TRES DECADAS DE EVALUACION DE RIESGO DE PLAGUICIDAS:

LAS AVES, LAS ABEJAS Y OTROS IMPACTOS DE LA AGRICULTURA MODERNA.

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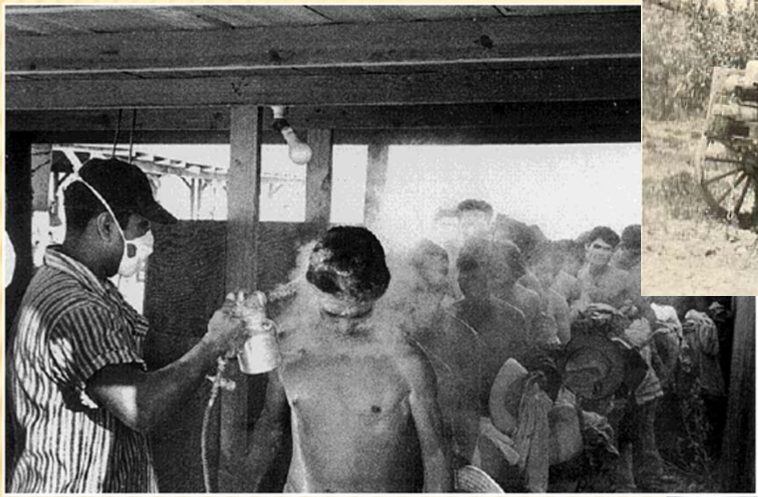
The birth of synthetic pesticides: organochlorine insecticides



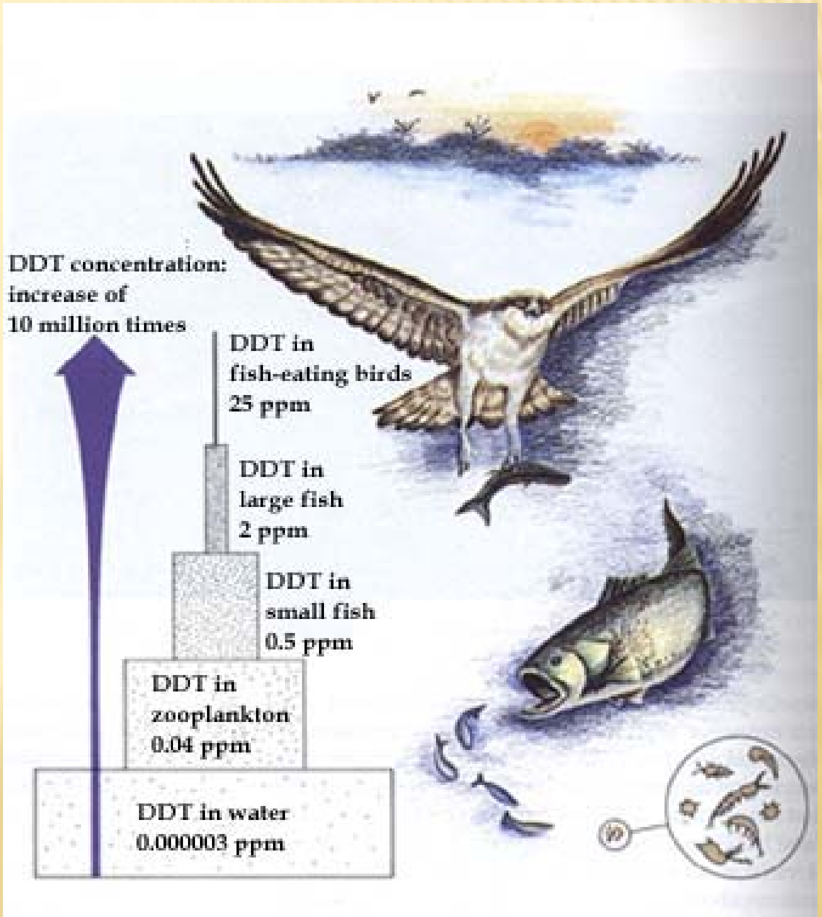
PLANTING THE SEEDS OF A PROBLEM!

MÜLLER`S SHORT LIST FOR THE IDEAL INSECTICIDE BASED ON HIS NOBEL ACCEPTANCE SPEECH

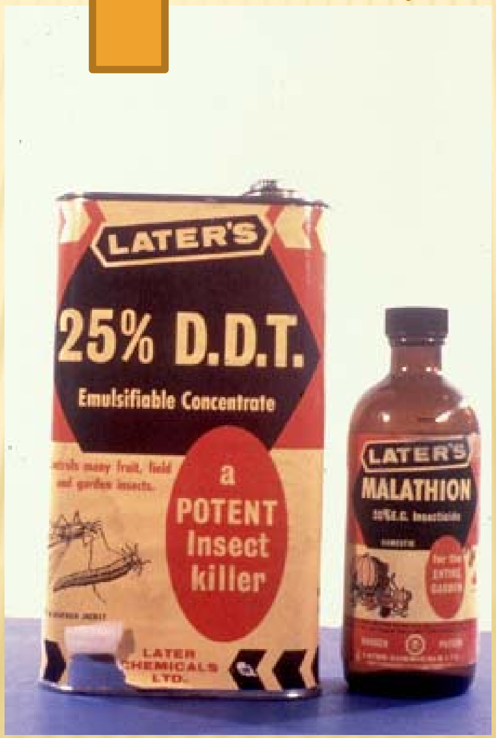
- Toxic to <u>most</u> insects but not to mammals, fish or plants (*note: birds not mentioned*)
- Acts rapidly - quick knockdown
- No irritating odour
- Inexpensive - easy to manufacture
- Kills all types of insect - contact poison would be best
- **Chemically stable !!!**

THE DOWNSIDE OF CHEMICAL STABILITY

Organochlorine bio-accumulation and bio-magnification



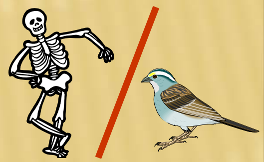
EVOLUTION OF INSECTICIDES: FROM ORGANOCHLORINES TO ORGANOPHOSPHOROUS AND CARBAMATE INSECTICIDES



HARD TO IMAGINE JUST HOW TOXIC TO BIRDS THESE COMPOUNDS ARE:

ONE HECTARE OF A CORN (MAIZE) FIELD TREATED WITH CARBOFURAN:
41 MILLION LETHAL DOSES FOR AVERAGE SONGBIRD
(ESTIMATED THAT THE GRANULAR FORMULATION ALONE WAS KILLING 17M-91M /YEAR IN U.S. MAIZE FIELDS ALONE)

Difference in killing power (average human vs average songbird):

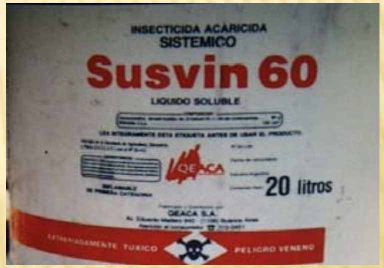


DDT: 430 X **Diazinon: 340,000 X**

THE BREADTH OF MORTALITY: 81 SPECIES RECORDED KILLED FROM CARBOFURAN IN U.S. AND CANADIAN AGRICULTURAL CROPS.

Waterfowl	7
Pheasant and grouse	3
Herons	1
Birds of prey	8
Rails	1
Shorebirds	2
Gulls	4
Doves	2
Owls	2
Woodpeckers	1
Cows and jays	3
Larks	1
Swallows	2
Tits	2
Wrens	2
Thrushes	2
Mimic thrushes	2
Starlings	1
Pipits	1
Waxwings	1
Tanagers	1
Buntings/A. sparrows	14
Finches	5
Blackbirds	11
Weavers	2

MONOCROTOPHOS – ANOTHER EXAMPLE OF A GOOD ‘AVICIDE’ !
ONE OF THE MOST POPULAR INSECTICIDES IN THE WORLD THROUGH TO THE 90s. STILL IN USE TODAY IN SEVERAL COUNTRIES.



1970 – Joint study with manufacturers’ collaboration

2 hectares of corn (maize) in Germany produced …

- 38 dead or paralyzed (tree?) sparrows
- 13 greenfinches
- 3 European robins
- 6 chaffinches
- 1 great tit
- 7 ring-necked pheasants
- 6 corn buntings (*Ali-Dervish, Novartis, 1970*)

1972 – Incident in two Florida potato fields

- 10,000 American robins (thrush) feeding on berry-producing shrubs next to the fields (*Lee 1972, Shell Chemical 1972*)

1994/95 – Kills of swainson’s hawks (Buteo) in Argentina

- Estimate of 20,000 birds (*Woodbridge pers. comm.*)

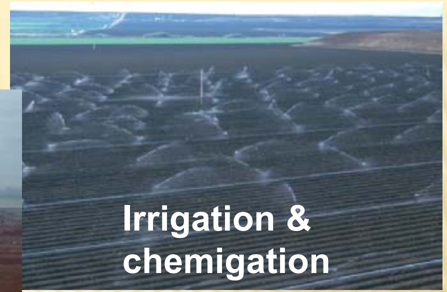
HOW COULD THERE BE SO MUCH MORTALITY WITHOUT IT BEING SEEN AT EVERY APPLICATION?

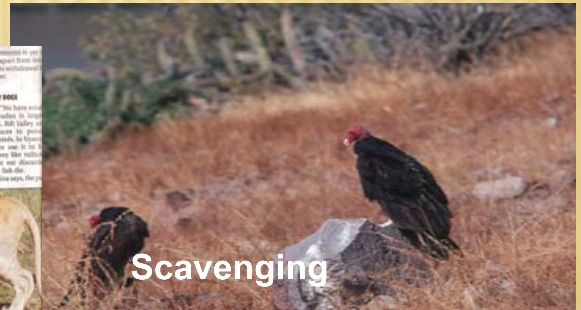
What people expect bird kills to look like.
The 'National Geographic' version!

The majority of bird kills in agriculture!

Corollary: The most significant impact is not always the visible one !

High risk situations for birds





High risk situations - continued
Tragically … species attracted to insect outbreaks !

High risk situations – continued

SEED TREATMENTS:

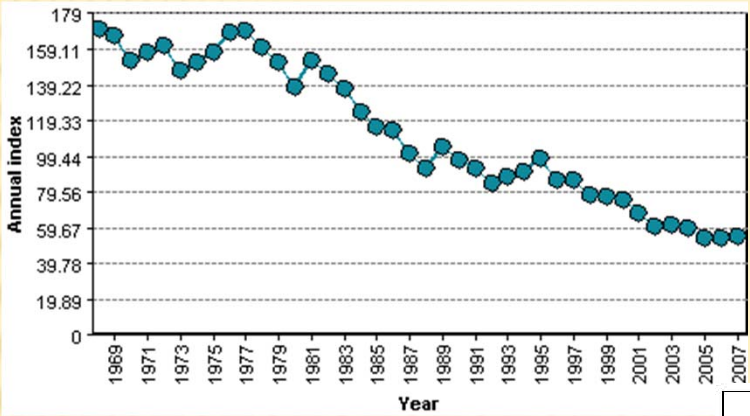
- Attractive to birds
- High loading of pesticide
- Incorporation rarely perfect
- Spills largely unavoidable
- Longer availability of the seeds
- Longer persistence of pesticide -- in absence of good soil contact
- Birds will dig and scrape for seeds below soil surface

Of course, it is much more than mortality

"Most impressive is the singular fact that ach is the only substance that can influence every physiological or behavioral response thus far examined" (MYERS CITED IN RUSSELL 1982)

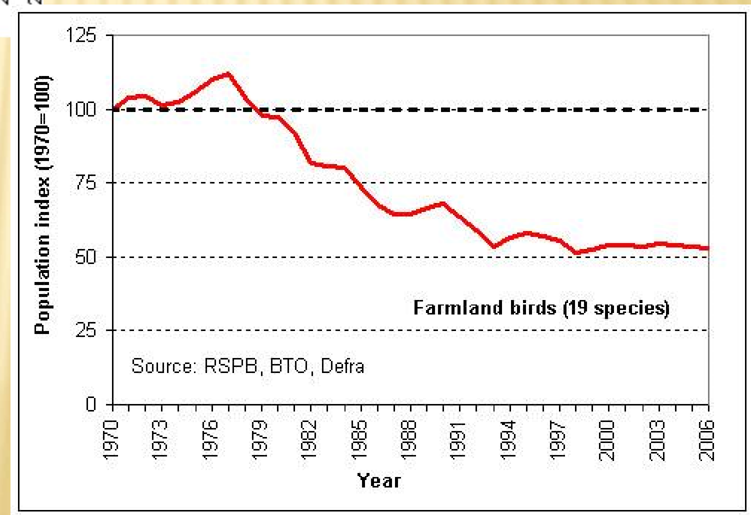
- Thermoregulation
- Endocrine modulation
  - metabolism
  - reproductive physiology & behaviour
- Circadian rhythms
- Sensory perception
- Long-lasting physiological changes
- Immunology
- Growth and development
- Memory (esp. short term & spatial)

WHY SHOULD WE CARE?
Grassland/farmland species trends – same all over the world



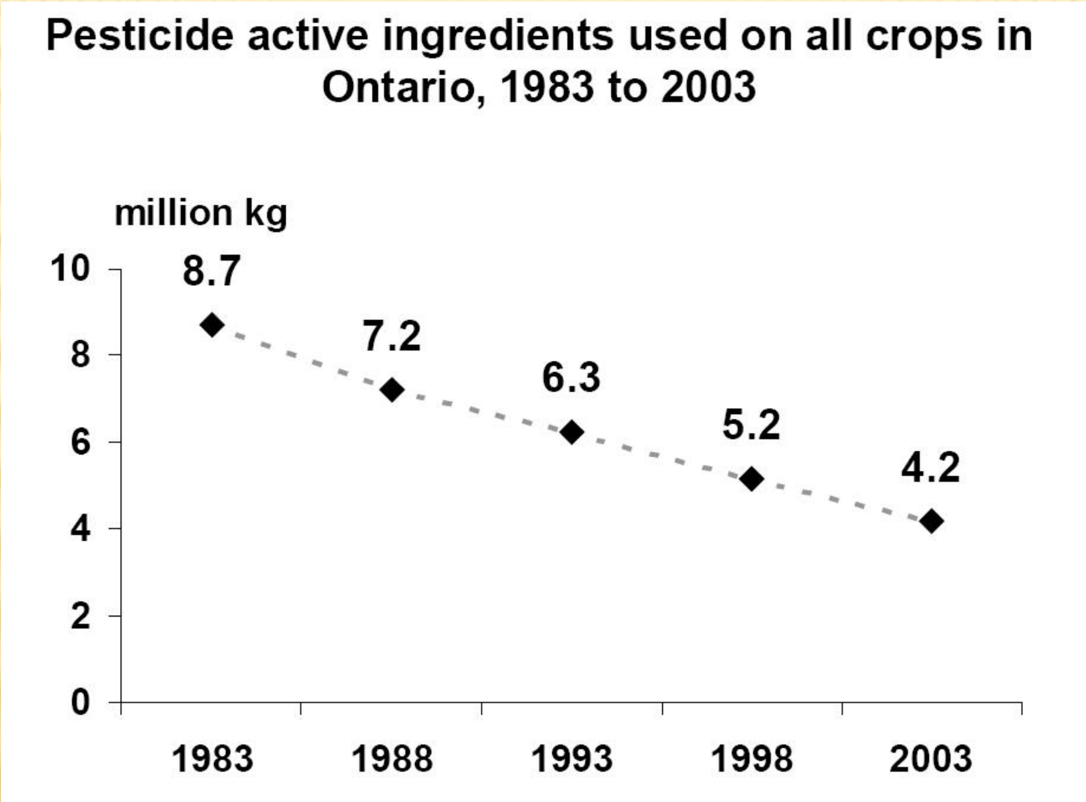
Central Canada

(***Breeding Bird Survey, Canadian Wildlife Service***)



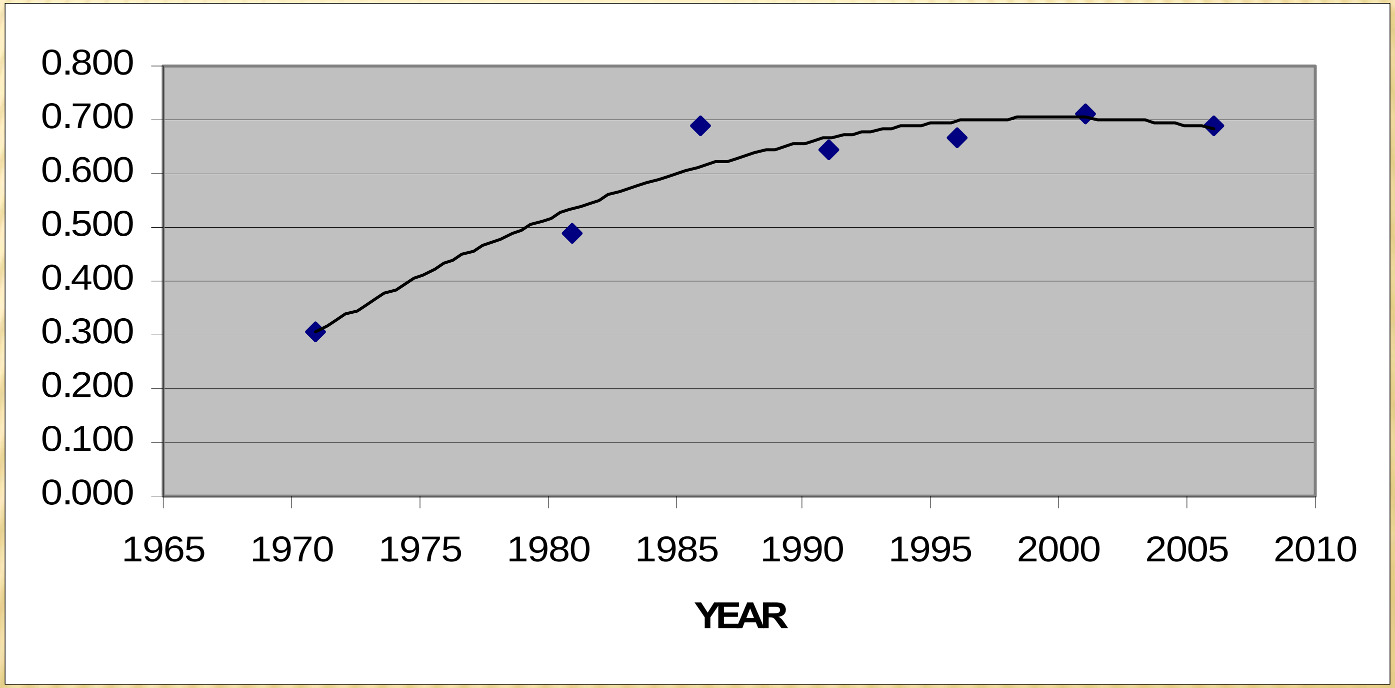
UK
(***BTO***)

THE PERCEPTION (PROPAGANDA !) : PESTICIDE USE IS DECREASING.
(Ontario is one Canadian province for which data available)



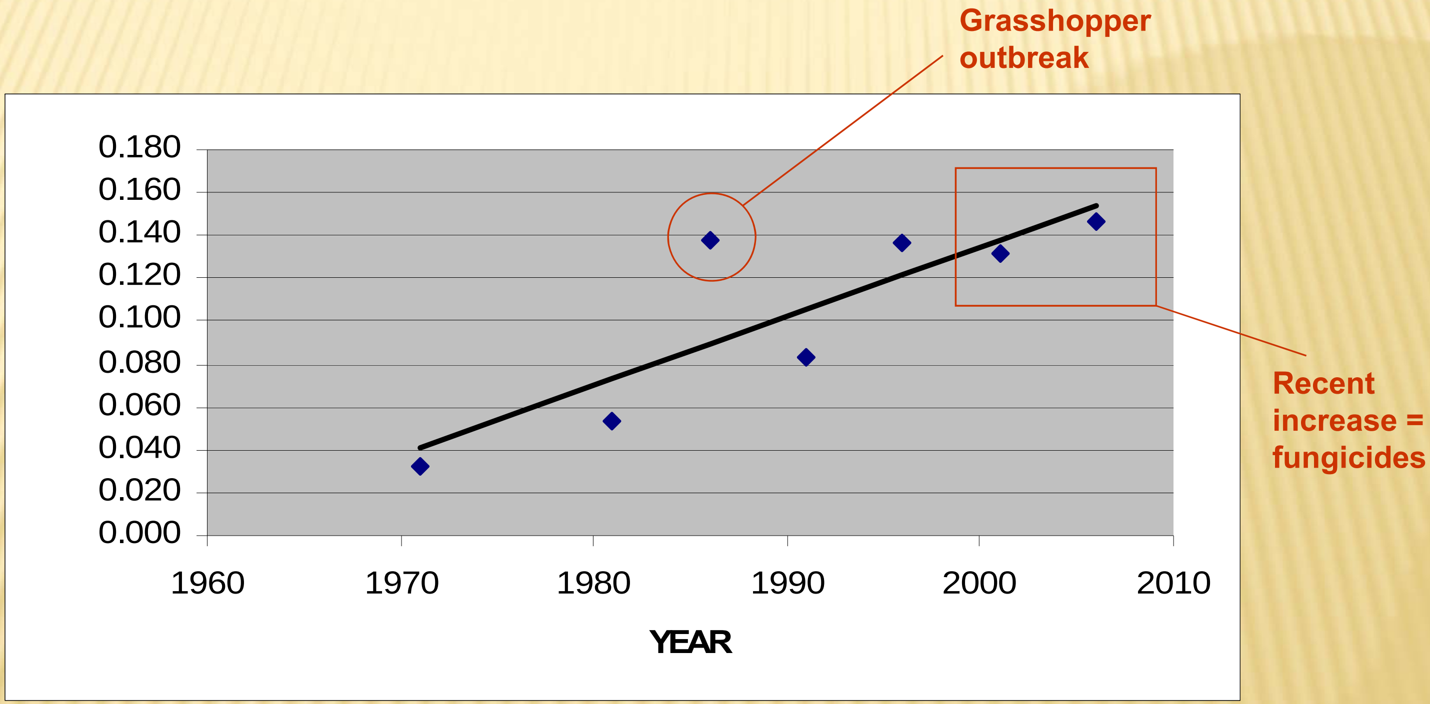
THE REALITY: PROPORTION OF CROPLAND TREATED WITH HERBICIDE HAS NOT DECREASED.

Only pastures not treated. Organic acreage negligible.



Source: Stats Can

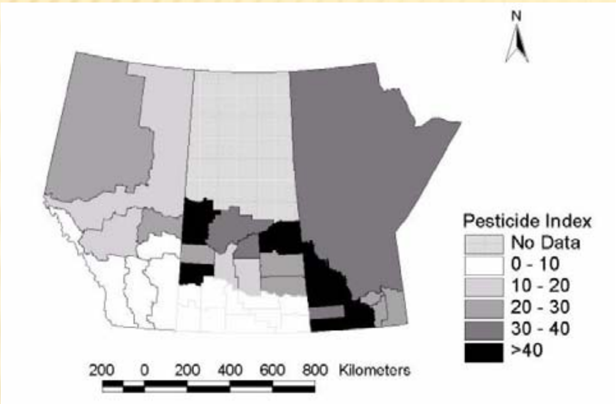
THE REALITY: PROPORTION OF CROPLAND TREATED WITH INSECTICIDES OR FUNGICIDES IN CANADA – NOT INCLUDING SEED TREATMENTS.



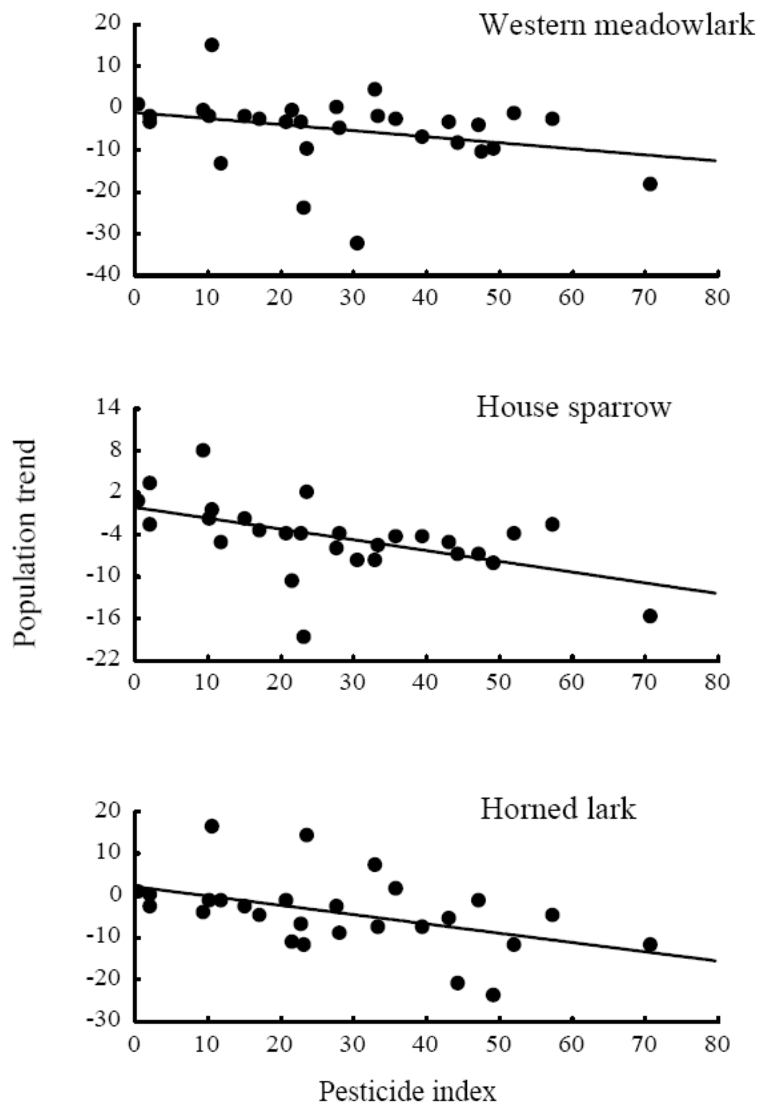
Source: Stats Can

Evidence of regional population declines as a result of toxic insecticide use.

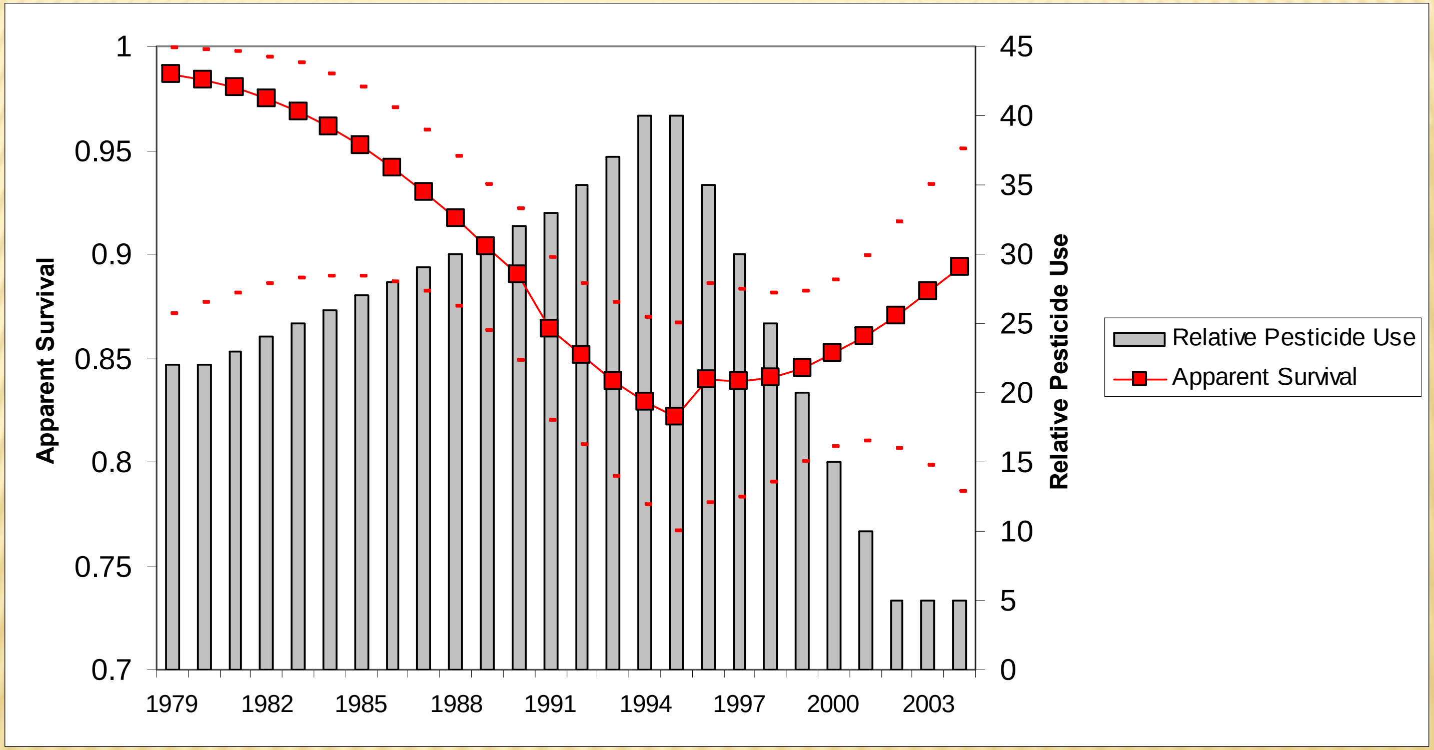
Granular insecticides used at seeding in oilseed rape.



Mineau et al. 2005
Patterns of bird species abundance in relation to granular insecticide use in the Canadian Prairies
Ecoscience 12(2):267-278



Impacts could be far away: Swainson's hawk adult survival rate (based on banding returns) in small U.S. SW population and relative pesticide use in the Argentine Pampas.



Data and slide from Brian Woodbridge, U.S. Fish and Wildlife Service

U.S.-wide analysis - Grassland (farmland) guild. Breeding Bird survey route regression analyses run between 1980 and 2003. (http://www.mbr-pwrc.usgs.gov/bbs/trend/guild03.html)

Variables	Δ AIC	Wi (Akaike weight)
- Lethal pesticide risk - Decrease in 'improved pasture' - Herbicide use	0.00 (Best model)	0.101
Lethal pesticide risk (from model)	1.71	0.043
Decrease in improved pasture	4.49	0.011
Farming Intensity (proportion in active cropping)	12.6	0.000

Mineau, P., M. Whiteside. 2013. Pesticide acute toxicity is a better correlate of U.S. grassland bird declines than agricultural intensification. PLoS ONE 8(2): e57457. doi:10.1371/journal.pone.0057457

REGULATORY AIM: PREDICTING WHAT HAPPENS TO BIRDS EXPOSED TO PESTICIDES.

AVIAN "RISK" ASSESSMENT IN THE EU OR US & CANADA

EXPOSURE ESTIMATE

TOXICITY ENDPOINT

likelihood

RATIO

TER in the EU

RQ in North America

RISK

TYPICAL RISK ASSESSMENT
(EXAMPLE OF AVIAN ACUTE RISK)

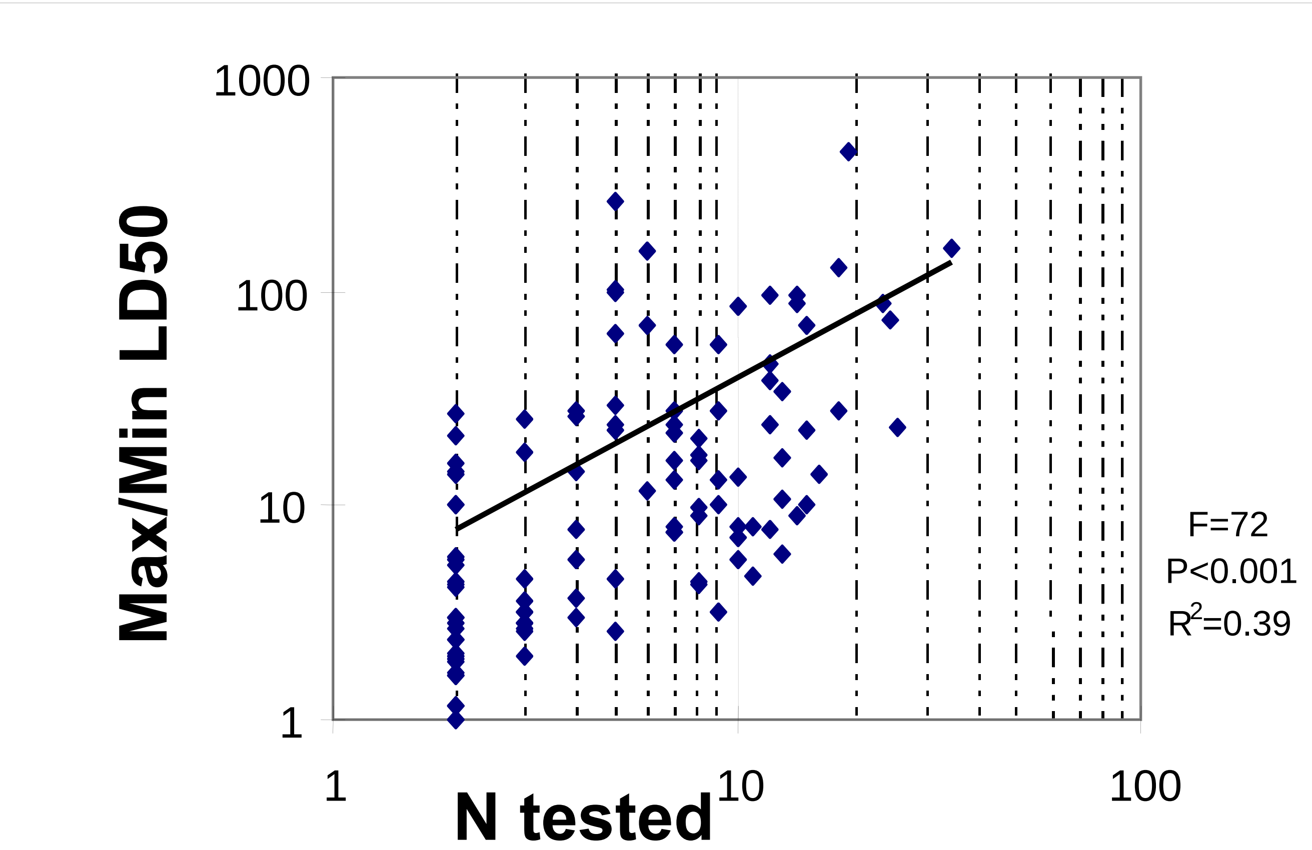
Toxicity:

- Lowest of two species (Mallard; Northern Bobwhite) but only one species technically required.

Exposure:

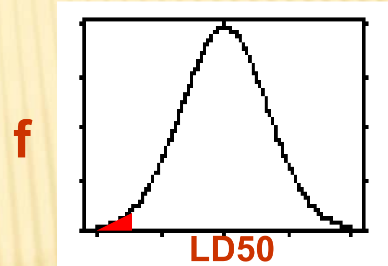
- Relevant 'worst case' scenario – e.g. sparrow with corresponding body weight and field metabolic rates
- Environmental concentrations on wildlife food items
- Composition of diet
- Food consumption rate – based on energy content – or allometric equations, now corrected for moisture content
- Time spent in treated area; initially 100%

Max/Min LD50 (mg/kg) against number of bird species tested (112 cholinesterase-inhibiting pesticides)



One solution: Towards a systematic assessment of toxicants

THE HD5 AS AN UNBIASED COMPARATIVE MEASURE OF AVIAN ACUTE TOXICITY



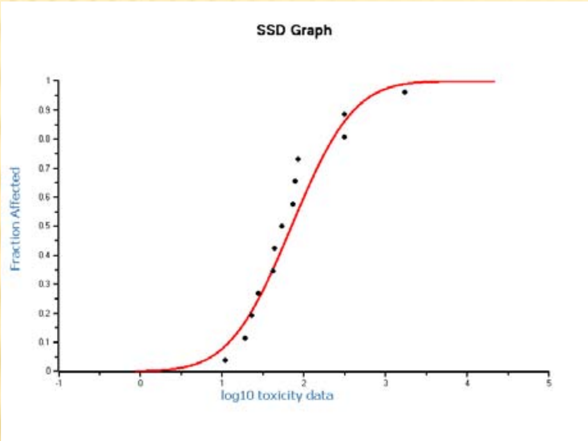
- HD_5 is the dose of a pesticide (in mg/kg) that is equal to or lower than the LD_{50} for 95% of all avian species. The probability that the calculated HD_5 is overestimated can also be specified.

Values used in comparative assessments should be the median estimates. (50% probability of overestimation)

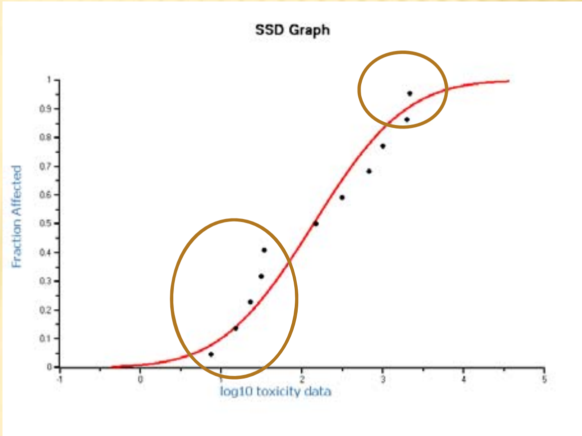
Mineau, Baril, Collins, Duffe, Joerman and Luttik. 2001. Pesticide acute toxicity reference values for birds. Rev Environ Contam Toxicol 170:13-74

COMPARISON OF THE ACUTE TOXICITY TO BIRDS OF TWO LOCUST INSECTICIDES

Fenitrothion



Fipronil



	Fenitrothion	Fipronil
HD50 (median estimate & 95% limits)	**70 (36 – 139)**	**138 (45 – 427)**
HD5 (median estimate & 95% limits)	**6.9 (1.8 – 15.9)**	**4.2 (0.4 – 16)**

Given equal application rates, which is safer?

Acknowledgments: Malsha Kitulagodage for unpublished FIP data.

TOXICITY DISTRIBUTION – CAN BE DIFFICULT TO UNDERSTAND

- Variation in sensitivity: assume continuous distribution (?)
- E.g. The acute toxicity of pyrethroids (here beta-cyfluthrin) to birds
  - Japanese quail: > 2000 mg/kg
  - Northern Bobwhite: >2000 mg/kg
  - Mallard: >2000 mg/kg .... Most would stop here !
  - Canary: c. 100 mg/kg !!!
  - Repeat canary: 170 mg/kg
  - Eared dove: 2271 mg/kg
  - Shiny cowbird: 2234 mg/kg

Addy-Orduna, L., M.-E. Zaccagnini, S.B. Canavelli, and P. Mineau. 2011. Formulated beta-cyfluthrin shows wide divergence in toxicity among bird species. J. Toxicology 2011, Article ID 803451, 10 pages, doi:10.1155/2011/803451.

POTENTIALLY A MORE SERIOUS PROBLEM

WHAT IS THE BASIS FOR ASSUMING 100% OF EXPOSURE IS FROM DIET ???

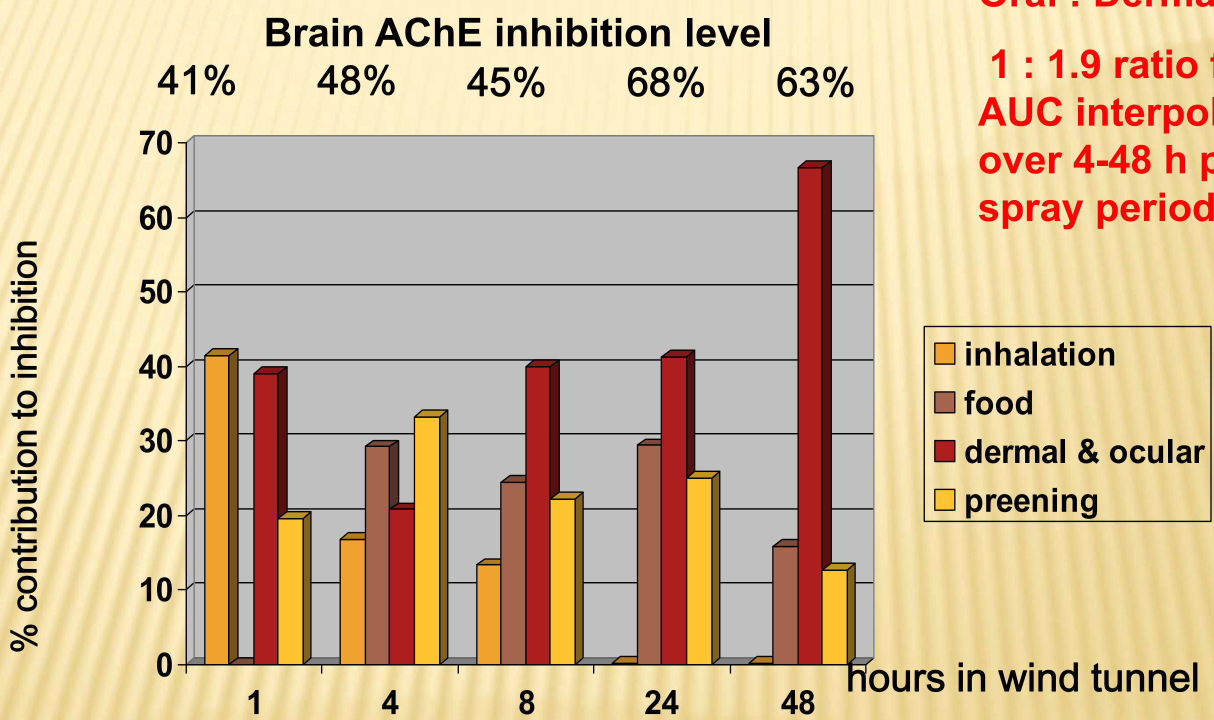
(ANSWER: HISTORIC ASSESSMENT OF OC PESTICIDES)

IN FACT – LOTS OF EVIDENCE TO CONTRARY

- 1965: Fowle (CWS Occ. paper 7) finds that 1-15 hr exposure to foliage contaminated with phosphamidon kills birds reliably.
- 1970s to early 1980s: FAO-sponsored research on Quelea determines they are killed from dermal exposure when sprayed with OPs (Pope & Ward 1972 etc….).
- 1973: Routine testing of toxicants by dermal route at DWRC for pest bird control – Rid-a-bird perch system.
- 1974: Rogers et al. (*Env. Phys.Chem. 4; 104*) measure uptake from bird feet in vivo.

Mineau et al. (1990. J. Environ.Sci.Health B25:105) A single high exposure to fenitrothion in spray chamber (with no dietary intake) produces similar impact as that seen during equivalent forest spray !

Routes of exposure to Methyl Parathion in quail – relative contribution to brain AChE depression



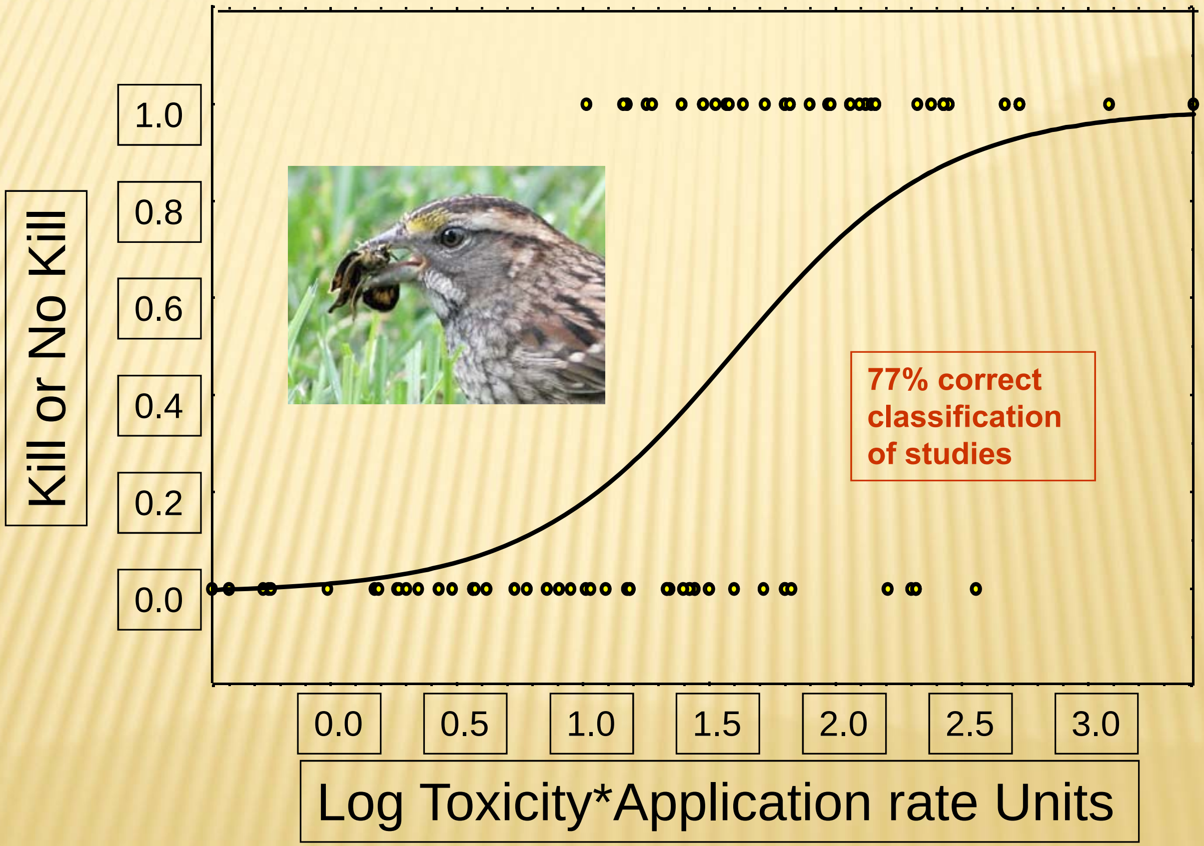
Oral : Dermal

1 : 1.9 ratio for AUC interpolated over 4-48 h post spray period.

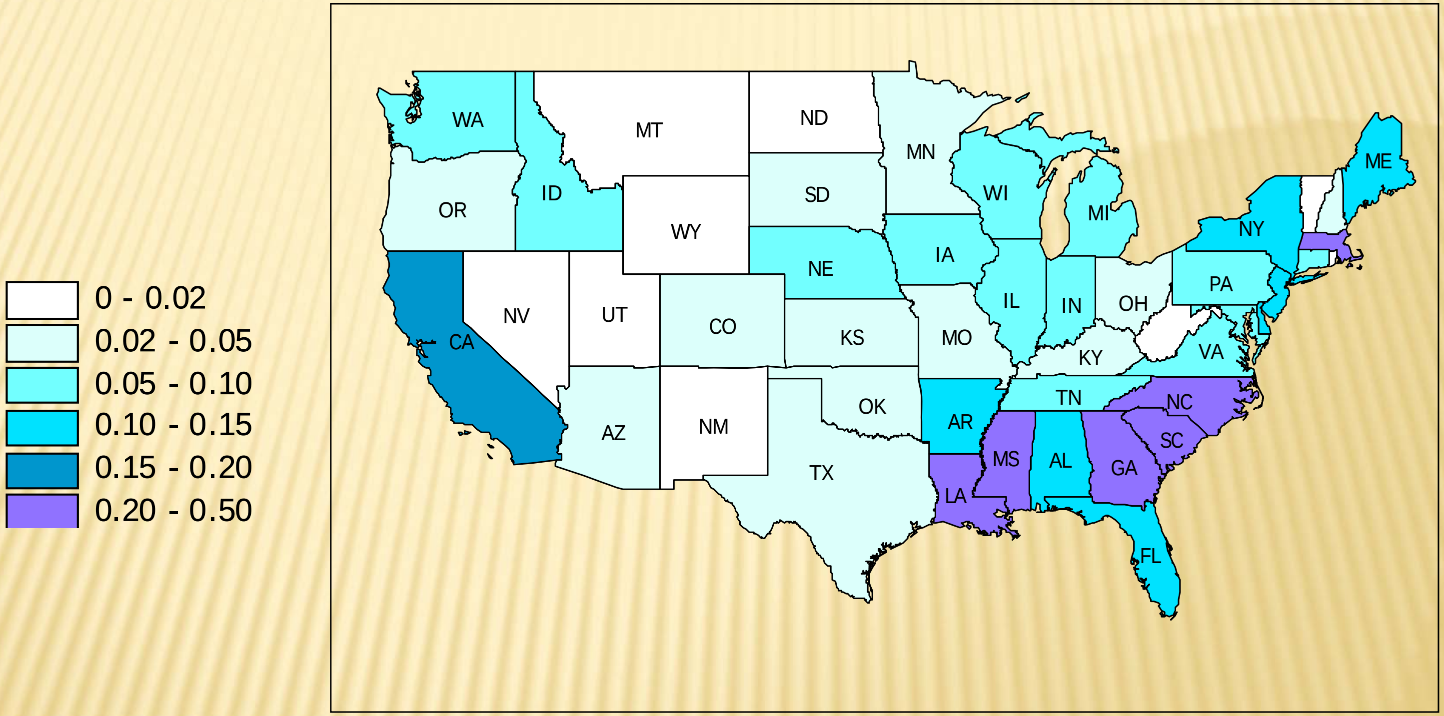
Driver et al. 1991
ET&C 10:21

Using a probabilistic approach to bird mortality following Insecticide use – industry studies and open literature.

Mineau, P. 2002. Estimating the probability of bird mortality from pesticide sprays on the basis of the field study record. Environmental Toxicology and Chemistry 24(7):1497-1506.



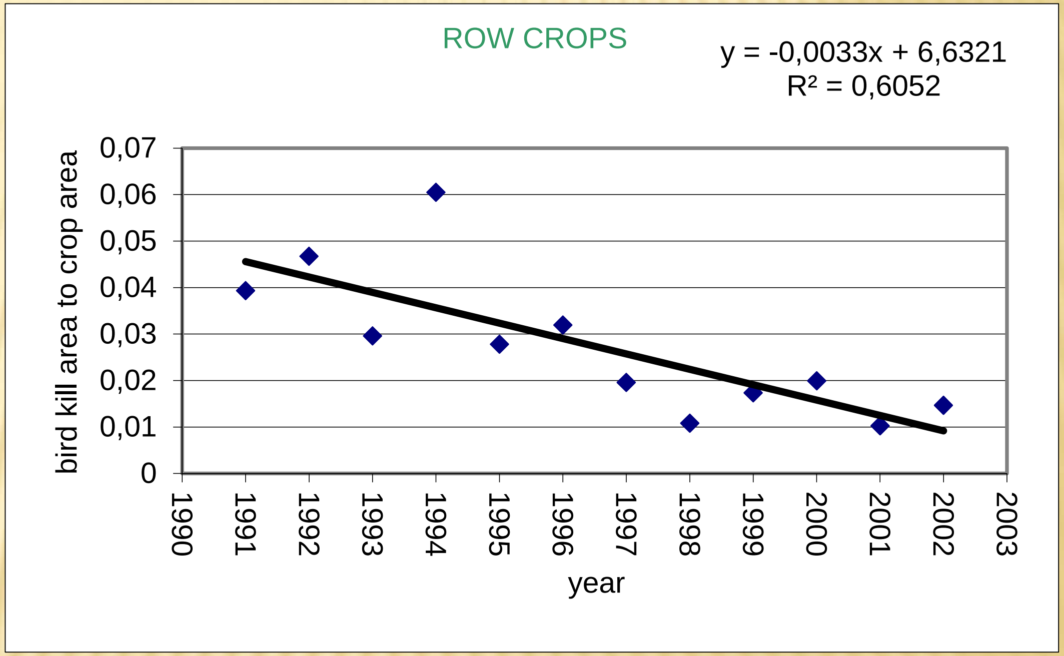
MODEL RESULTS:
PROPORTION OF THE TOTAL 1997 US FARMLAND AREA WHERE THE USE OF PESTICIDES CREATED A SITUATION WHERE BIRD DEATHS WERE EXPECTED.



Mineau, P. and M. Whiteside. 2006. The lethal risk to birds from insecticide use in the U.S. A spatial and temporal analysis. Environmental Toxicology and Chemistry 25(5):1214-1222..

Hope for change?

Recent product substitution under U.S. Food Quality Protection Act <u>has</u> reduced bird risk in most (not all) cases.



Mineau, P. and M. Whiteside. 2006. The lethal risk to birds from insecticide use in the U.S. – A spatial and temporal analysis. Environmental Toxicology and Chemistry 25(5):1214-1222.

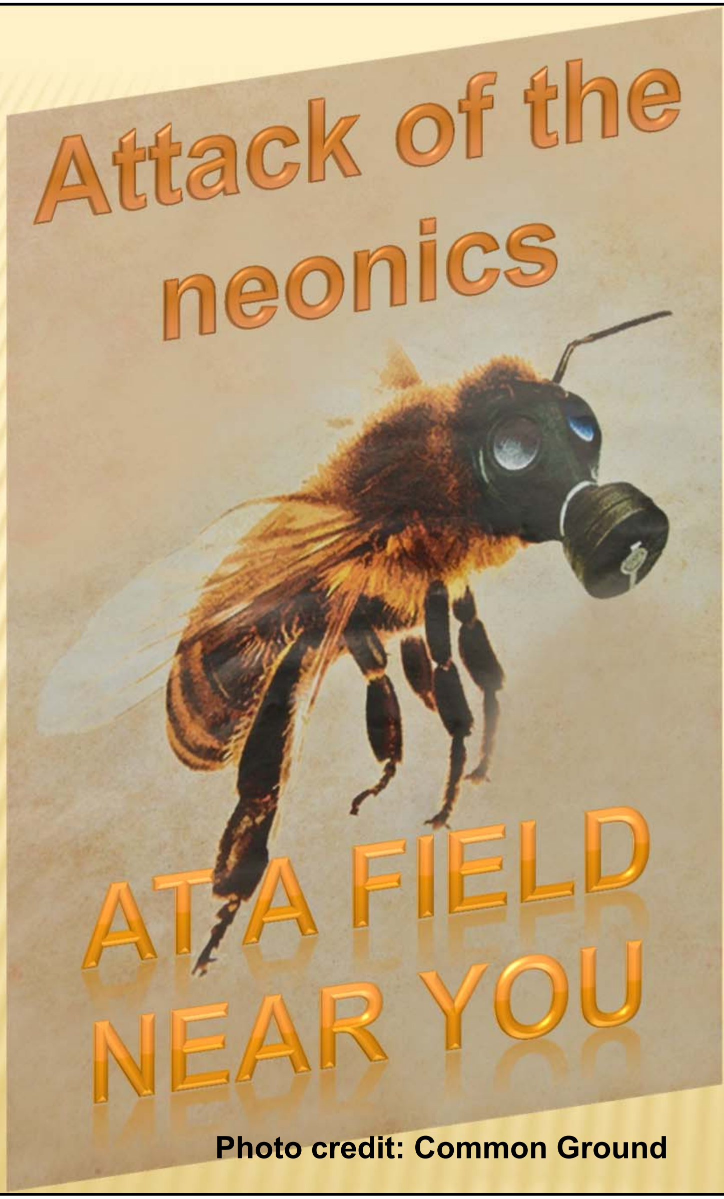


Photo credit: Common Ground

WHY THE NEONICOTINOID INSECTICIDES MIGHT PROVE TO BE THE 'PERFECT STORM'

- Very toxic to broad range of invertebrates – beyond bees
- Bind almost irreversibly to invertebrate neural receptors – cumulative action
- Systemic!!! (Always there whether needed or not!)
- Very persistent in soil
- Very prone to runoff
- Known to cause sub-lethal behavioural effects in invertebrates and foster disease at low dose
- Meteoric rise in popularity (virtually every crop now)
- Lower in acute toxicity to the handler (Easy to over-apply)
- BUT : INCREASING EVIDENCE OF HUMAN TOXICITY !!!!

SEED TREATMENTS MAY STILL CAUSE POISONINGS

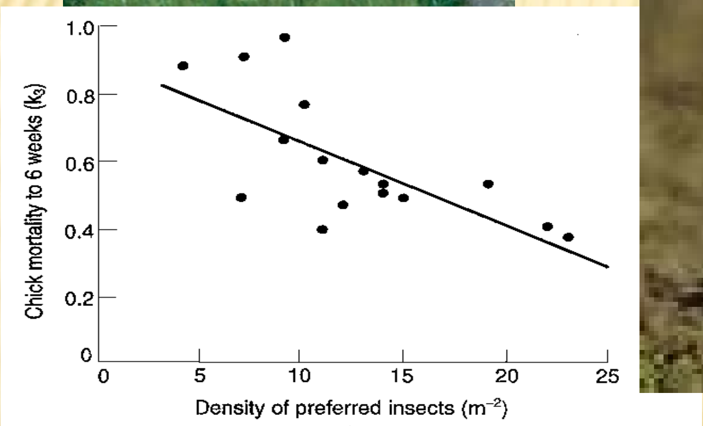
Estimated no. of seeds needing to be ingested by a 15g bird to achieve a 50% chance of lethality (*given sensitivity at the 5% tail of the bird distribution).

Active ingredient	Seed type	mg/seed	Critical endpoint	Endpoint value (mg/kg)	No. seeds to lethality
imidacloprid	Corn	1.34	HD5*	8.5	0.1
	canola/rapeseed	0.029	HD5*	8.5	4.4
	Wheat	0.033	HD5*	8.5	3.9
clothianidin	Corn	1.25	HD5*	149	1.8
	canola/rapeseed	0.012	HD5*	149	186.3
	Wheat	0.025	HD5*	149	89.4
thiamethoxam	Corn	0.8	HD5*	162	3.0
	canola/rapeseed	0.012	HD5*	162	202.5
	Wheat	0.018	HD5*	162	135.0
acetamiprid	canola/rapeseed	0.0072	HD5*	8	16.7

Mineau, P. and C. Palmer. 2013. The impact of the nation's most widely used insecticides on birds. Unpublished report prepared for the American Bird Conservancy, March 2013. 96 pp.

We have known for a long time that indirect effects from pesticides could also be important.

In the UK and most other EU countries, indirect effects thought to dominate pesticide impacts.



Data from the Partridge
Potts and colleagues, Game Conservancy

PRINCIPAL ACTIVE INGREDIENTS
PHYS-CHEM PROPERIES

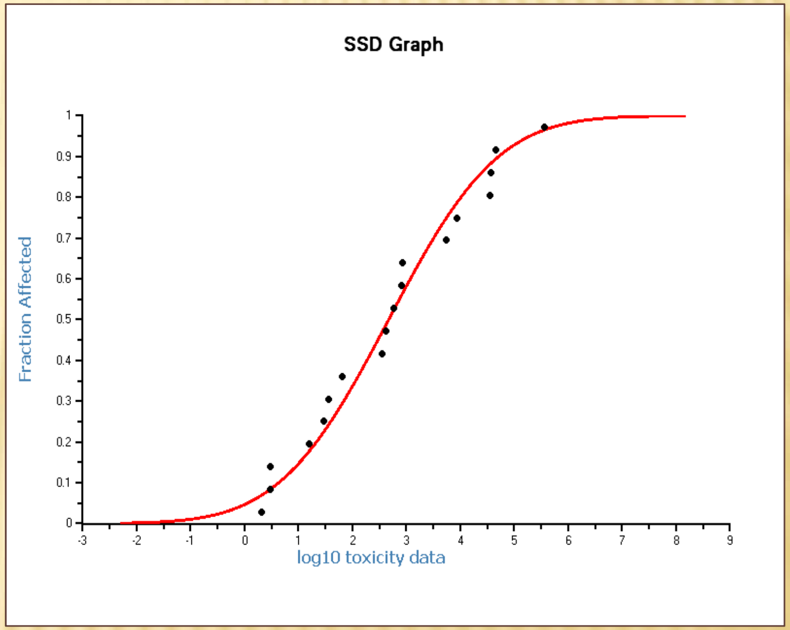
Product	GUS index (>2.8 = high leaching potential) **(Atrazine = 3.3)**	DT_{50} (field) **(Atrazine = 75 d)**
Imidacloprid	3.76	191 d
Thiamethoxam	3.66	50 d
Clothianidin	4.91	545 d

~40%

Source: Footprint DB

Imidacloprid. Summary of acute toxicity values in µg/l for crustacean species.

Species	Study Time (h)	Toxicity (EC/LD50) ppb
Ceriodaphnia dubia*	48	2.07
Cypridopsis vidua	48	3
Ilyocypris dentifera	48	3
Cypretta seurati	48	16
Gammarus roselli	96	29
Americamysis bahia	96	36
Hyalella azteca	96	65
Gammarus pulex	96	350
Palaemonetes pugio	96	417
Ceriodaphnia dubia*	48	572
Gammarus fossarum	48	800
Chydorus sphaericus	48	832
Ceriodaphnia reticulata	48	5553
Asellus aquaticus	48	8500
Daphnia magna	48	35539
Daphnia pulex	48	36872
Moina macrocopa	48	45271
Artemia sp.	48	361230



EXPOSURE CONCENTRATIONS OF IMIDACLOPRID PREDICTED TO CAUSE IMPACTS TO INVERTEBRATE COMMUNITY (µg/l)

Source	Reference level for PEAK exposure	Reference level for AVERAGE exposure
EPA (2007) (US)	**35**	**0.5**
EFSA (2008) (Europe)	**0.55**	**0.2 - 0.6**
RIVM (2008) (Netherlands – non regulatory)	**0.2**	**0.07**
Nagai et al. 2012	**0.43**	
EPA (2012) (US – non regulatory)	**35**	**1.05**
Mineau and Palmer (2013)	**1.0**	**0.01 – 0.03**

Maximum surface water concentrations detected to date (under-estimate of true peak):

- **3.05 µg/l (California – season-wide)**
- **11.9 µg/l (PEI – Canada)**
- **325 µg/l (Netherlands – effects seen)**

Maximum ground water concentrations detected to date:

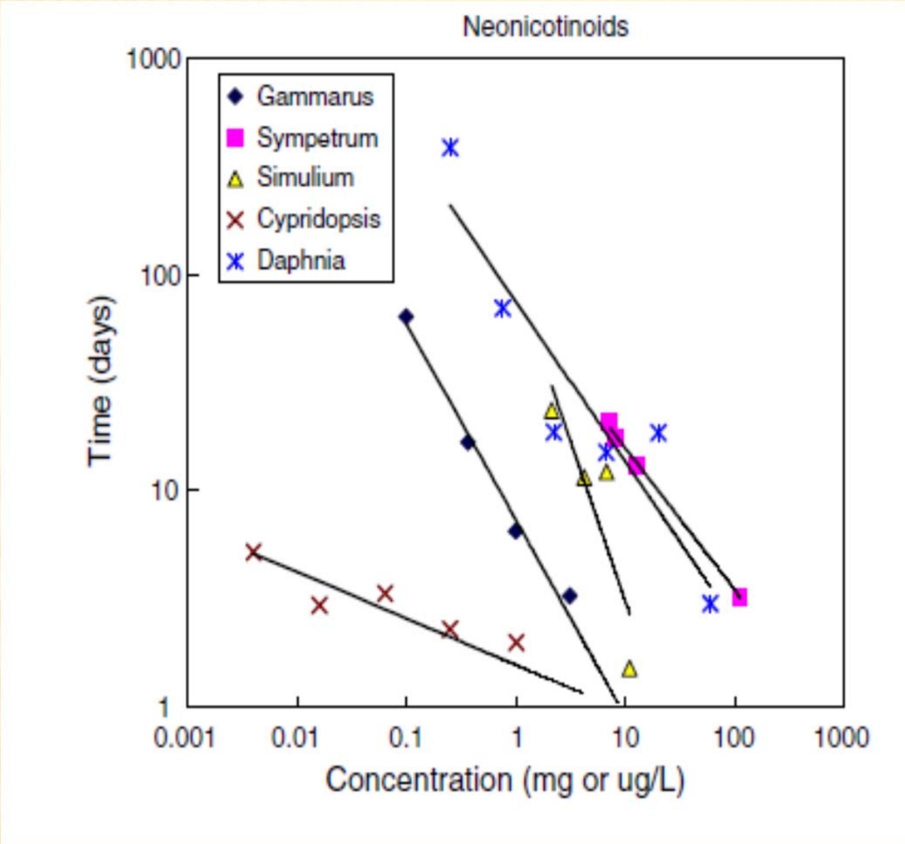
- **1.0 µg/l (California (California – 1997)**
- **7.0 µg/l (New York State – 2008**
- **9.0 µg/l (Wisconsin – 2013)**
- **6.4 µg/l (Quebec – 2003)**

NOTE: Should look at sum of residues. Cumulative effect & similar toxicity for all neonicotinoids. Data very limited for other neonics.

CAN IT GET ANY WORSE!!!!

TOXICITY VS. EXPOSURE TIME IN AQUATIC INVERTEBRATES

Time to 50% mortality for arthropods exposed to neonicotinoid insecticides.



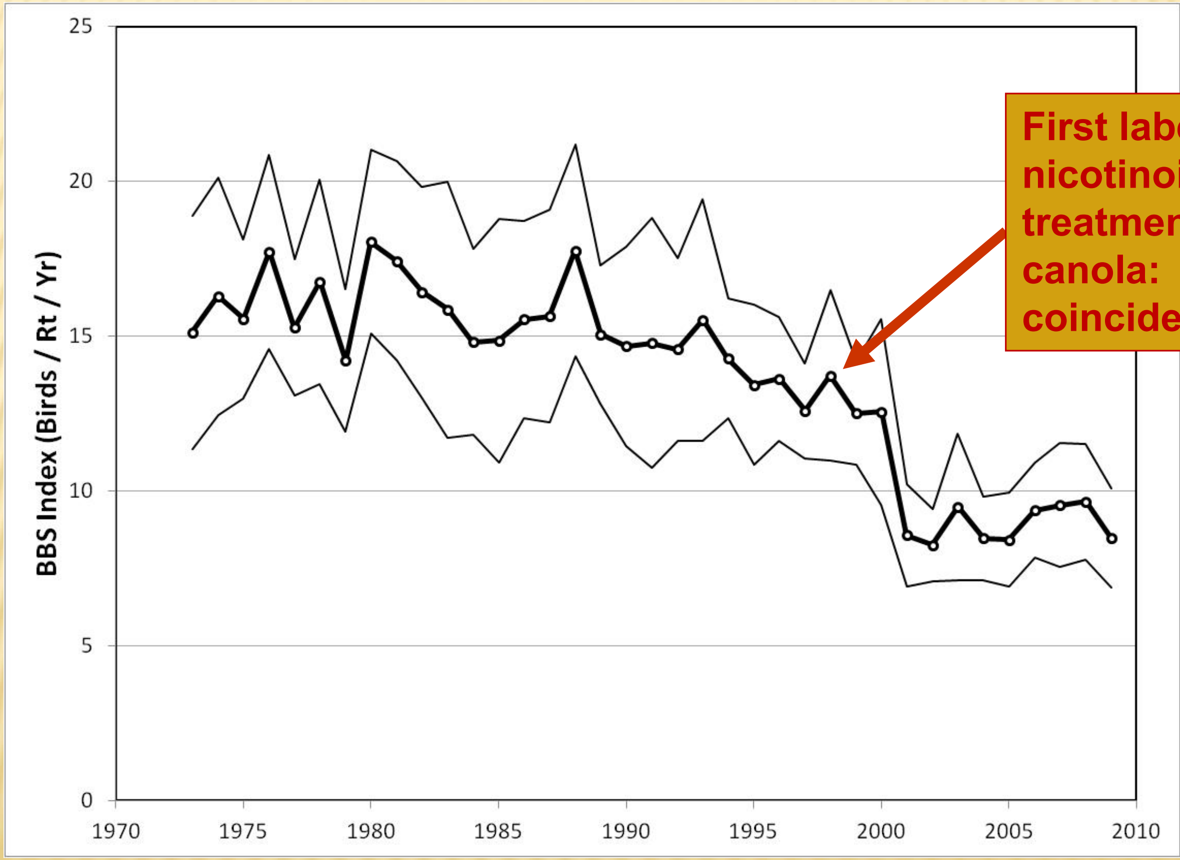
Note: Accepted guideline for risk assessment is a 48 hour exposure test !!!

Evidence of similar increase in toxicity merely by extending the observation period after the test subjects have been transferred to clean water !!!!

From: Sanchez-Bayo 2009 Ecotoxicology 18:343

Aerial insectivores in decline

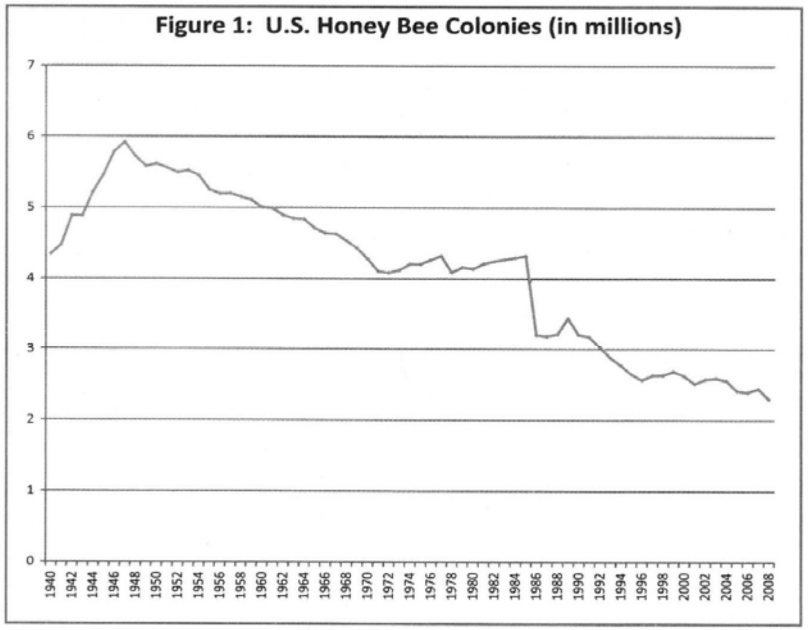
e.g. barn swallows in the Canadian prairies.



First label of neo-nicotinoid seed treatments in canola: coincidence?

BBS data, Canadian Wildlife Service

MOST OF THE ATTENTION HAS BEEN ON POILLINATORS – AND MOST OF THAT ON HONEYBEES !!!!!



December 2009

Honey bees and wild bees are critical to many crops. Yet, they are disappearing from fields because of: poor management, disease (introductions), landscape simplification and pesticides.

Source: Brett Adee, EPA Pollinator Summit 2013.

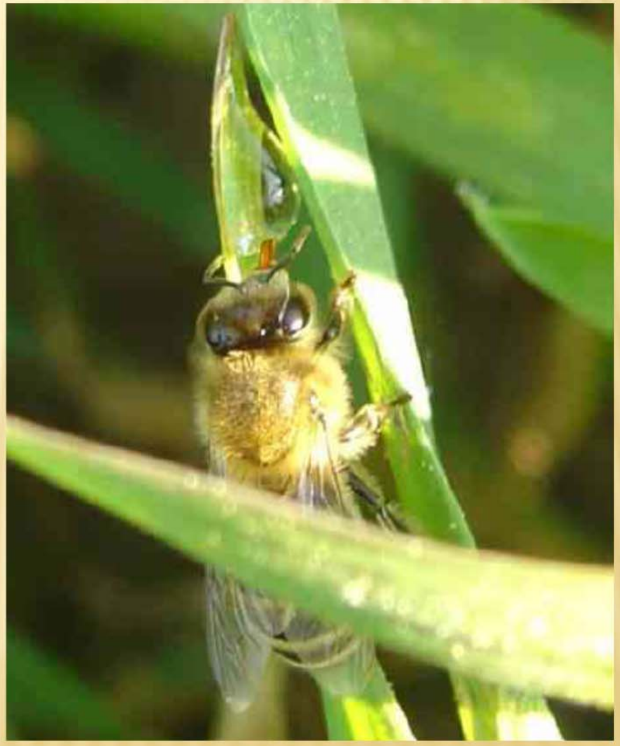
Conflicts between pollinators and the use of pesticides are NOT new !

However, the increase in the use of systemic products, often applied prophylactically as seed treatments has greatly increased the risk (and impacts !)

Many new routes of pesticide exposure need to be considered.

E.g. Drinking guttation droplets.

Also dew, surface water, possibly spray solution?



Source: Hedwig Riebe, Deutcher Berufs und Erdwerbs Imkerbund

E.g. Ingestion of contaminated pollen and nectar – weeks or months after application.

Multiple residues in honey are now the norm ! Will there be a consumer backlash?

Eg. Abrasion of seed coatings during planting – worsened by the use of talcum or graphite lubricants – creates a toxic dust cloud.

Most serious is the increasing amount of information linking low level exposure to behavioural and immune disfunction of hives.

THE CURRENT STATUS OF NEONICOTINOIDS

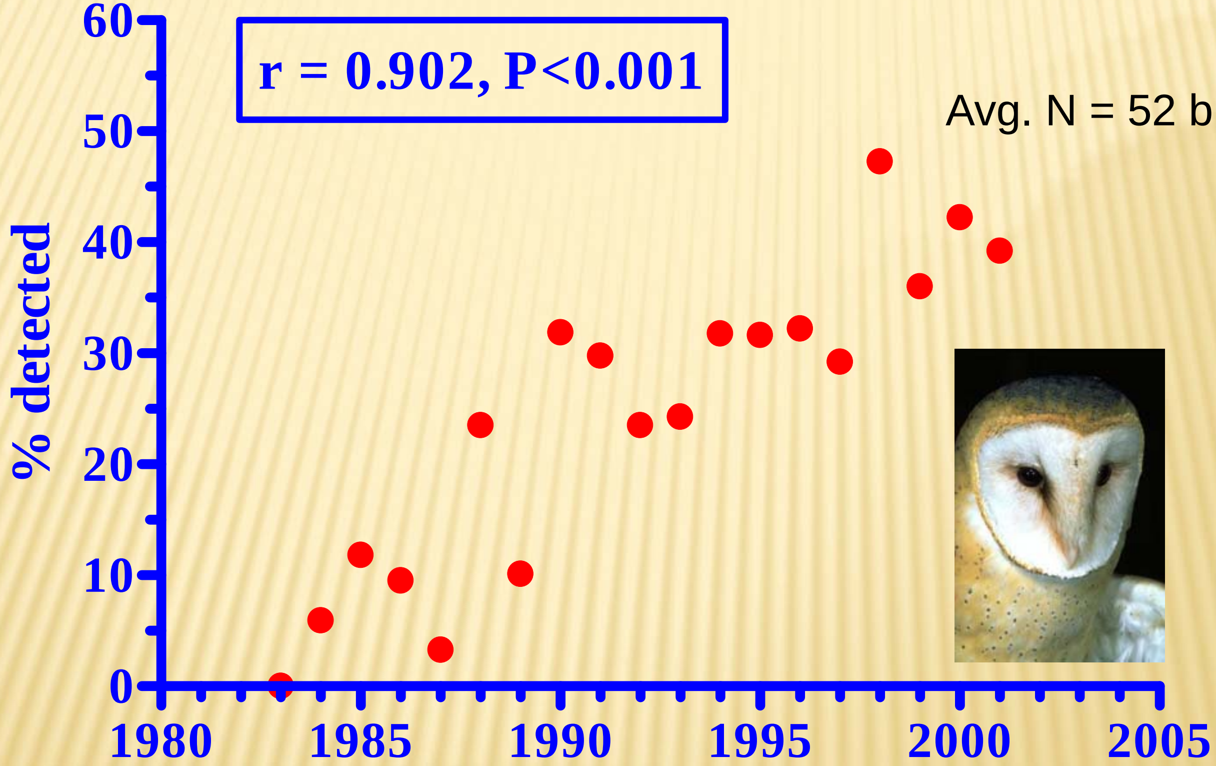
- First introduced in 90s & early 00s
- Meteoric rise in haste to replace OPs and carbs
- Imidacloprid now the most widely used insecticide in the world
- Temporary bans of some seed treatment uses (clothianidin, thiamethoxam) in France, Italy & Germany in response to incidents
- January 2013: EFSA concludes they present an unacceptable risk to bees & industry studies were flawed
- April 2013: EU instigates 2 yr. moratorium on flowering crops
- New information coming out all the time on link to immune function and disease.

STAY TUNED. THE CONTROVERSY IS FAR FROM OVER

SGARS (SECOND GENERATION ANTICOAGULANT RODENTICIDES)

- Single feed, persistent anticoagulants ubiquitous in rodent control
  - Brodifacoum
  - Difenacoum
  - Bromadiolone
  - Flocoumafen
- Poisoning documented in numerous species; principally predators and scavengers
- More worrisome is frequency of exposure in most species examined to date; usually >40%, often70-90% of individuals (bias?); even in species that do not typically feed on rodents e.g. accipiters; and where use of the products is confined to buildings or their immediate vicinity

UK: CHANGES IN EXPOSURE OVER TIME.
(OVERALL RATE OF DETECTION UNDERESTIMATED BY ~ 2.5% IN ORDER TO ACCOUNT FOR CHANGING DETECTION LIMITS)

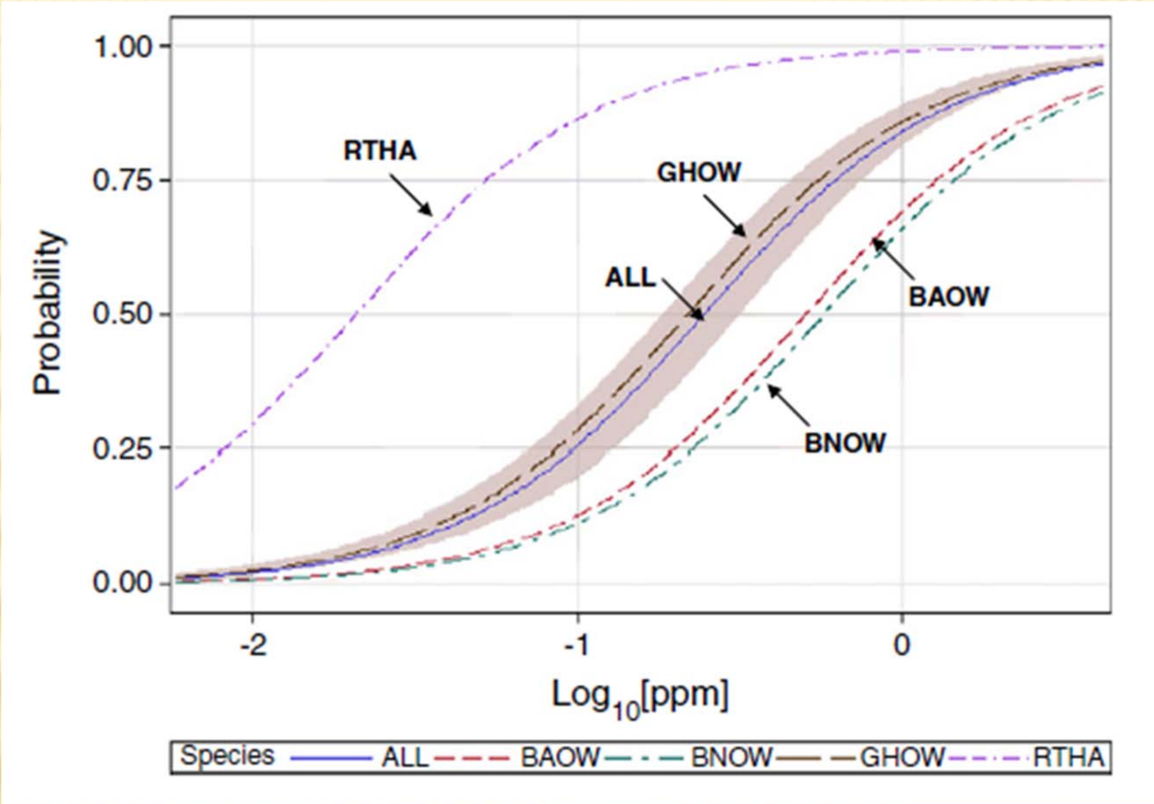


Suspected underestimation of bromadiolone

Predatory Bird Monitoring Scheme

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

Recent attempt to establish significance of liver residues: Probability of pathological effects against liver residues.



Thomas, P.J., P. Mineau, R.F. Shore, L. Champoux, P. Martin, L. Wilson, G. Fitzgerald, J. Elliott. 2011. Second generation anticoagulant rodenticides in predatory birds: probabilistic characterisation of toxic liver concentrations and implications for predatory bird populations in Canada, Environment International 37(2011): 914-920.

Tentative conclusion based on Great Horned owl data (N.A.) (1988-2003! – Indications are that this is an increasing problem.)

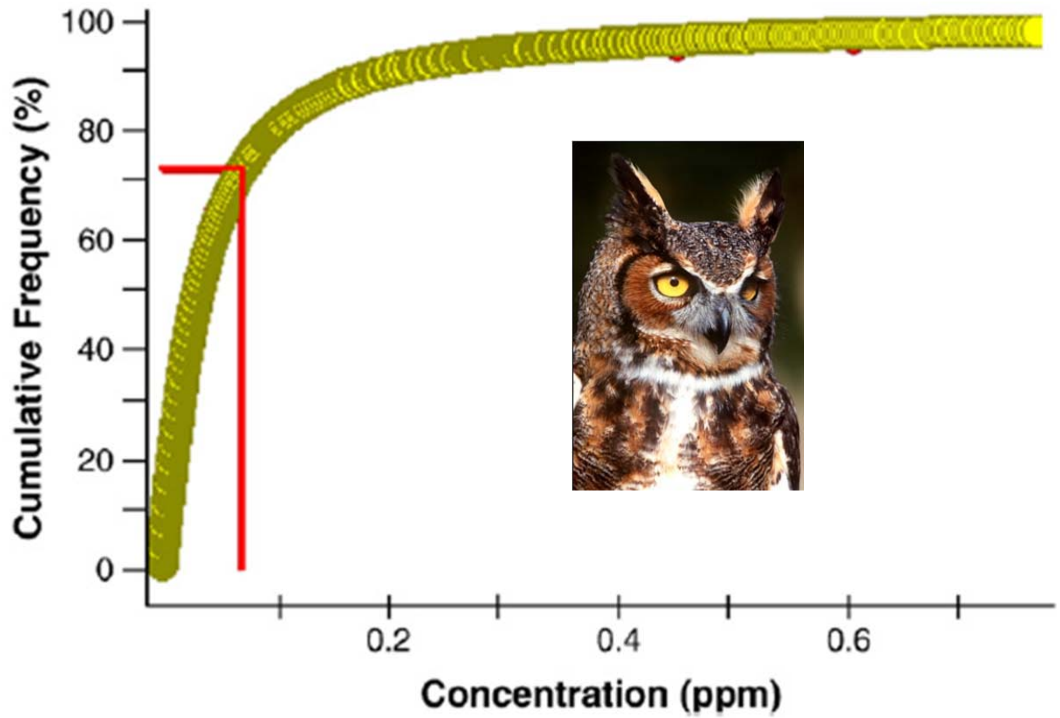


Fig.4. Cumulative frequency graph for liver SGAR residues in 79 great horned owls. Red line represents the 20% probability level for effect (0.07 mg/kg; Table 1).

Approximately 25% of Great horned Owls have liver residues that exceed the 20% probability level for effect.

THE DEVELOPMENT OF ENVIRONMENTAL RISK AND EVIDENCE-BASED STANDARDS, MEASURES AND INDICATORS.

PESTICIDE INDICATORS ANALYSED AND FOUND UNSATISFACTORY (MINEAU AND WHITESIDE 2005)

- AARI and ATRI
- APPLES (Env. Canada)
- BRI
- Danish Hasse Diagram
- Danish Load Index
- Dutch Yardstick
- EcoRR
- EIQ
- EPRIP
- ERIP
- ERS
- ESCORT_2
- FA
- IPEST
- Norwegian indicator
- PEAS & MATF (Cons. Union)
- PEI relative ranking (Dunn)
- p-EMA
- PERI
- PESTDECIDE
- POCER
- SCRAM
- Stemilt growers
- SYNOPS
- SyPEP
- U. California HPPRS
- WWF

OUR APPROACH

- Develop a comprehensive measure of pesticide impact
- Make it usable at the field level to inform grower choice
- Allow for specific use pattern information; e.g. application rate and methodology
- Where possible, use **field impact studies or incident data** to derive impact measure or indicator
- Where field data lacking, follow regulatory approach (augmented by recent developments in risk assessment)
- Maximise use of openly-available information
- Keep different environmental sectors separate
- As a last step, allow combination of impact scores to account for multiple applications per field

COMMON METHODOLOGY: E.G. AQUATIC STANDARDS

STEP 1: SEARCH FOR TOXICITY DATA & SELECTION PROCESS (NOT NECESSARILY A TRIVIAL EXERCISE)

- Source of data:

  US EPA Registration data, ECOTOX, AGRITOX, European Commission pesticide review reports, Pesticide Manual…

- Select data to maximize the number of species:

Taxa	Accepted endpoint	Accepted exposure periods
Fish	LC_{50} and/or EC_{50} (Immobilization)	24 – 96 hours (1 – 4 days)
Crustaceans	LC_{50} and/or EC_{50} (Immobilization)	24 – 96 hours (1 – 4 days)
Aquatic Insects	LC_{50} and/or EC_{50} (Immobilization)	24 – 96 hours (1 – 4 days)
Algae	EC_{50} (Growth or population effects)	24 – 120 hours (1 – 5 days)
Macrophytes	EC_{50} (Growth or population effects)	24 – 336 hours (1 – 14 days)

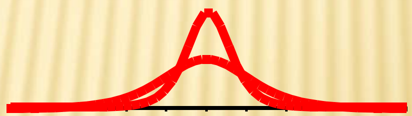
E.g. Dataset for initial analysis of pre-2005 AG products:
- Data for 682 species for 260 active ingredients
- 238 fish sp.
- 183 crustacea
- 175 aquatic insects
- 74 algae
- 12 macrophytes

STEP 2: USE OF SPECIES SENSITIVITY DISTRIBUTIONS TO AVOID BIASES ASSOCIATED WITH QUANTITY OF DATA AVAILABLE AND SINGLE SPECIES TOXICITY TESTS.

Data Preparation:

- Technical active ingredients
- Eliminate duplicate values
- Calculate species geo-mean when more than one data point present

Generating species sensitivity distribution

Species Geo-means →  → HC_5 for each taxon

HC5 is the value that is lower than the LC50 for 95% of species. The probability that the calculated HC5 is no higher than the actual HC5 can also be specified.

Using ETX 2.0 (log-normal) and/or BurrliOz
***Small sample method when < 5 species**

USING AN APPROPRIATE TOXICITY ENDPOINT ALLOWS FOR A MEANINGFUL COMPARISON AMONG PESTICIDES – IN THE FORM OF TOXICITY UNITS (TU)

Exposure and toxicity expressed as total number of toxic units

$$TU = \frac{\text{Concentration of pesticide}}{\text{Geomean } LC_{50} \text{ or } HC_5}$$

(HC_5: taxon appropriate – crustacea, insecta, fish ...)

Where concentration-based TU not possible (e.g. birds):

TU = No. HD_5-equivalent doses/ kg bird / M^2 of field area

STEP 3: LOOKING FOR EMPIRICAL DATA – FIELD IMPACT STUDIES

Criteria for selection of aquatic studies in literature review

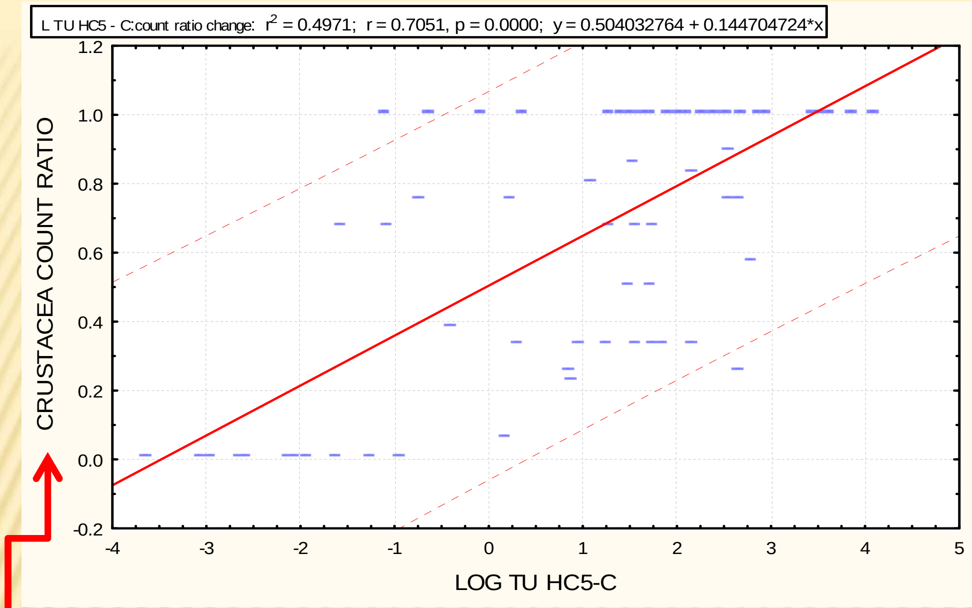
- 60 studies selected for modeling representing 184 experiments and 33 pesticides
- System structure and location characteristics such as type (pond, lake, mesocosm or stream), dimensions, volume of water in enclosure, water regime, and country
- Water properties such as pH, temperature, dissolved oxygen, conductivity, total phosphorus, and total nitrogen
- Trade name & formulation of pesticide, method of application, solvent used, peak concentration in water column, taxonomic group, effect & type of control

Step 4: Building an effect model

- Two main measurements of response: proportion of taxa affected by treatment and relative abundance of modeled taxon.

Count Ratio of Effect (CR) = $\frac{\text{Number of signif. affected species}}{\text{Total number within the system}}$

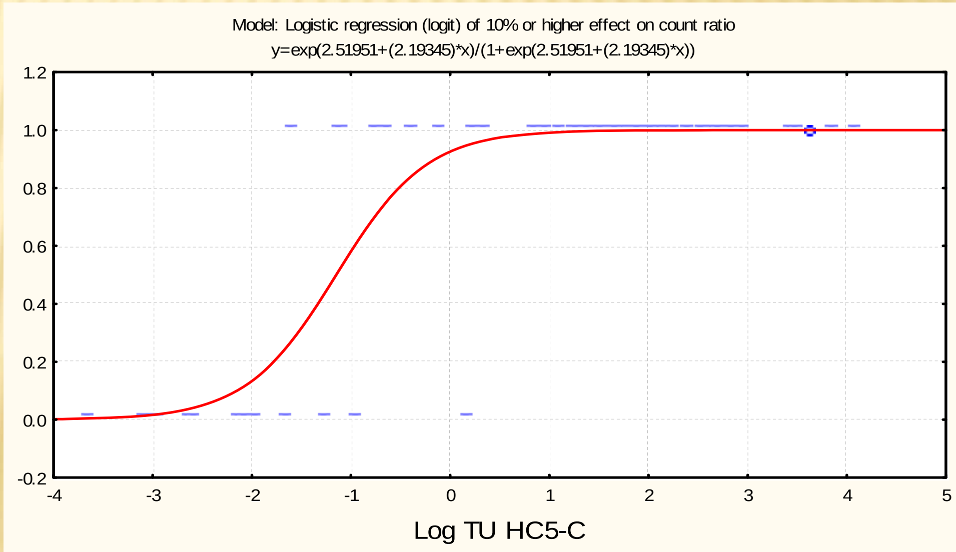
Abundance Ratio* (AR) = $\frac{\text{Quantity of species in control}}{\text{Quantity of species in treatment}}$



Example: Aquatic crustacea index

See: Guy, Singh, Mineau 2011; IEAM 7(3):459-465

Proportion of taxa significantly affected



As the probability that 20% of species are significantly affected.

** See detailed 'white paper' available for each index

ENVIRONMENTAL RISK INDICATORS

Acute indices – calibrated against available field studies

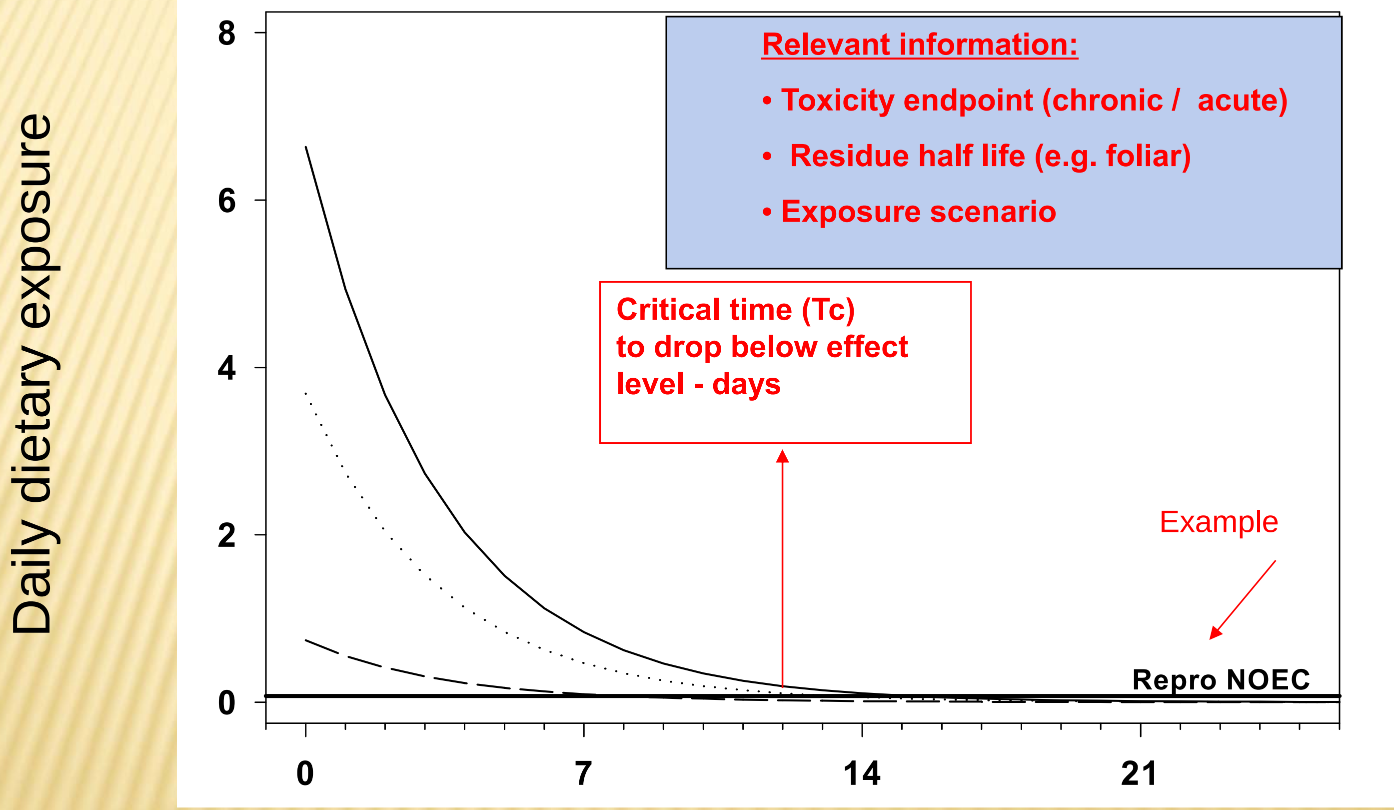
- **Avian:** Probability that a given application will give rise to bird mortality.
- **Small Mammal:** Probability of a population-level effect.
- **Earthworms:** Probability of >35% loss of biomass.
- **Aquatic Invertebrates:** Probability that >10% of taxa will be impacted significantly (typically 50-90% loss of population).
- **Algae:** Probability that >20% of species will be impacted significantly.
- **Pollinators** (under construction) : Probability that foraging bee swill be exposed to lethal doses from several exposure routes on and off crop.

Chronic / reproductive indices – Follow risk assessment methodology but not calibrated against actual field outcomes.

- **Avian & fish:** Proportion of the breeding season over which reproduction is compromised.

RISK BANDS:	< 10%	10 – 50 %	> 50 %
	Negligible	Moderate	High

NOVEL ELEMENT FOR CHRONIC ENDPOINTS: INCORPORATING TIME IN THE RISK ASSESSMENT PROCESS – AVIAN, MAMMALIAN AND FISH REPRODUCTION INDICES OVER WHAT PROPORTION OF THE BREEDING SEASON WILL REPRODUCTION BE IMPAIRED?



Example from Woudschoten workshop, Sept. 1999; SETAC Press 2001

See also proceedings of British conference 2005.

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COMBINING TREATMENTS PER FIELD

e.g. earthworm impacts

1. Pyraclostrobin @ 225 g ai/ha = 31% loss

2. Phosalone @ 625 g ai/ha = 33% loss

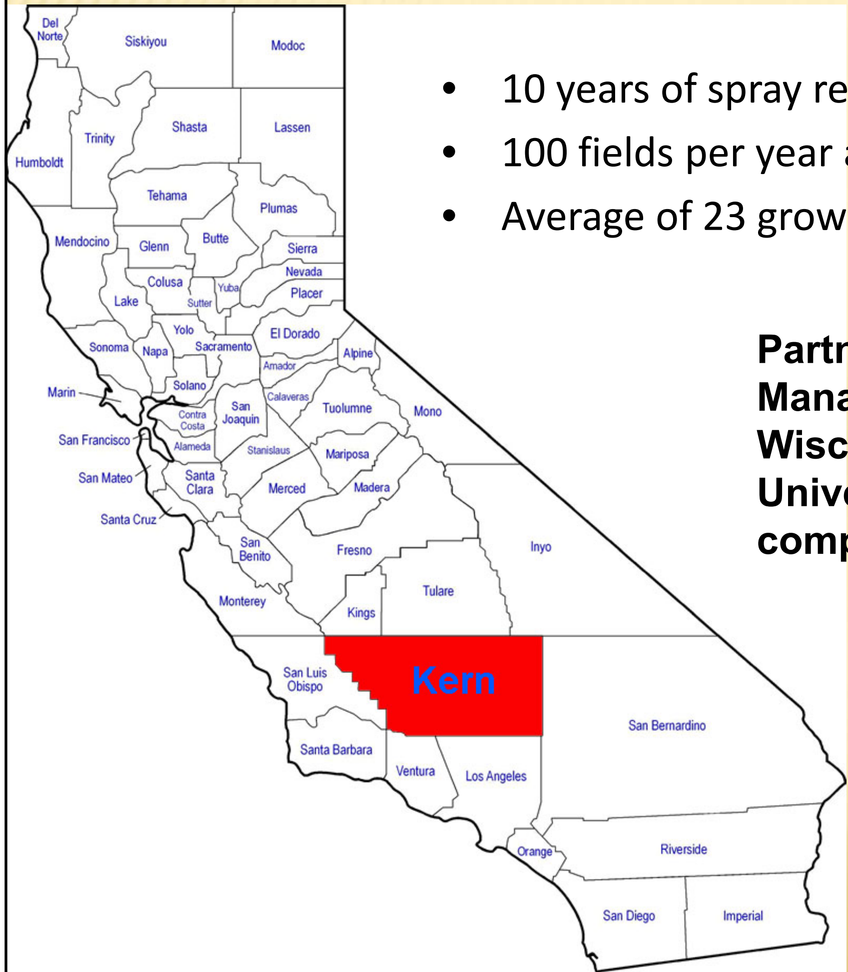
Combination of two independent* probabilities is the product of the two:

$P_{loss} =$ 1 – [(1 - 0.33) * (1 – 0.31)] = 0.56

General proposed solution

$$= 1 - [\prod_{k=1}^{n} (1 - Pk)]$$

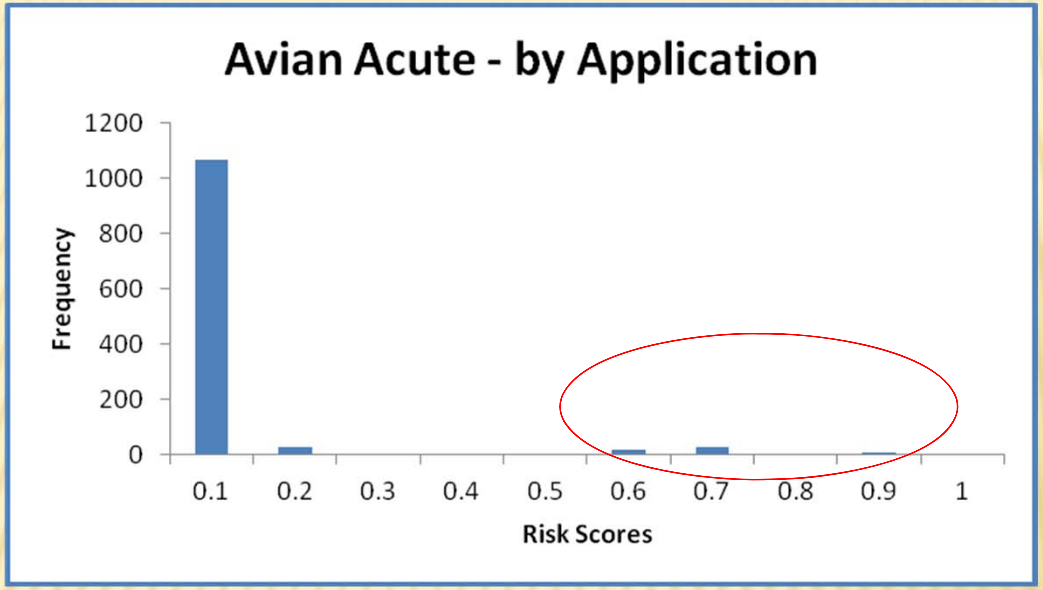
OUTPUT EXAMPLE : California Cotton Data



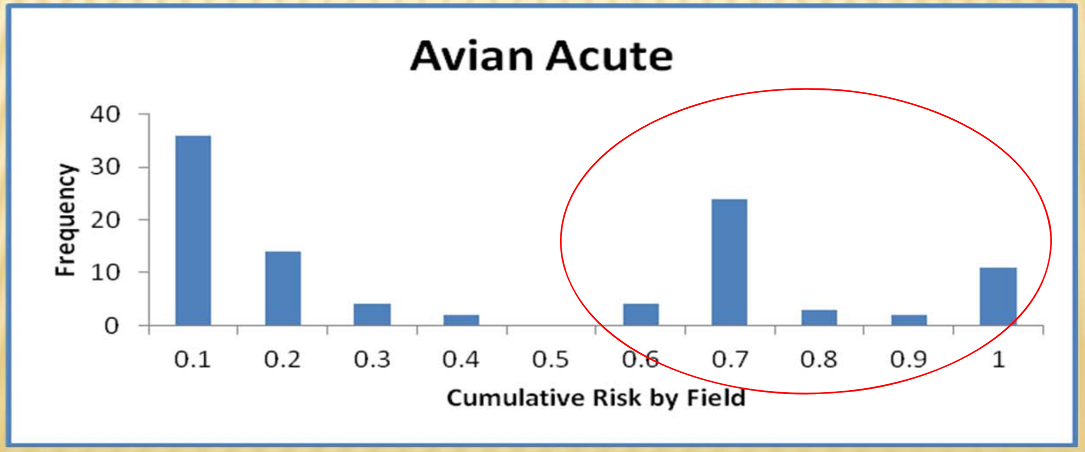
- 10 years of spray records (2001-2010)
- 100 fields per year analyzed
- Average of 23 growers per year, 40 growers total

Partnership with the Integrated Pest Management Institute in Madison Wisconsin and Oregon State University. Development of computerised platform: PRiME

Eg. Comparing performance of growers



e.g. 2010



RISK “CREEP”’

$$= 1 - [\prod_{k=1}^{n}(1 - Pk)]$$

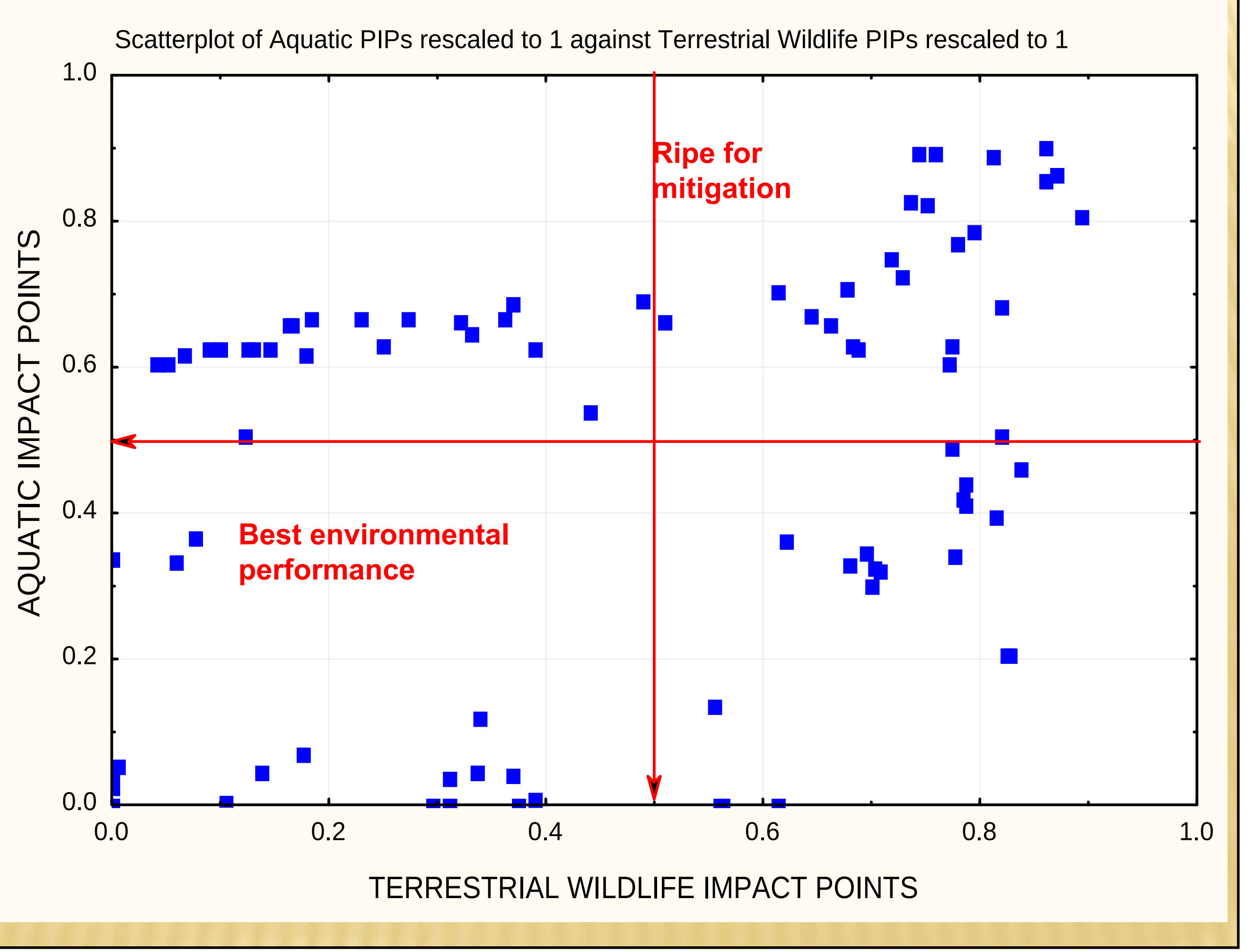
Sample of cotton fields & performance quartiles - 2001

Terrestrial

- avian acute
- avian chronic
- small mammal

Aquatic

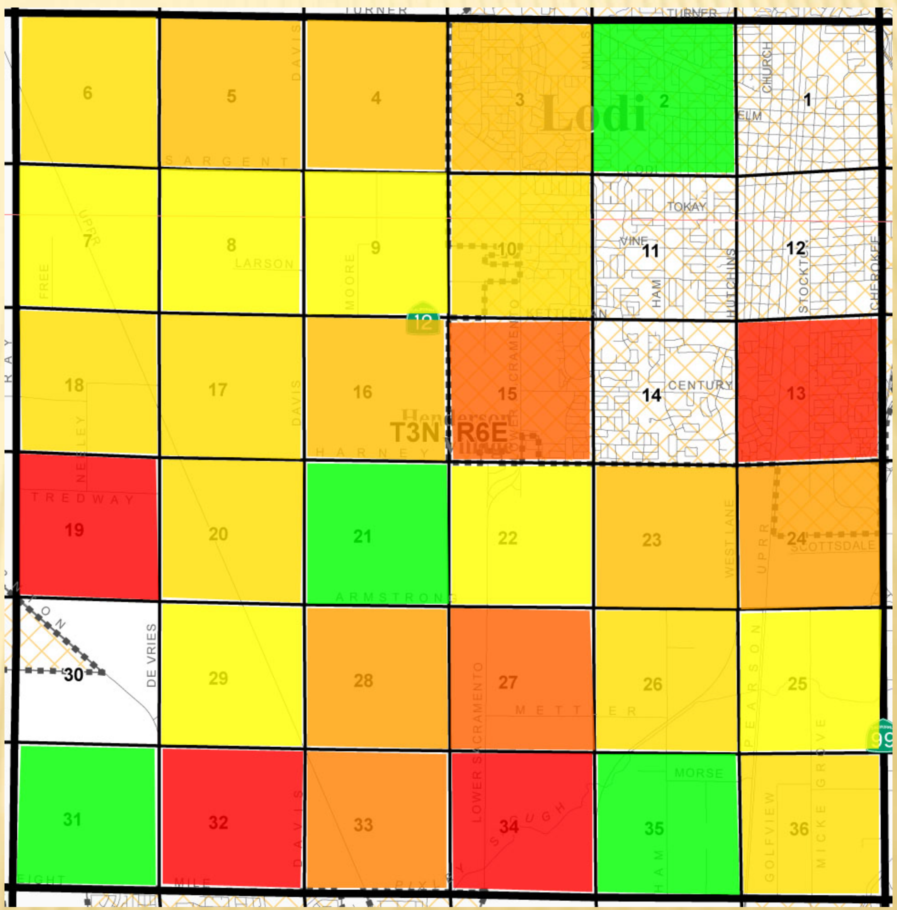
- inverts acute
- fish chronic
- algae acute



Spatial analysis: Proportion of High Risk Scores for Aquatic Invert.

% High Risk Scores

- >24%
- 21-24%
- 18-21%
- 15-18%
- 12-15%
- 9-12%
- 6-9%
- 3-6%
- 0-3%
- No High Risk Scores



Can be compared to biodiversity or other biotic measurements.

GRATIAS ! PREGUNTAS?

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