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

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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**

D.G Thompson (Ph.D.)

Canadian Forest Service, Natural Resources Canada

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Photo credit: ***B. Richardson***

Glyphosate Herbicide & Canadian Forest Service Goals

Sustainable Forestry

- Cost-effective and efficacious
  - particularly on remote, rich sites with multi-species competitors
  - a critical component of IVM, particularly for enhanced conifer regeneration on most productive sites

Environmental Protection

- Significant R& D efforts have been made to ensure
  - Optimized application rates meeting silvicultural objectives
  - Best practices are use to minimize off-target deposit
  - Environ. conc. < non-target biological effect thresholds
- Weight of scientific evidence indicates environmental acceptability

Risk vs. Benefit

- Benefits of herbicide use for vegetation management are well-established
  - enhanced crop tree survivorship & growth
  - economical re-establishment of conifer component on the landscape
  - shorter rotations, potentially smaller management footprint on the landscape
  - Sustainable forest production & increased international competitiveness

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- All human activities carry some element of risk
  - driving a car; brush saws, biocontrol agents or herbicides for vegetation management
- Risks of herbicide use are intensively studied and well-quantified
  - same cannot be said for some other veg. control options
  - herbicide risk assessments conducted nationally by PMRA under PCPA (2002); widely considered most rigorous regulatory program in the world
  - registration indicates the agencies conclusion that labeled uses do not pose unacceptable risks to humans or the environment
  - provincial regulatory agencies provide another independent level of review
- Primarily concerned with ecological risk estimation
  - use of toxicology & ecology data to estimate the probability that some undesirable ecological event will occur (*Wilson and Crouch 1987*)

Major Scientific Reviews

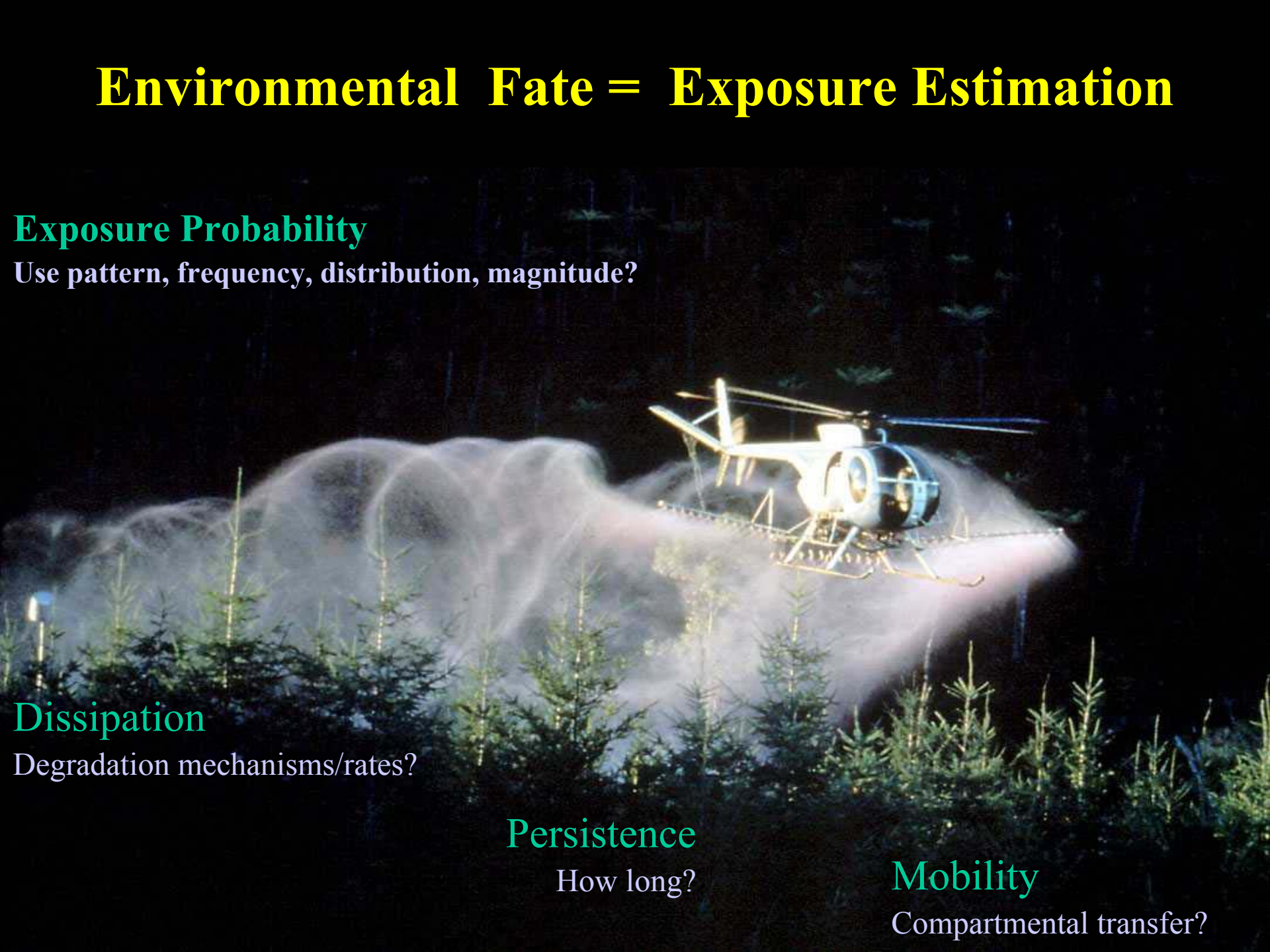
Fate and effects of Glyphosate in the Environment

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

Fate and Effects Studies Specific to Glyphosate Use in Forest Ecosystems

- **386 published journal papers** in CFM database
  - *Fate and effects of glyphosate in forestry generally*
- Numerous field studies specific to Eastern boreal forest region
  - Legris 1988
  - Legris and Couture 1989
  - Dostie et al 1988
  - Legris & Couture 1990
  - Goldsborough and Brown 1993
  - Thompson et al. 2004
  - Wojtasek et al. 2004
  - Roy et al. 1989 a
  - Thompson et al. 2000
  - Thompson et al. 1997
  - Thompson et al. 1994
  - Roy et al. 1989b
  - Payne and Thompson 1992
  - Lautenschlager et al. 1997
  - Wojtasek et al. 2006 (in press)

Environmental Fate = Exposure Estimation



Exposure Probability

Use pattern, frequency, distribution, magnitude?

Dissipation

Degradation mechanisms/rates?

Persistence

How long?

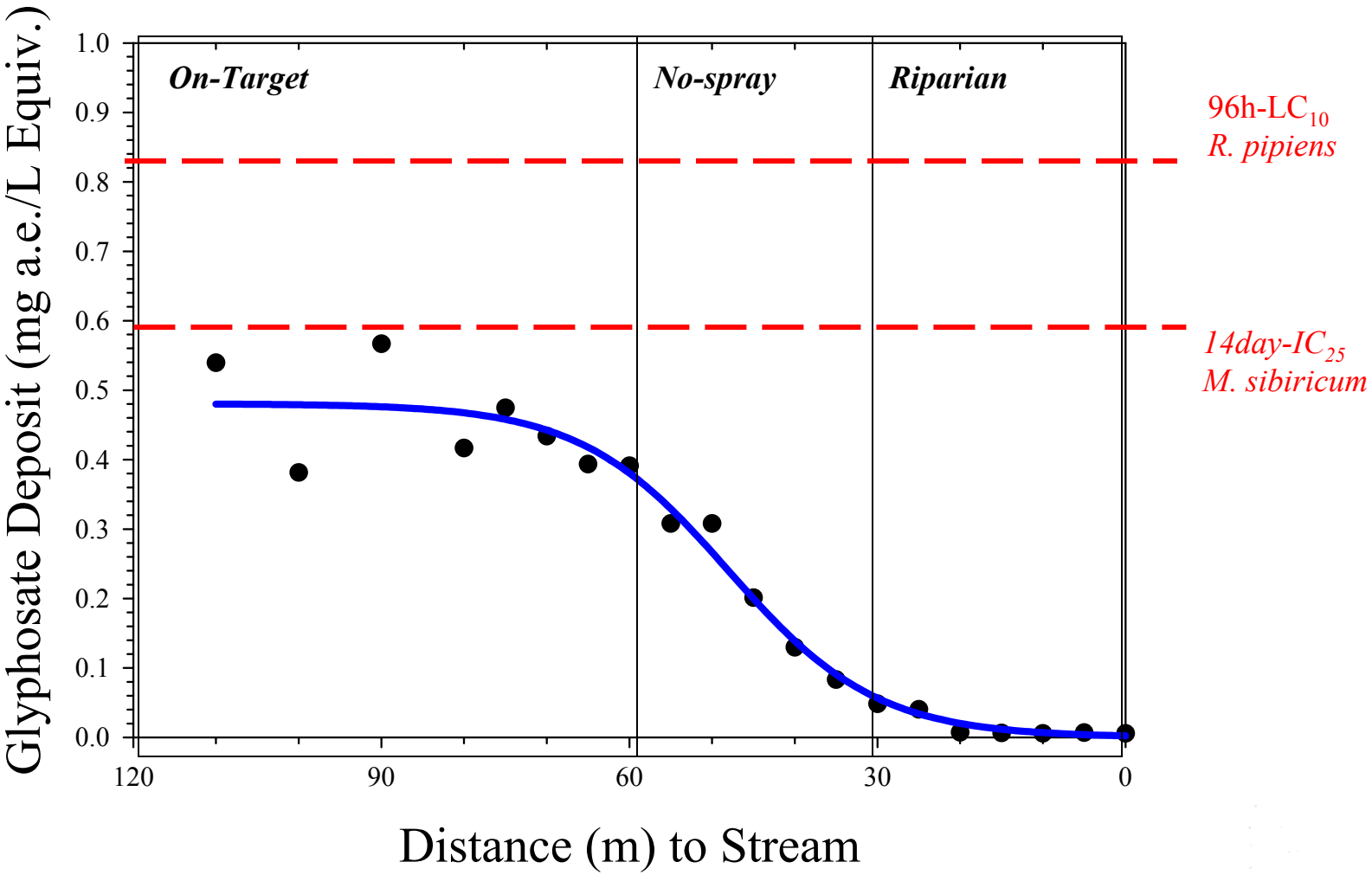
Mobility

Compartmental transfer?

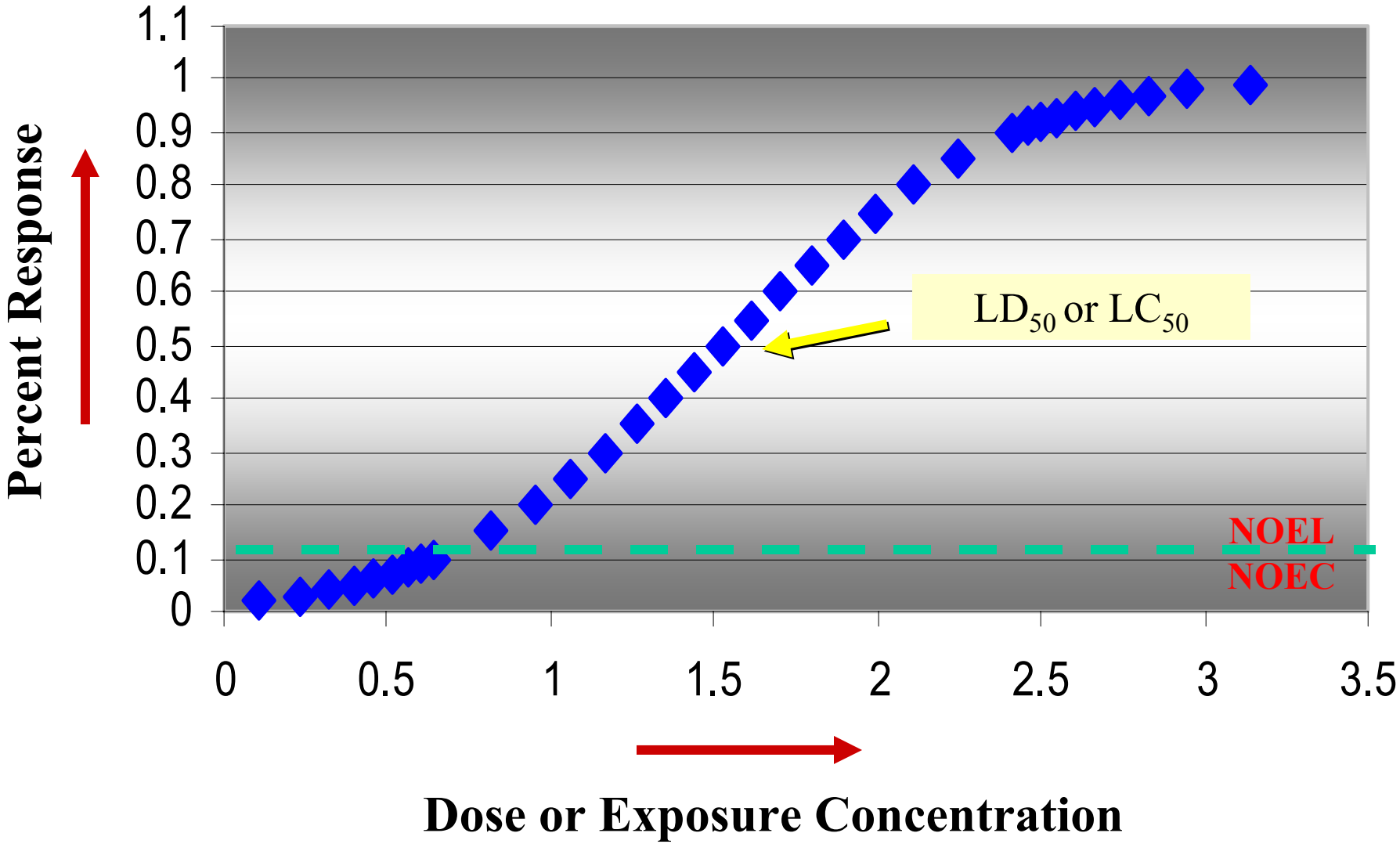
Wildlife Exposure & Risk Estimation for Glyphosate in Canadian Forest Ecosystems

- **No exposure = no effect**
- **Probability, duration and magnitude of wildlife exposures to glyphosate is very low**
  - Glyphosate treatment is made to 146,000 ha/yr, representing only 0.05% of the 310 million ha of forested land in Canada
  - application to any given site only 1-2 x per 50-80 year rotation
  - Glyphosate does not persist, bioaccumulate nor move easily off-target, therefore only organisms foraging or inhabiting treatments sites are likely to receive any meaningful level of exposure
  - No spray and cut reserve buffers around sensitive aquatic systems effectively mitigate against exposure
  - Exposure of organisms in soil and water compartment even within spray blocks is significantly mitigated by interception of chemical in the competing vegetation canopy

Deposition Through Buffer Zones



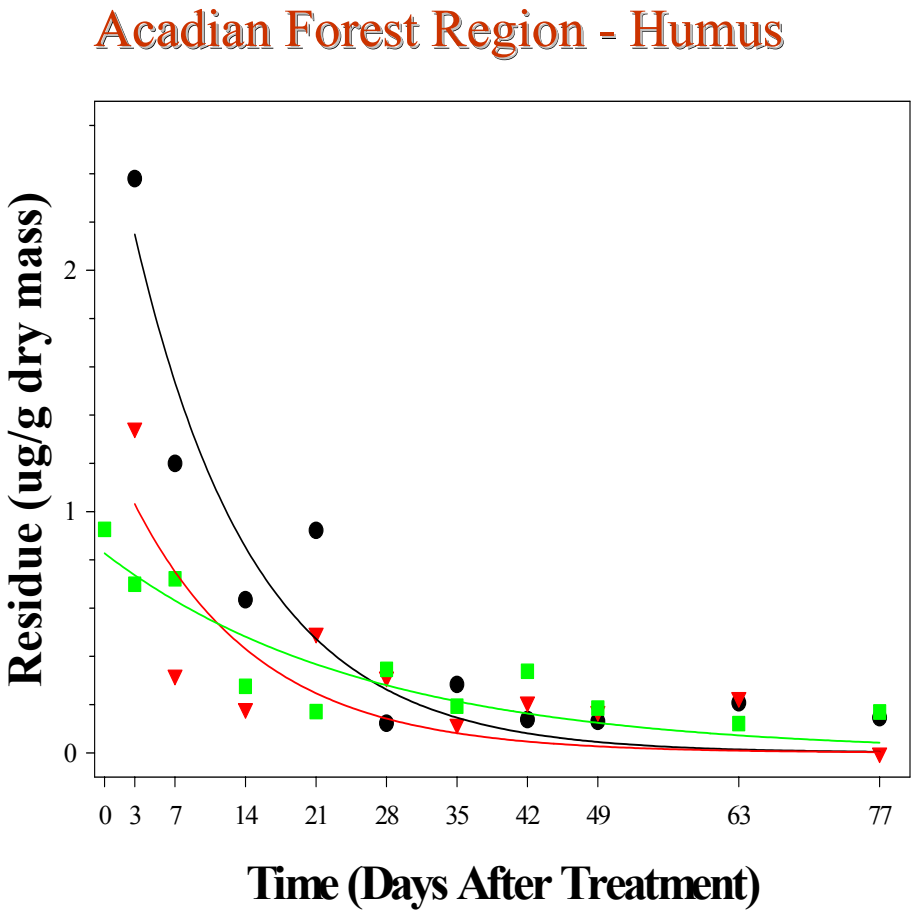
Dose-Response Relations



Glyphosate Fate & Persistence in Plants

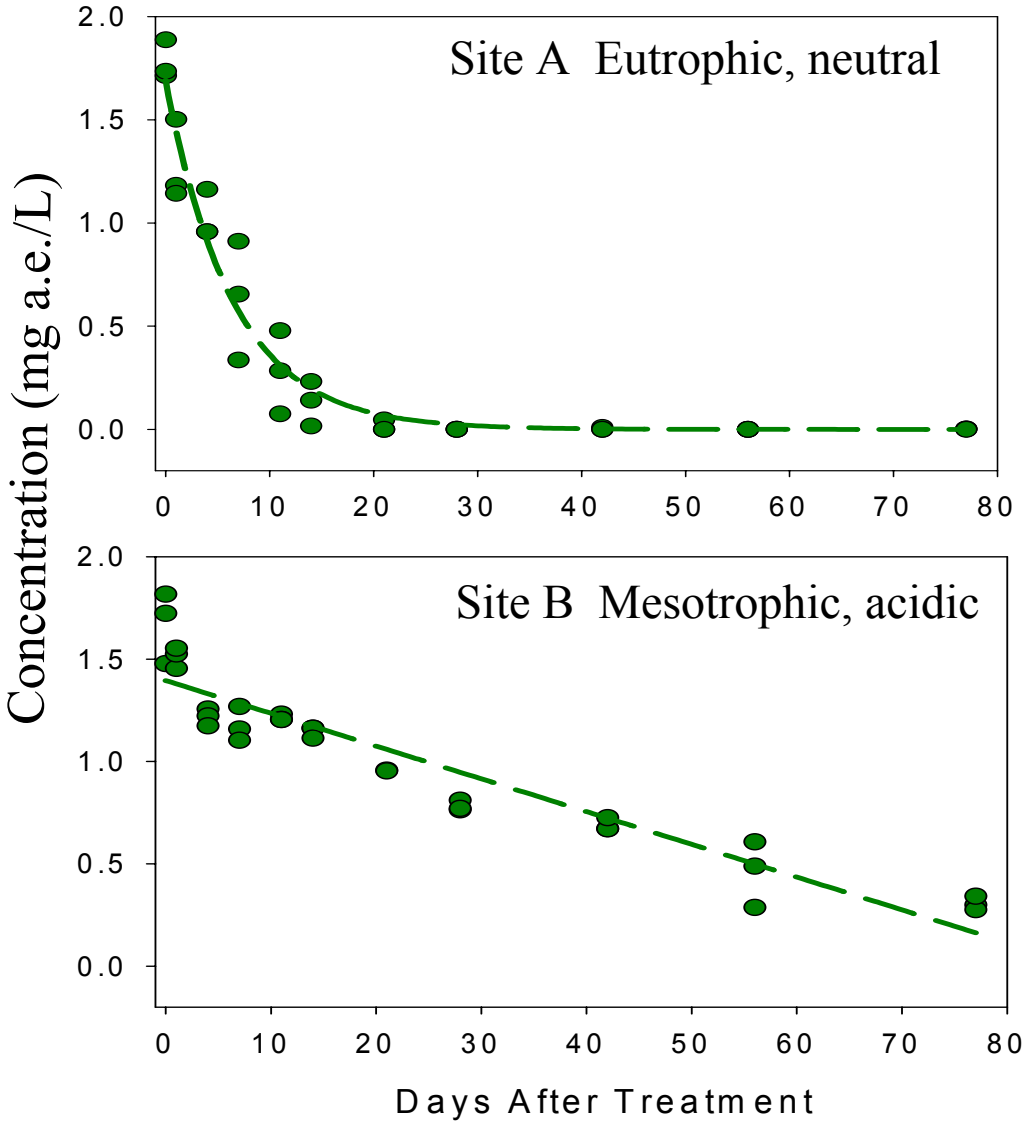
- majority (>65~70%) of depositing spray cloud intercepted by target brush & herbaceous canopy
- rapid uptake through leaves and translocation to both shoots or roots, DT_{50} < 2 days in foliage
- Limited duration of exposure for organisms foraging in or browsing in vegetation
- Rain wash is insignificant after 36 hrs
- Minimal exposure of soil or aquatic organisms under canopy
- Residues in ripe berries more persistent (DT_{50} < 20 days)
- Max residue levels 45 mg/kg > NDI of 21 mg/kg calculated for humans
- Signage to mitigate exposure

Glyphosate Persistence in Soils



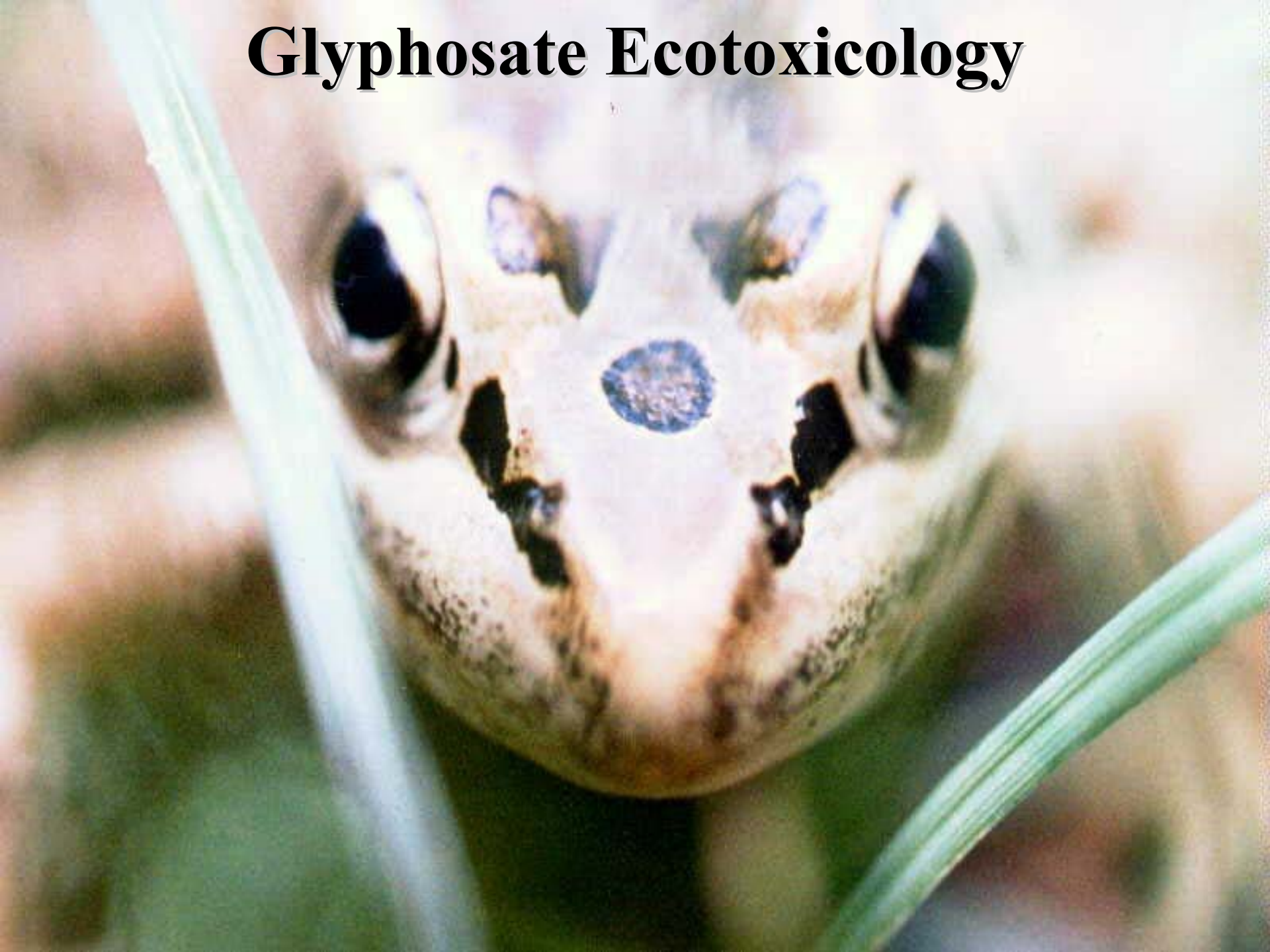
- Glyphosate binds strongly & almost irreversibly to soils
- Not susceptible to leaching
- Not susceptible to movement over ground surface
- Not persistent (DT_{50} = 7- 60 days)
- Maximum soil concentrations of 1-3 ug/g d.m.
- Concentrations below levels which have deleterious effects on soils organisms or their ecological function (NOEC = 5 ug/g)

Glyphosate Dissipation in Forest Wetlands



- Glyphosate disspates rapidly from the water column and sorbs strongly to organic sediments and biofilms
- Dissipation is more rapid (DT_{50} = 4.2 d) in shallow, biologically active systems
- Aerial herbicide applications at typical operational rates yield avg. aqueous conc. ~ 0.3 to 0.4 mg a.e/L in directly overspray ponds
- Upper 99th centile CL for concentrations in forest wetlands operationally overprayed 0.55 mg a.e./L

Glyphosate Ecotoxicology



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

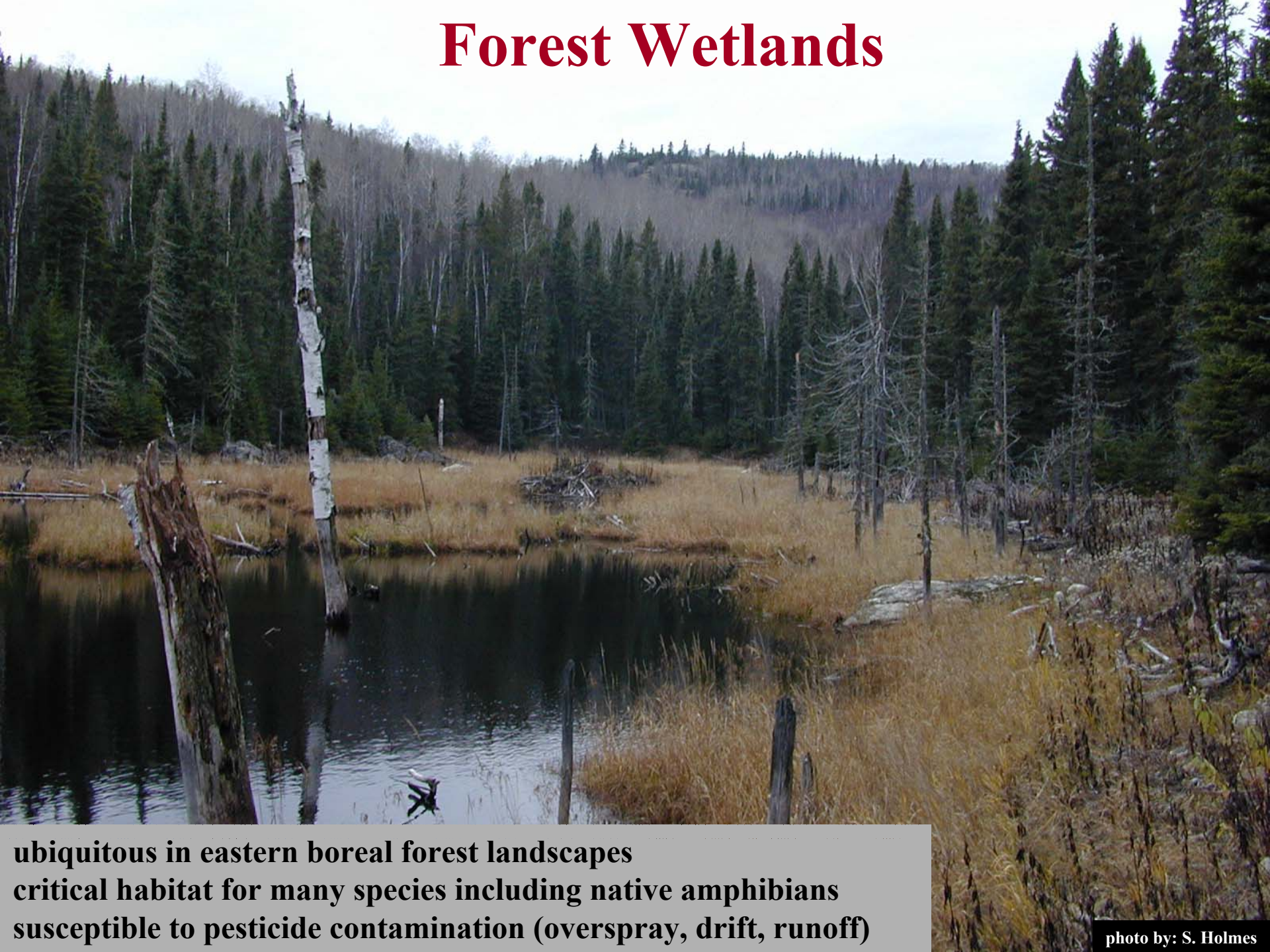
Units vary with endpoint

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



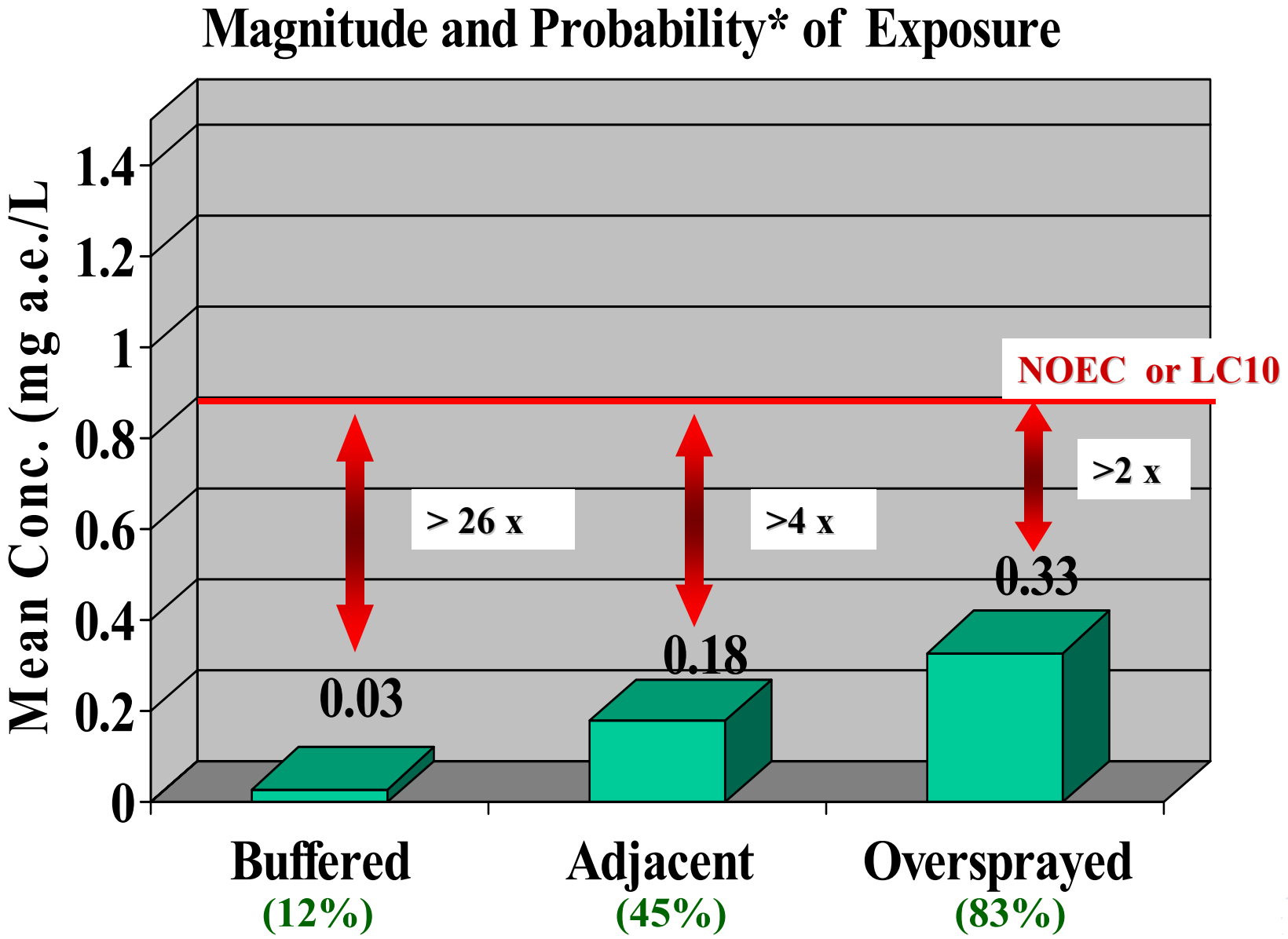
ubiquitous in eastern boreal forest landscapes
critical habitat for many species including native amphibians
susceptible to pesticide contamination (overspray, drift, runoff)

photo by: S. Holmes

Operational Monitoring Studies

monitoring in 51 different wetlands (overprayed, adjacent or buffered)
aerial applications of glyphosate (Vision) avg 1.9 kg a.e./ha
In-situ biological monitoring with caged larvae (green & leopard frogs)

Environmental Exposures vs Toxicity Threshold



* Probability of exposure to any detectable level (0.01 mg a.e./L) of glyphosate

Take Home Points

- Veg. management - essential to sustainable forest production
- Environ. assessment -essential to protect ecological integrity
- glyphosate (Vision) herbicide best meets 3E criteria
  - Efficacy, Environmental acceptability, Economic feasibility
- 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
- Conclusion is consistent with PMRA decision to register the product and numerous risk assessments conducted by national and international panels of experts

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.

Integrated Vegetation Management

Shear blade

Mechanical

Bräcke scarifier

Brushsaw

Motor-Manual

Chainsaw

Alternative Harvesting

Silvicultural

Precommercial Thinning

Temporal/Spatial Integration

Glyphosate

Chemical

Triclopyr

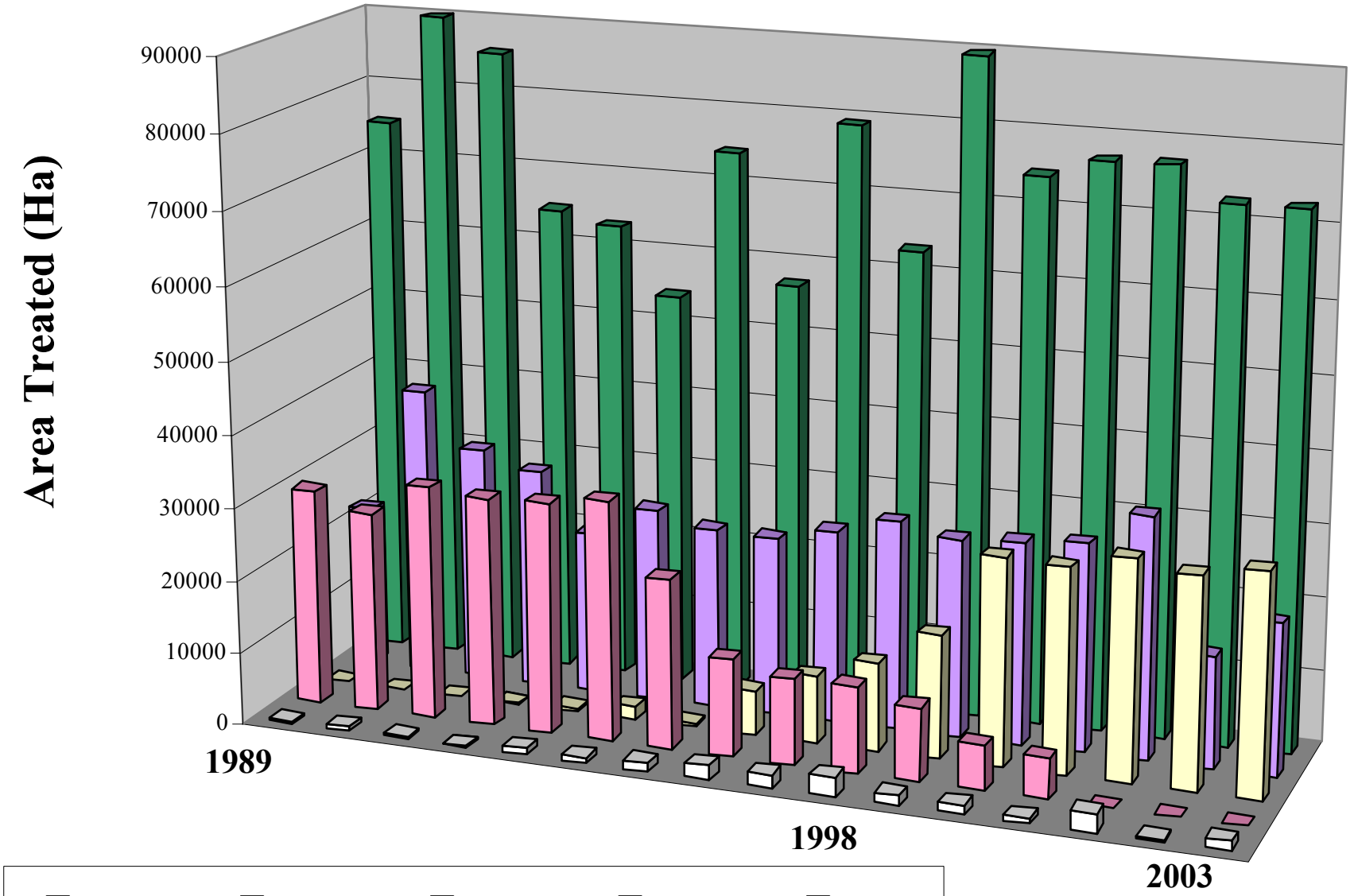
Prescribed Fire

Fungal pathogens

Biological

Insects

Glyphosate Use in Forest Sector of Key Canadian Provinces

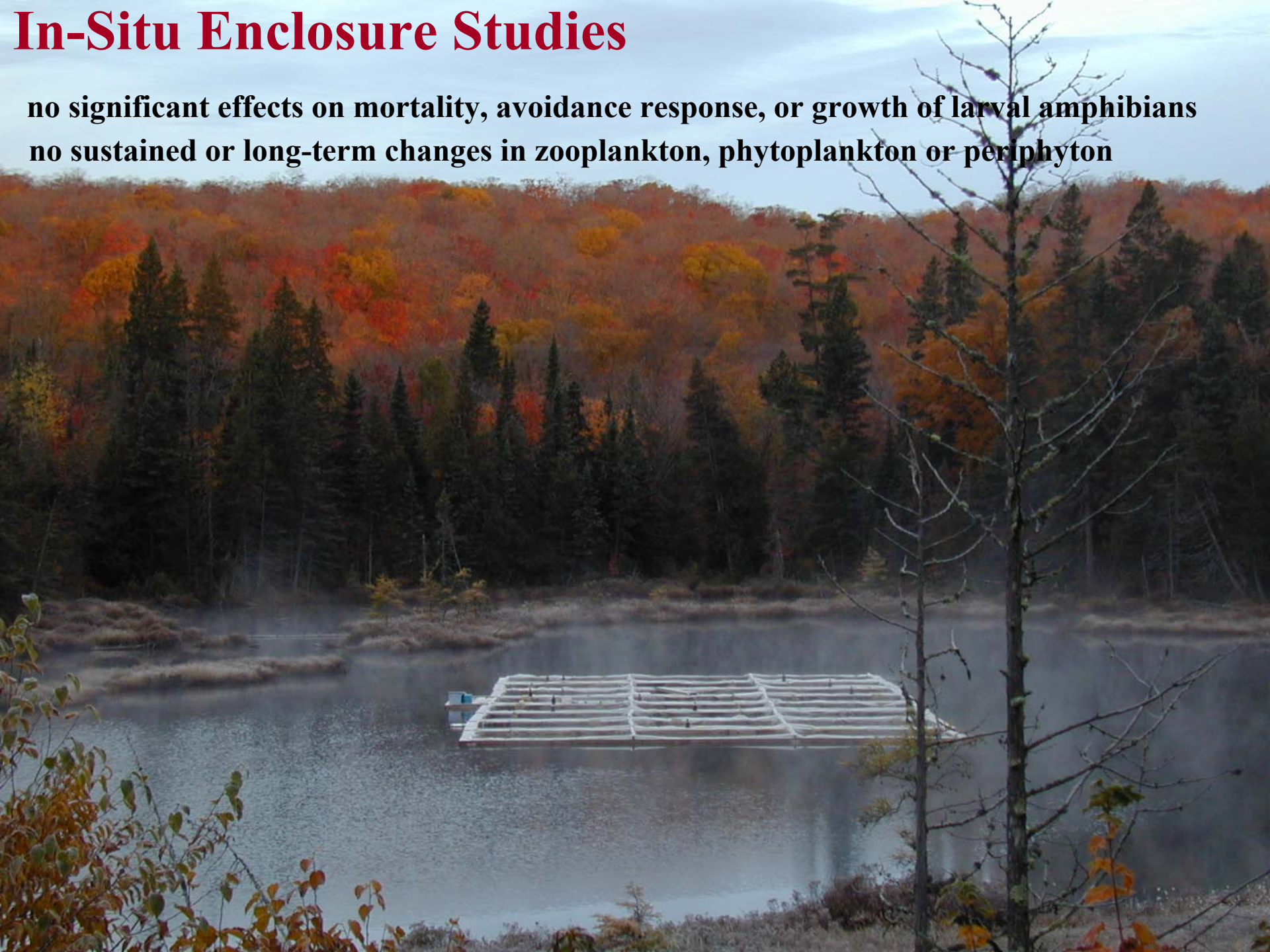


Source National Forestry Database Program
http://nfdp.ccfm.org/

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

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

Improved Aerial Application Technologies & Buffers Mitigate Potential Non-Target Effects

Electronic Guidance
Remote Sensing
Low drift nozzles
Smart-booms
GIS
DGPS
Dose-Response Modeling
Decision Support Systems

Extensive Management

- crop tree mortality & impaired growth rates
- low productivity/ha
- greater ecological footprint
- jeopardizes international competitiveness
- economically non-sustainable

Intensive Management

- improved conifer survivorship and growth rate; enhanced regeneration of conifer on the landscape
- high productivity/ha – reduced footprint
- high quality fibre
- Enhanced sustainability & international competitiveness