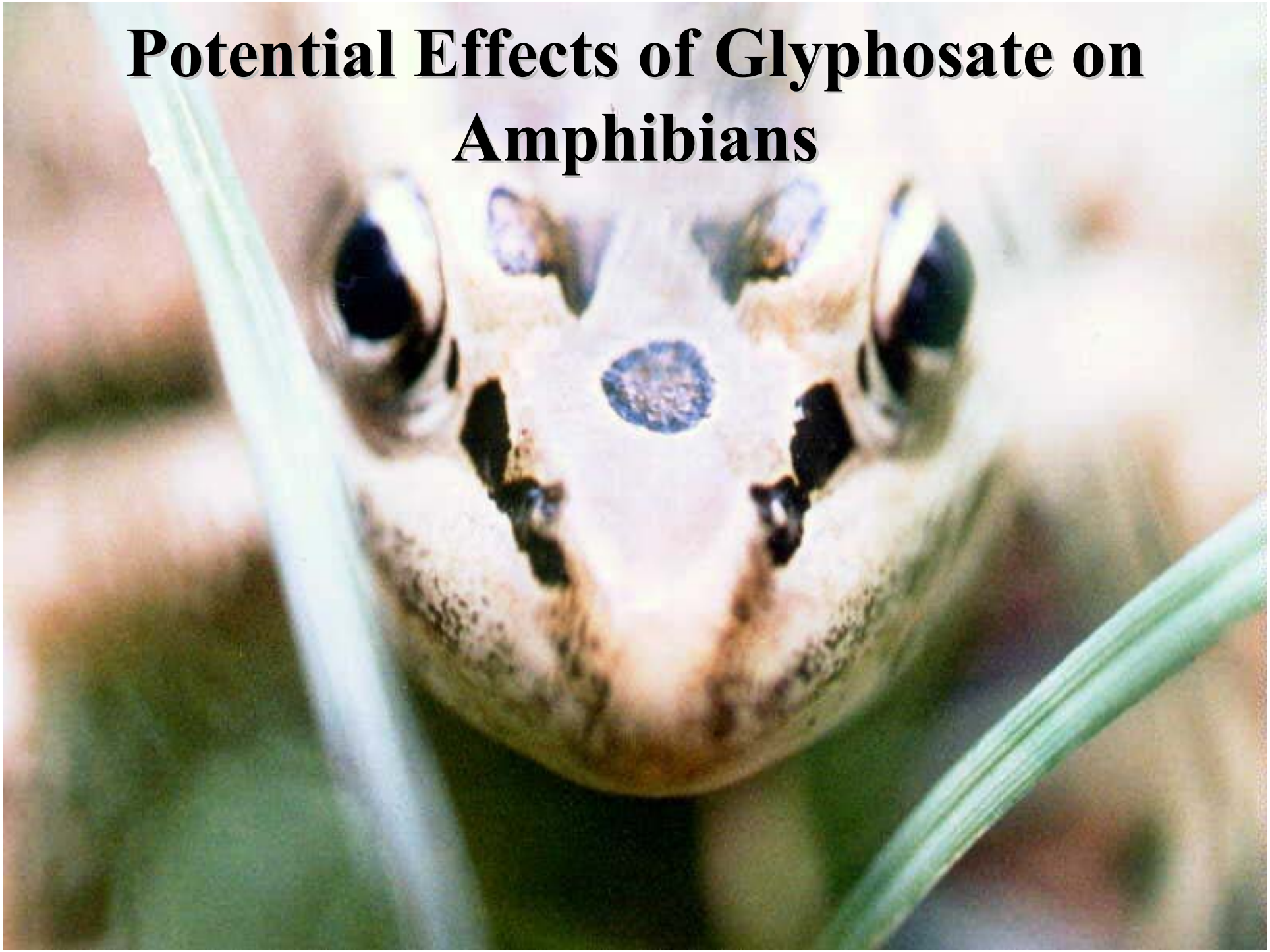
Forest Wetlands



ubiquitous in eastern boreal forest landscapes
critical habitat for many species including native amphibians
susceptible to pesticide contamination (overspray, drift, runoff)

photo by: S. Holmes

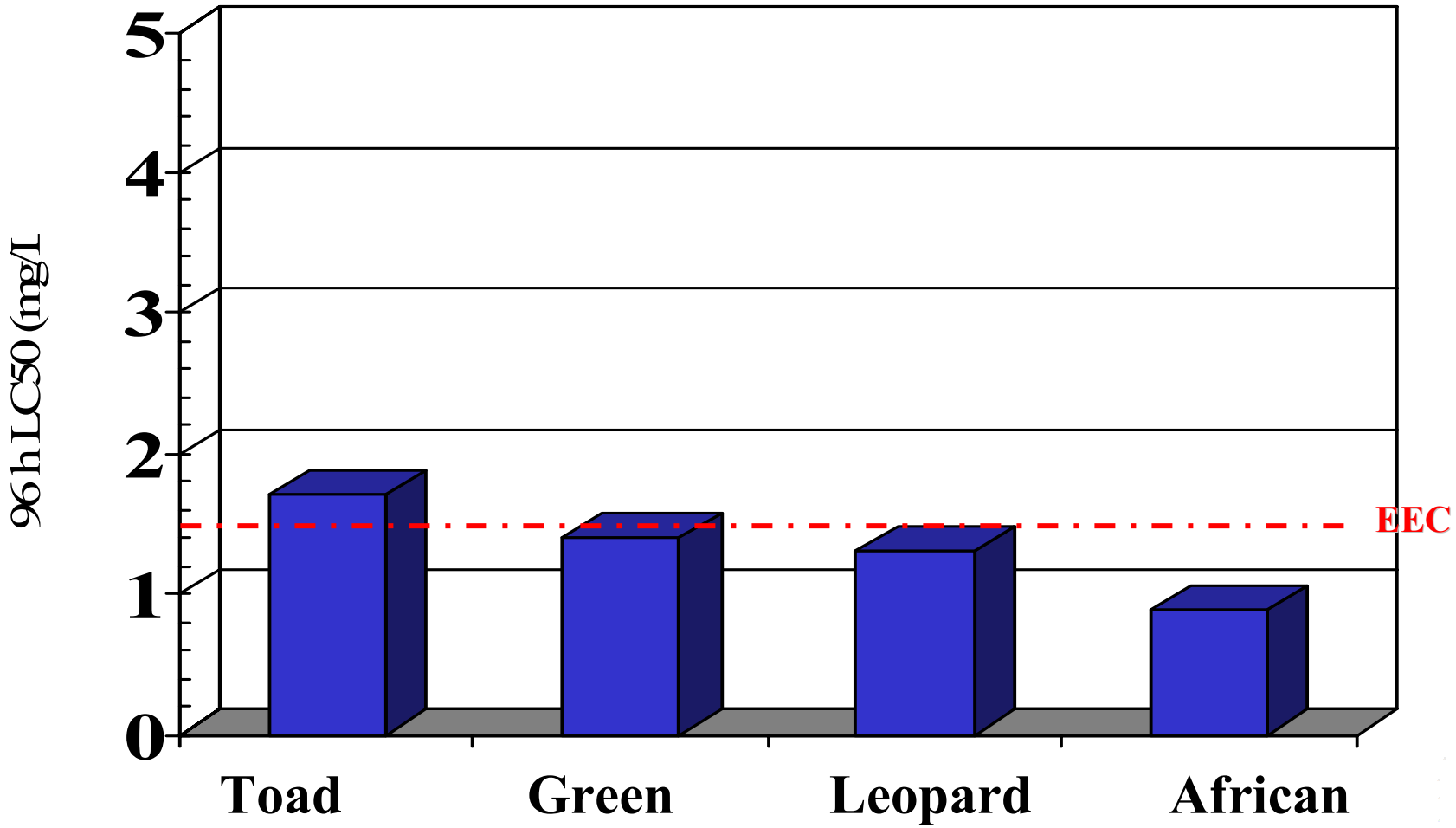
Potential Effects of Glyphosate on Amphibians



Comparative Lab Toxicity

Larval Amphibians

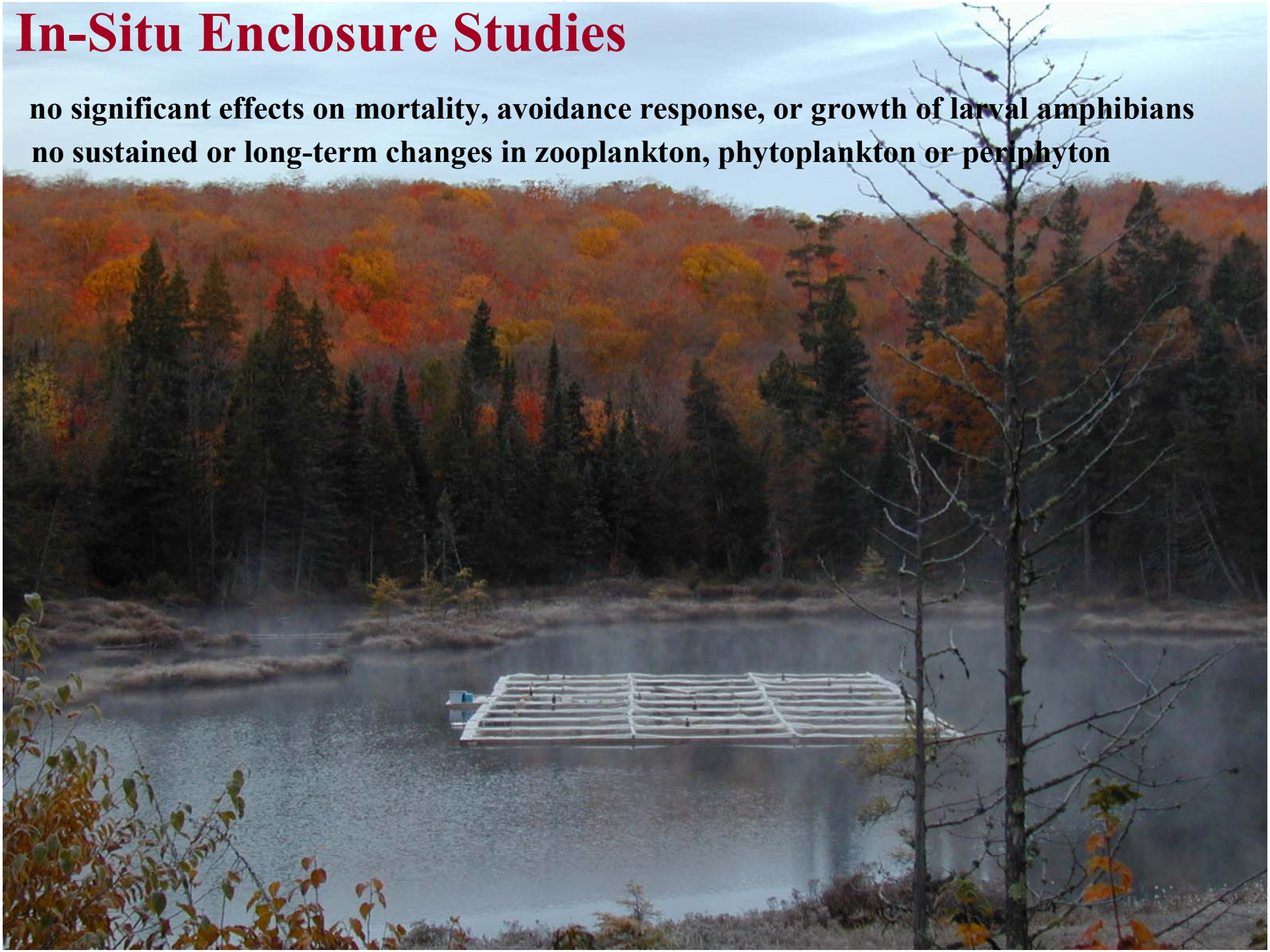
Vision @ pH 7.5



In-Situ Enclosure Studies

no significant effects on mortality, avoidance response, or growth of larval amphibians

no sustained or long-term changes in zooplankton, phytoplankton or periphyton

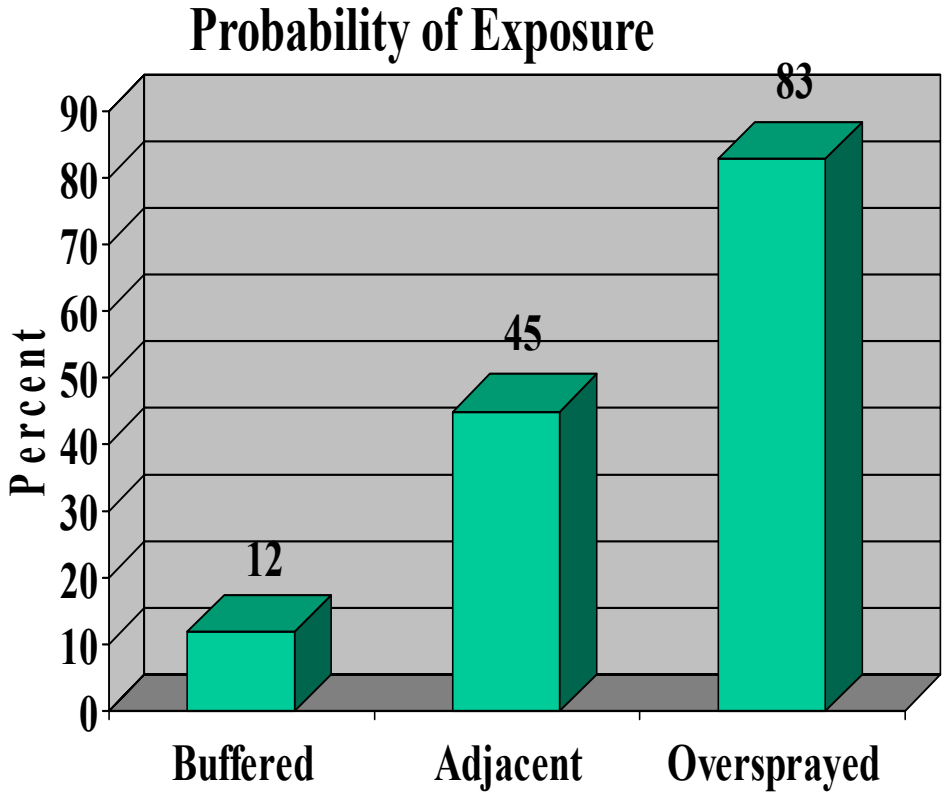


Operational Monitoring Studies

- Small shallow wetlands classified as buffered, adjacent or oversprayed
- Chemical monitoring for glyphosate aqueous residues
- Biological monitoring with caged larvae (green & leopard frogs)

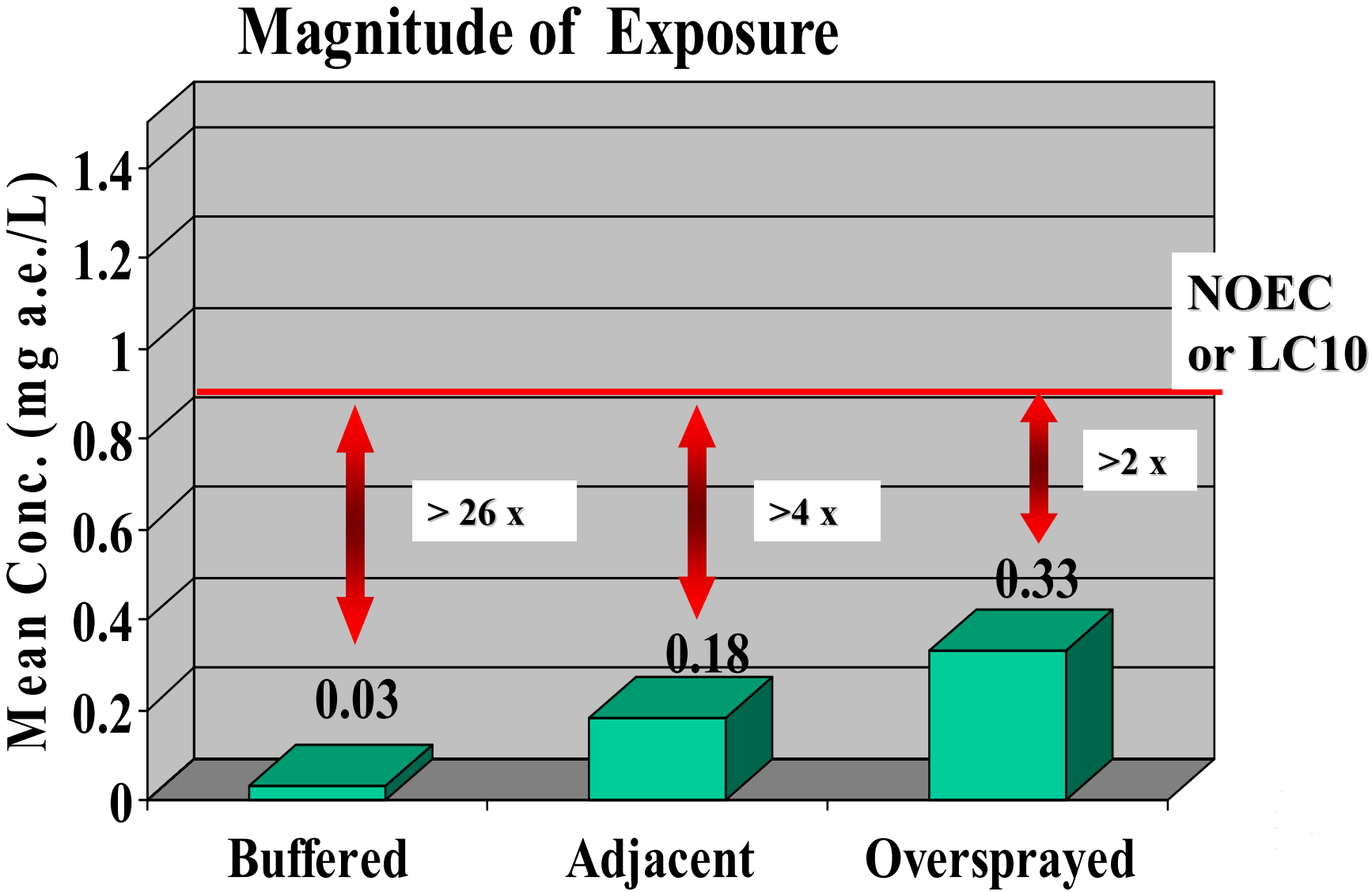
monitoring in 51 different wetlands
aerial applications of glyphosate (Vision)
Average application rate 1.9 kg a.e./ha
either fixed wing or rotary wing aircraft

Probability of Exposure

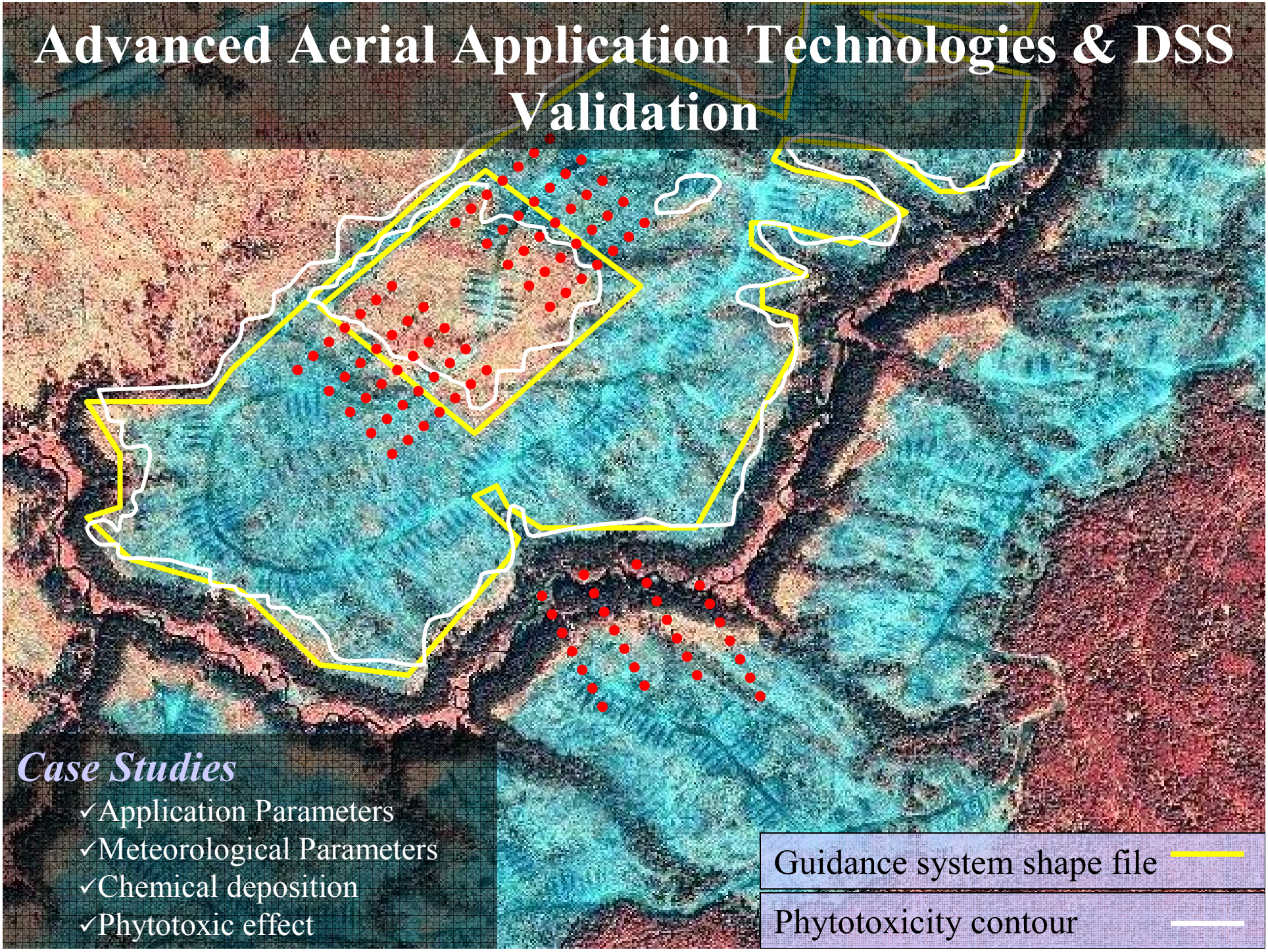


- Probability of exposure to any quantifiable levels of glyphosate (> 0.01 mg a.e/L)
- Buffered wetlands - low (12%)
- Adjacent wetlands (45%)
- Oversprayed wetlands (83%)

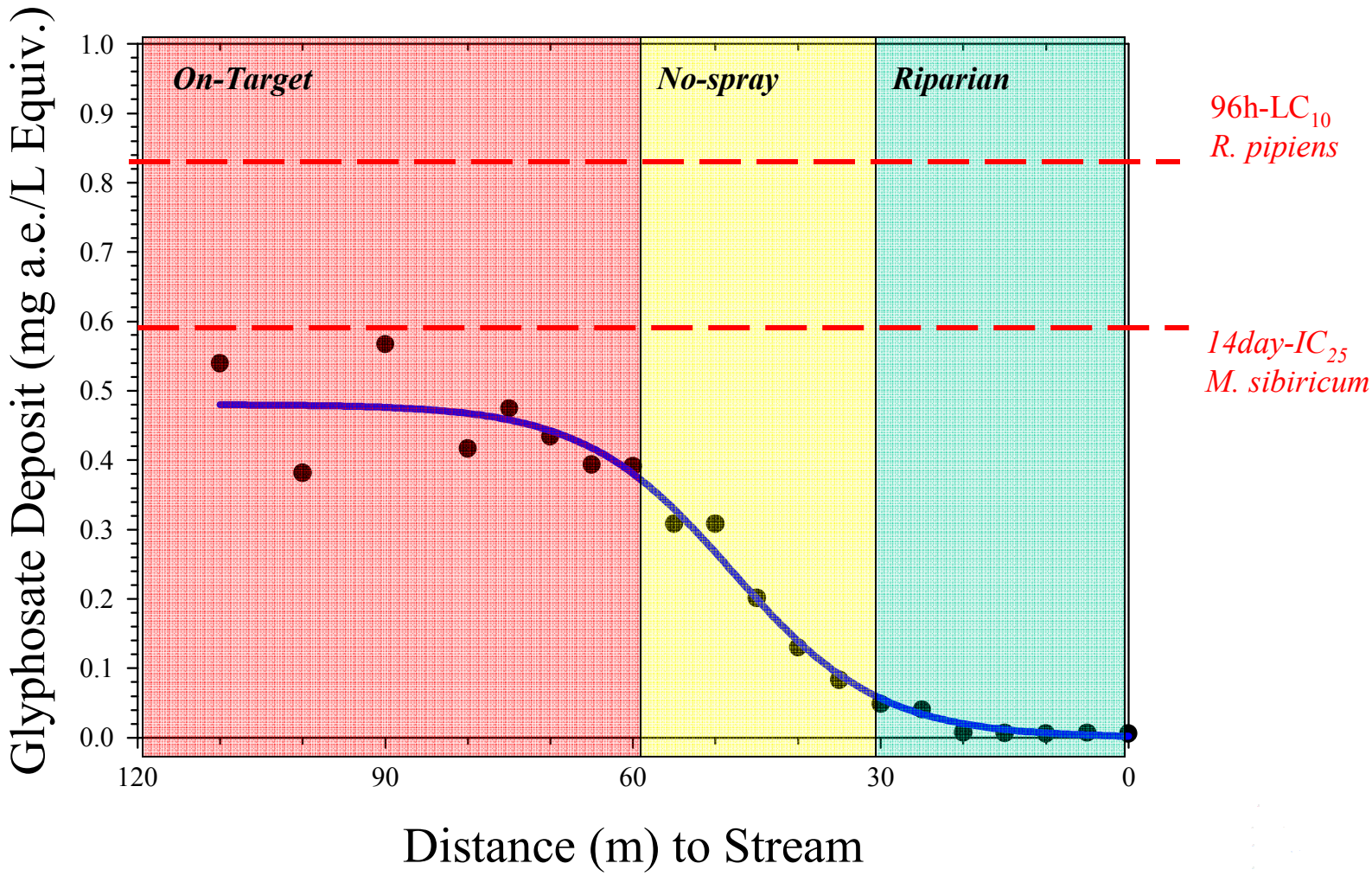
Environmental Exposure vs Toxicity Threshold



Advanced Aerial Application Technologies & DSS Validation



Deposition Through Buffer Zones



Take Home Points

- Veg. management - essential to sustainable forest production
- Environ. assessment -essential to protect ecological integrity
- glyphosate (Vision) herbicide best meets 3E criteria
- A wealth of scientific data directly pertinent to fate and effects in Canadian forest ecosystems exist
- The vast weight of scientific evidence clearly demonstrates that glyphosate (Vision) as used for forest vegetation management in accordance with label recommendations does not pose an unacceptable risk to humans or the environment
- Several national & international risk assessments concur

Financial Contributions to Research

- Canadian Forest Service *(EPMM, GreenPlan, PRUF programs)*
- Health and Environment Canada *(TSRI program)*
- Natural Sciences & Engineering Research Council
- National Research Council *(IRAP program)*
- Spray Efficacy Research Group International
  (OMNR, Manitoba, US Forest Service, Forest Protection Ltd)
- Ontario Ministry of Natural Resources *(VMAP)*
- TEMBEC- Forest Research Partnership
- B.C. Forest Research & Development Agreement
- Monsanto
- J.D. Irving Ltd.