

The Systemic Insecticides: A Disaster in the Making

Dr. Henk Tennekes

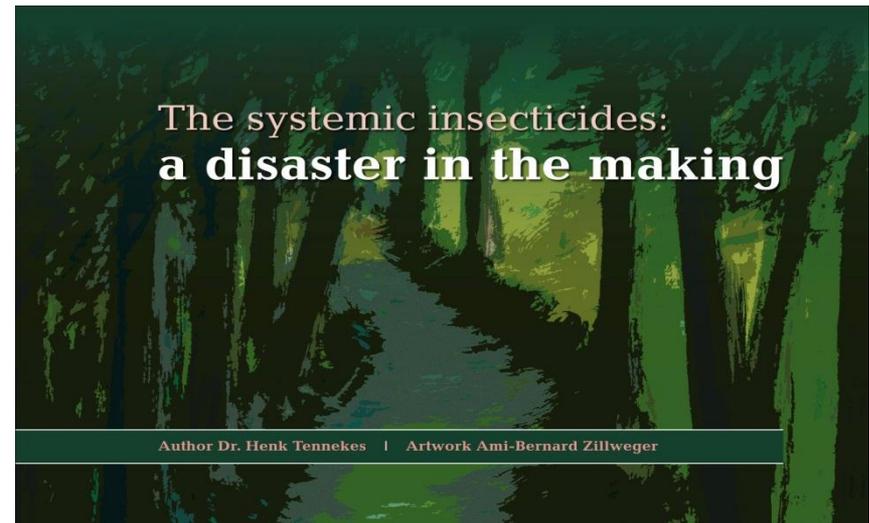
Hampshire Beekeepers Association Convention
10 November 2012



„Knowing what I do, there would be no future peace for me if I kept silent...”

Rachel Carson

- Henk Tennekes graduated from the Agricultural University of Wageningen, The Netherlands in 1974 and performed his Ph.D. work at Shell Research in Sittingbourne in the UK.
- He worked at the German Cancer Research Centre in Heidelberg from 1980-1985, where renowned pharmacologist and oncologist Hermann Druckrey became his mentor
- In 2009, Tennekes discovered that the dose response characteristics of the toxicity of widely used neonicotinoid insecticides to arthropods were strikingly similar to those of genotoxic carcinogens. **The effects of these compounds are reinforced by exposure time**
- Realising the dire consequences of environmental pollution with these insecticides, Tennekes decided to write a book to warn the general public about an impending environmental catastrophe



German Edition of 'A Disaster in the Making'

Preface by Professor Hubert Weiger, Chairman, *Friends of the Earth Germany*

German Translation: Sven Buchholz Tomas Brückmann Patricia Cameron



Das Ende der Artenvielfalt: **Neuartige Pestizide töten Insekten und Vögel**

Autor: Dr. Henk Tennekes | Illustrationen: Ami-Bernard Zillweger

Herausgeber: Bund für Umwelt und Naturschutz Deutschland e.V. (BUND)

The Legacy of Rachel Carson

Silent Spring (1962)

- In 1962, the American biologist Rachel Carson published her book „Silent Spring“, in which she describes rapidly declining biodiversity caused by widespread use of pesticides, such as DDT
- “Silent Spring” remains one of the most effective denunciations of industrial malpractice ever written and is widely credited with triggering popular ecological awareness in the US and Europe



The Legacy of Rachel Carson

Silent Spring (1962)

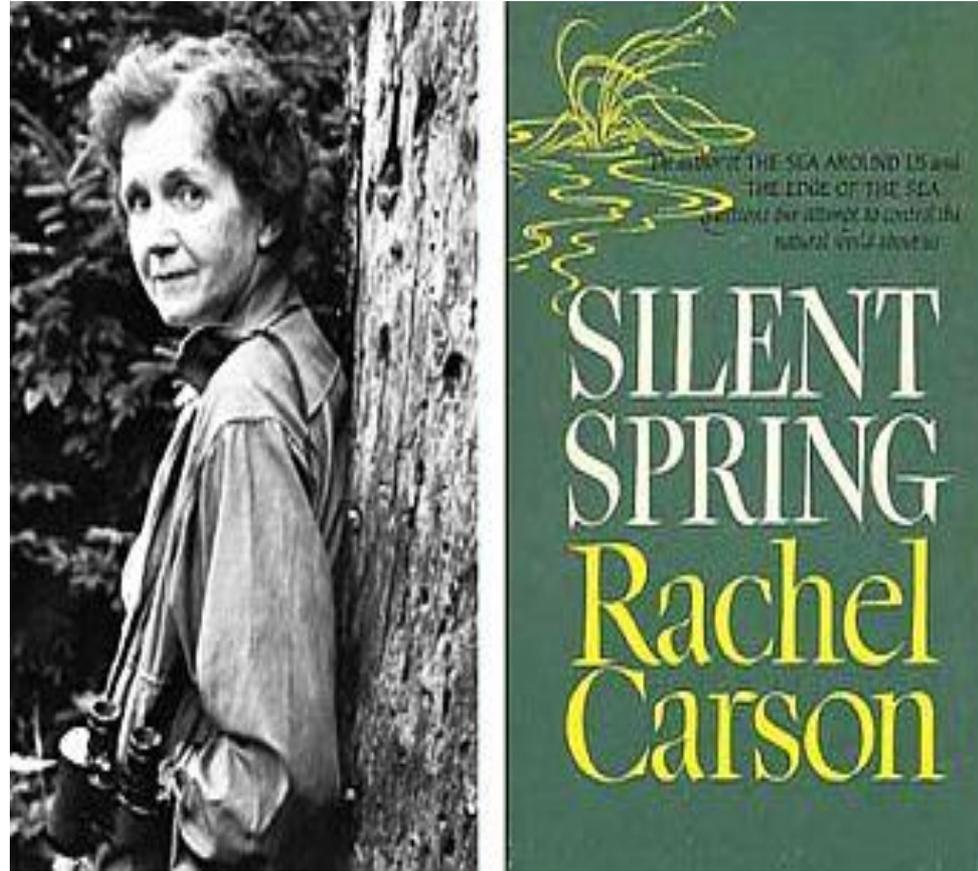
- At the Women's National Press Club, Rachel Carson denounced the links that had been established between science and industry:
- *"When a scientific organisation speaks," she asked, "whose voice do we hear – that of science or of the sustaining industry?"*
- The question remains as pertinent today as it did in 1962



The Legacy of Rachel Carson

Silent Spring (1962)

- Nor have matters improved. Neonicotinoids, insecticides used in seed dressing, have been linked to colony collapse disorder in honeybees, a condition that already in 2007 alone saw 800,000 hives wiped out in the US



DDT Becomes Concentrated In Food Chains

- DDT is highly lipophilic and only slowly metabolised, and becomes concentrated as it passes through a food chain
- The hazard of DDT to non-target animals is particularly acute for those species living at the top of food chains
- Carnivores at the ends of longer food chains (e.g. ospreys, pelicans, falcons, and eagles) suffered serious declines in fecundity and hence in population
- The use of DDT was banned (1972) in the United States



Neonicotinoids Break Food Chains And May Have Adverse Effects on Human Health, Especially On The Developing Brain

- Neonicotinoid insecticides that are currently in use are water soluble (hydrophilic) and permeate the whole plant
- Advantage:
Application rates are much lower than for traditionally used insecticides
- Catastrophic Disadvantages:
Non-target insects such as honey bees or butterflies that collect pollen or nectar from the crop are poisoned
- Moreover, neonicotinoids may leach from soils, threatening non-target invertebrates in general. Breaking one link on the food chain means that all of the organisms above that link are in threat of extinction
- Neonicotinoids as well as nicotine directly act on mammalian nicotinic acetylcholine receptors (nAChRs), and residues of neonicotinoids in food may have various adverse effects on the human health, especially on the developing brain



Lethal Effect of Imidacloprid on Honey Bees

Toxicity Is Reinforced By Exposure Time

Suchail S, Guez D, Belzunces LP, 2001. Environ. Toxicol. Chem. 20: 2482-2486
Tennekes HA, Sánchez-Bayo F, 2012. J. Environment. Analytic Toxicol. S4- 001

- The *lower* the exposure concentration, the *longer* the latent period up to a lethal effect, the *lower* the lethal dose
- The dose : response relationship is a Druckrey-Küpfmüller equation

$$\ln T50 \text{ (hrs)} = 5.11 - 0.22 \ln C \text{ (}\mu\text{g. L}^{-1} \text{ or kg}^{-1}\text{)}$$

or

$$C \times T50^{4.5} = \text{constant}$$

Concentration C ($\mu\text{g/L}$)	Latent Period T50 (hours)	Lethal Dose ($\mu\text{g/L} \times \text{hours}$)
57	48	2,736
37	72	2,664
10	173	1,730
1	162	162
0.1	240	24



Lethal Effect of Imidacloprid on the Ostracod *Cypridopsis vidua*

Toxicity Is Reinforced By Exposure Time

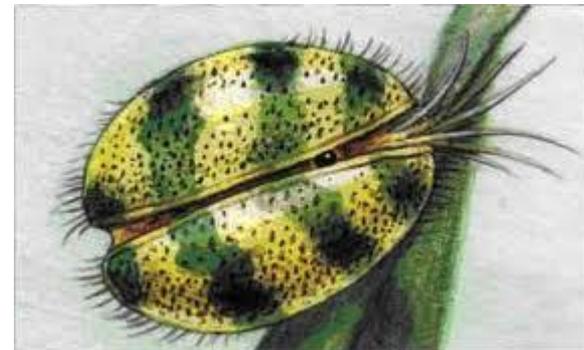
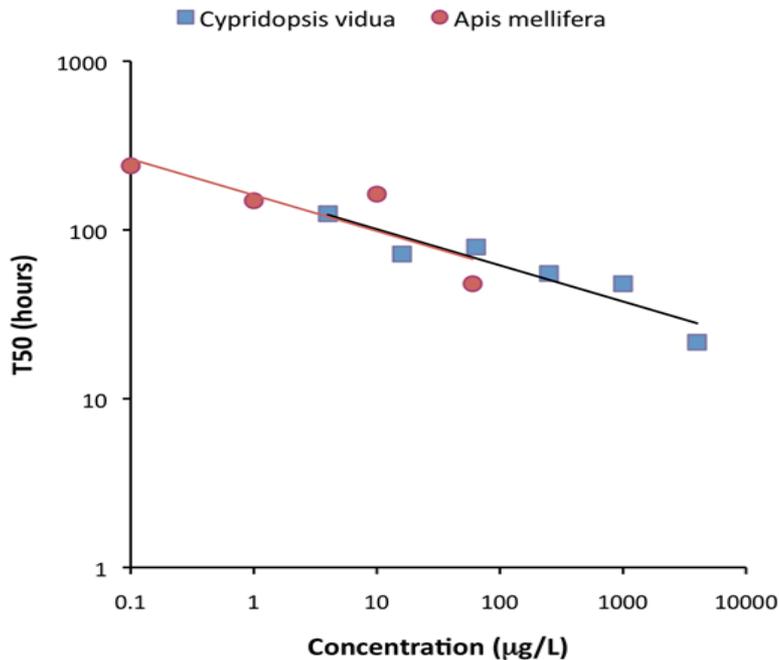
Sánchez-Bayo F. 2009. *Ecotoxicology* 18: 343-354

Tennekes HA. 2010. *Toxicology* 276, 1-4.

Tennekes HA, Sánchez-Bayo F. 2012. *J. Environment. Analytic Toxicol.* S4- 001

- The *lower* the exposure concentration, the *longer* the latent period up to a lethal effect, the *lower* the lethal dose

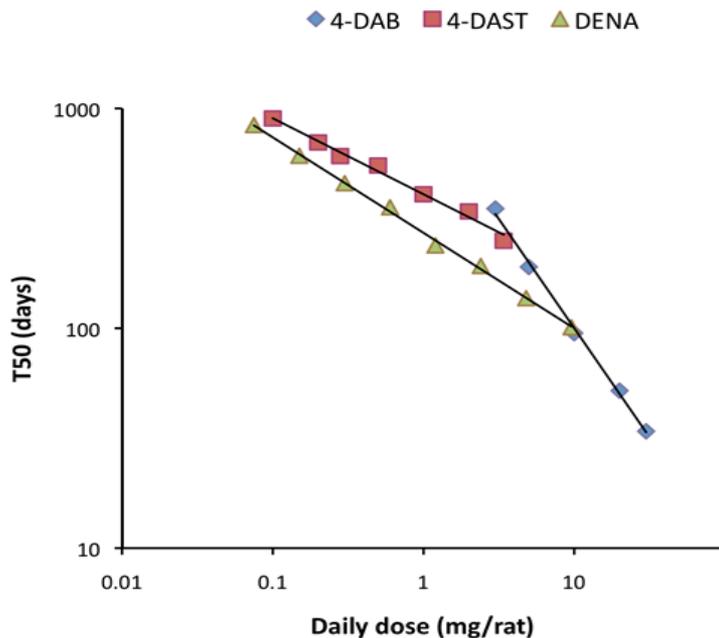
Concentration (µg/L)	Latent Period (days)	Lethal Dose (µg/L x days)
4,000	0.9	3,600
250	2.3	575
64	3.3	211.2
4	5.2	20.8



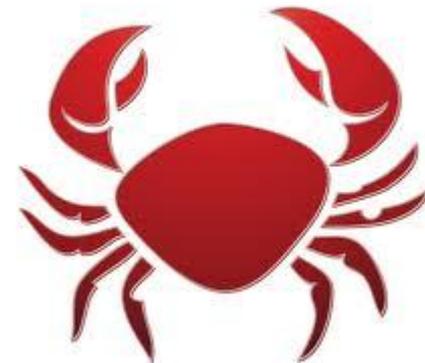
Induction of Liver Cancer In Rats By Diethylnitrosamine Toxicity Is Reinforced By Exposure Time

Druckrey, H., Schildbach, A., Schmaehl, D., Preussmann, R., Ivankovic, S., 1963. *Arzneimittelforsch.* 13, 841–851

- The *lower* the exposure concentration, the *longer* the latent period up to a carcinogenic effect, the *lower* the carcinogenic dose



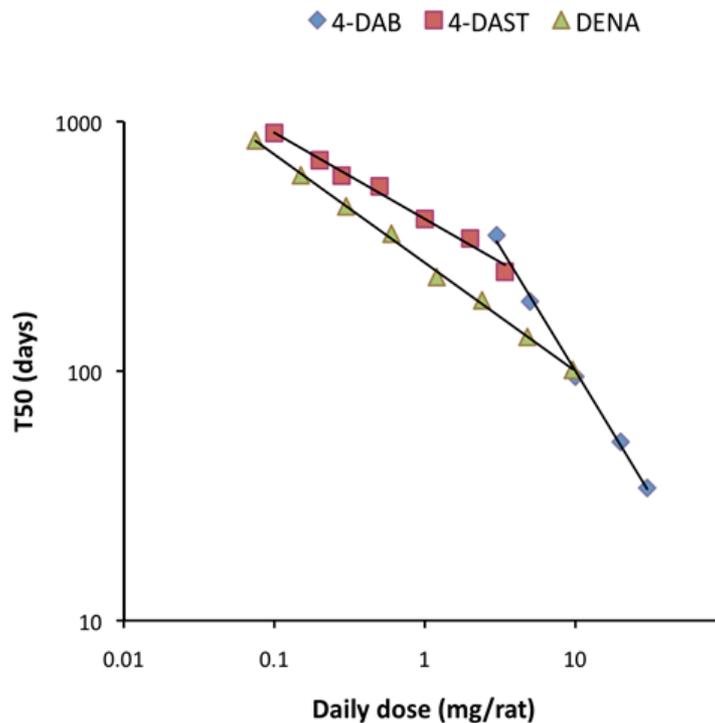
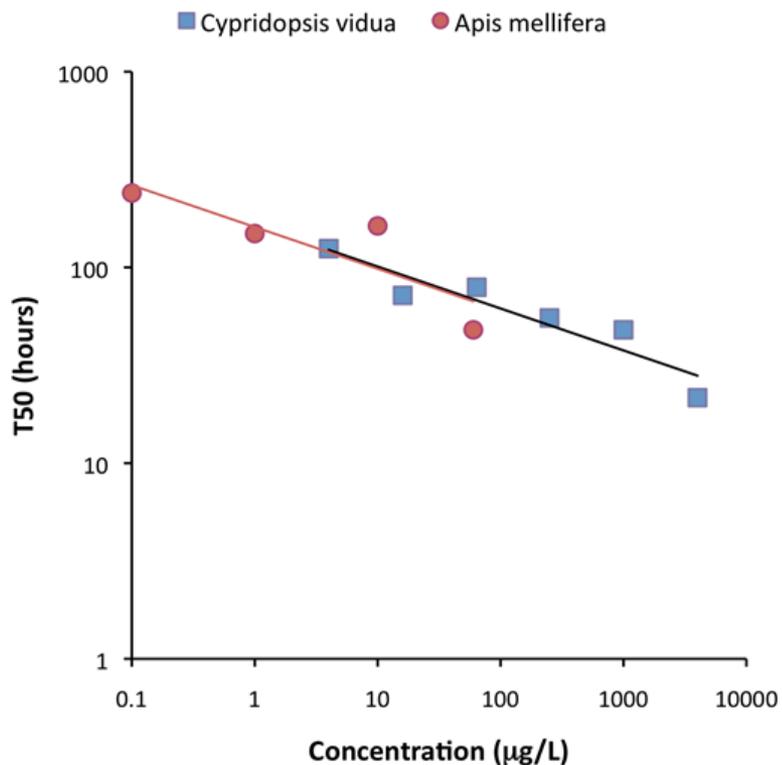
Daily Dose (mg/kg)	Latent Period (Days)	Carcinogenic Dose (mg/kg)
9,6	101	963
1,2	238	285
0,3	457	137
0,075	840	64



The Dose:Response Characteristics Of Genotoxic Carcinogens (Right) And Neonicotinoids (Left) Are Strikingly Similar

Druckrey-Küpfmüller Equations $C \times T50^n = \text{constant}$, with $n \geq 1$

Tennekes, H.A. (2010) Toxicology 276, 1–4.



Risk Assessment of Neonicotinoids

C. Maus & R. Nauen (2011) Toxicology 280: 176-177

H.A. Tennekes (2011) Toxicology 280: 173–175

- Drs Christian Maus and Ralf Nauen of Bayer CropScience asserted that *“there is no substantiation for concerns that effects like described by the Druckrey–Küpfmüller equation might entail a higher chronic toxicity than currently determined”*.
- They refer to numerous studies providing evidence that *“there is under realistic conditions no correlation between exposure of honey bees to imidacloprid-treated crops and increased colony mortality”*,

Neonicotinoids are lethal to honeybees at infinitesimal exposure concentrations:

$$\ln T50 \text{ (hrs)} = 5.11 - 0.22 \ln C \text{ (}\mu\text{g. L-1 or kg-1)}$$

or

$$C \times T50^{4.5} = \text{constant}$$

Food Source	Imidacloprid Content (ppb)	Expected Lethal Effect (days)
Nectar	1	6.9

Current Toxicological Risk Assessment Can Lead To Serious Underestimates Of Actual Risk

Neonicotinoids Are A Case In Point

Tennekes HA, Sánchez-Bayo F (2011) J Environment Analytic Toxicol S4:001. doi:10.4172/2161-0525.S4-001

- The traditional approach to toxicity testing is to consider dose (concentration)-effect relationships at arbitrarily fixed exposure durations which are supposed to reflect 'acute' or 'chronic' time scales.
- This approach measures the proportion of all exposed individuals responding by the end of different exposure times.
- Toxicological databases established in this way are collections of endpoint values obtained at fixed times of exposure. As such these values cannot be linked to make predictions for the wide range of exposures encountered by humans or in the environment.
- An increasing number of researchers are using a variant of the traditional toxicity testing protocol which includes time to event (TTE) methods.
- This TTE approach measures **the times to respond for all individuals**, and provides information on the acquired doses as well as the exposure times needed for a toxic compound to produce any level of effect on the organisms tested.
- Consequently, extrapolations and predictions of toxic effects for any combination of concentration and time are now made possible.



The Risk Of Imidacloprid For Honey Bees Is Underestimated

Suchail S, Guez D, Belzunces LP, 2001. Environ. Toxicol. Chem. 20: 2482-2486

Bonmatin JM et al., 2007. Environmental fate and ecological effects of pesticides. Pp. 827-834

Mullin CA et al, 2010. PloS One 5, e9754



- Druckrey-Küpfmüller equation

$$\ln T50 \text{ (hrs)} = 5.11 - 0.22 \ln C \text{ (}\mu\text{g. L}^{-1} \text{ or kg}^{-1}\text{)}$$

or

$$C \times T50^{4.5} = \text{constant}$$

- *The concentrations of imidacloprid detected in nectar or pollen cause lethal effects in honey bees within a week*

Food Source	Imidacloprid Content C ($\mu\text{g/kg}$ or ppb)	Expected Latent Period (T50) (Days)
Nectar	1	6,9
	3	5,4
Pollen	0,7	7,5
	10	4,2

Nicotine Is A Neuroteratogen

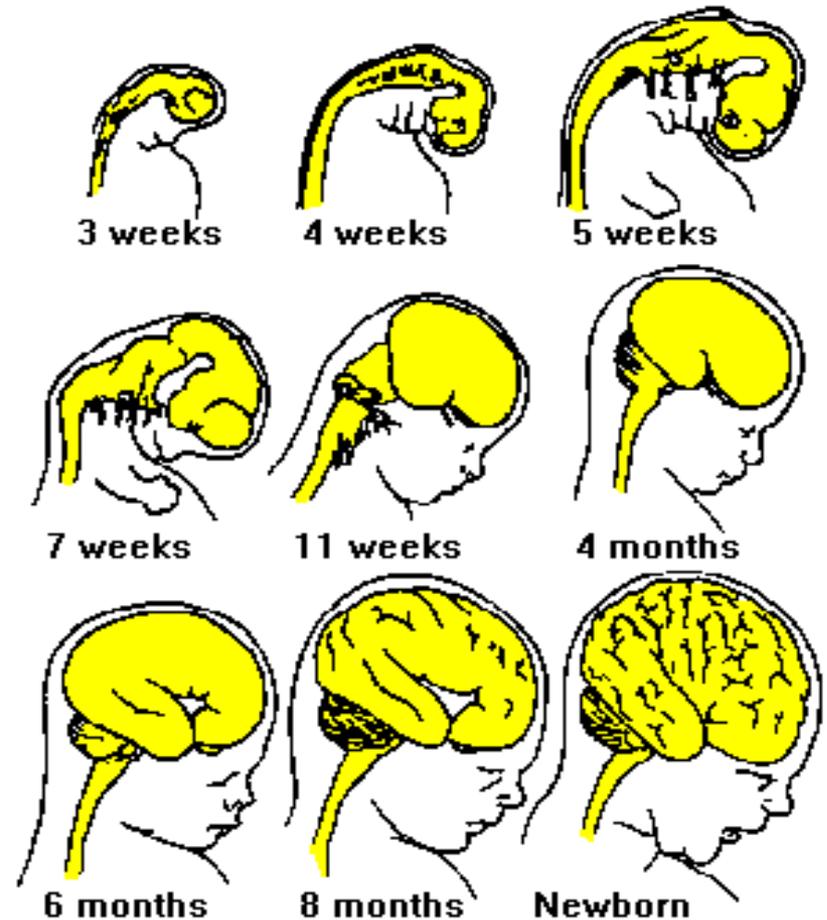
Nicotine Alters The Developmental Trajectory Of The Brain

Eppolito AK et al. (2010) Neurotoxicology and Teratology 32 : 336–345

Dwyer JB et al. (2009) Pharmacol Ther. 122 : 125–139

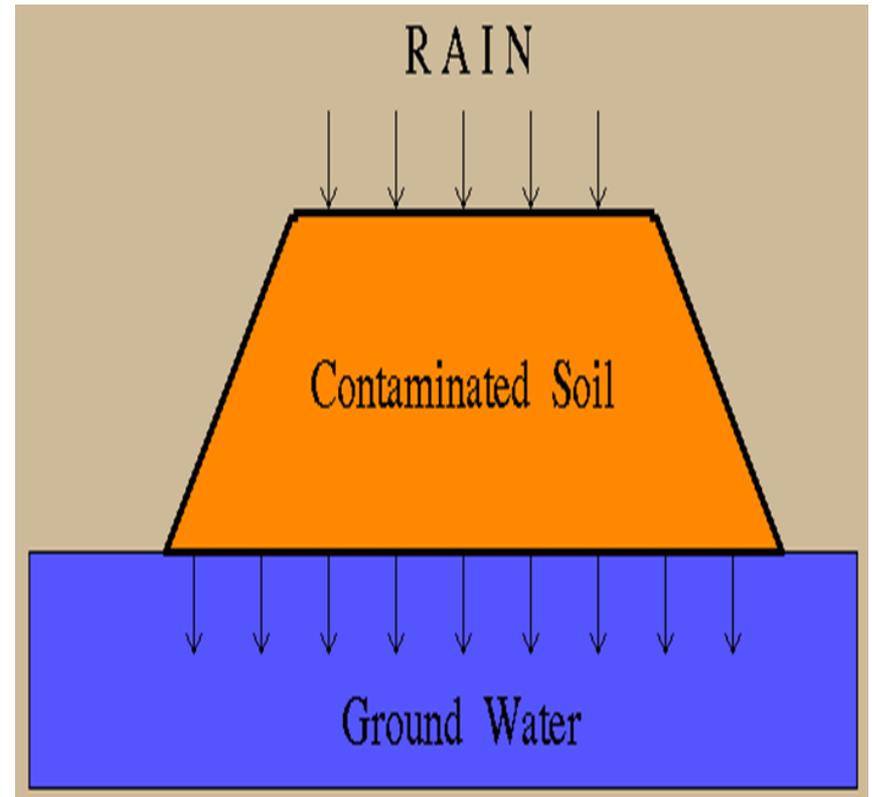
Kimura-Kuroda J et al. (2012) PLoS ONE 7(2): e32432. doi:10.1371/journal.pone.0032432

- Nicotinic acetylcholine receptors (nAChRs) regulate critical aspects of brain maturation during the prenatal, early postnatal, and adolescent periods
- Nicotine disrupts the normal developmental influences of acetylcholine
- Neonicotinoids as well as nicotine directly act on mammalian nAChRs and, therefore, may have various adverse effects on the human health, especially on the developing brain.



Neonicotinoids May Be Washed Out Of The Soil Into Waterways and Groundwater

- Not only are neonicotinoids water soluble and mobile in soil, they are also quite persistent in soil and water.



Neonicotinoids Are Diffusing Through The Environment Breaking The Food Chain

- Imidacloprid is diffusing through the environment, killing or debilitating non-target insects and possibly other arthropods, and by doing so progressively reducing invertebrate prey for higher organisms



Immune Suppression by Neonicotinoid Insecticides At The Root Of Global Wildlife Declines

R Mason, H Tennekes, F Sánchez-Bayo, P Uhd Jepsen. *Journal of Environmental Immunology and Toxicology* 2012; X:XX-XX (in press)

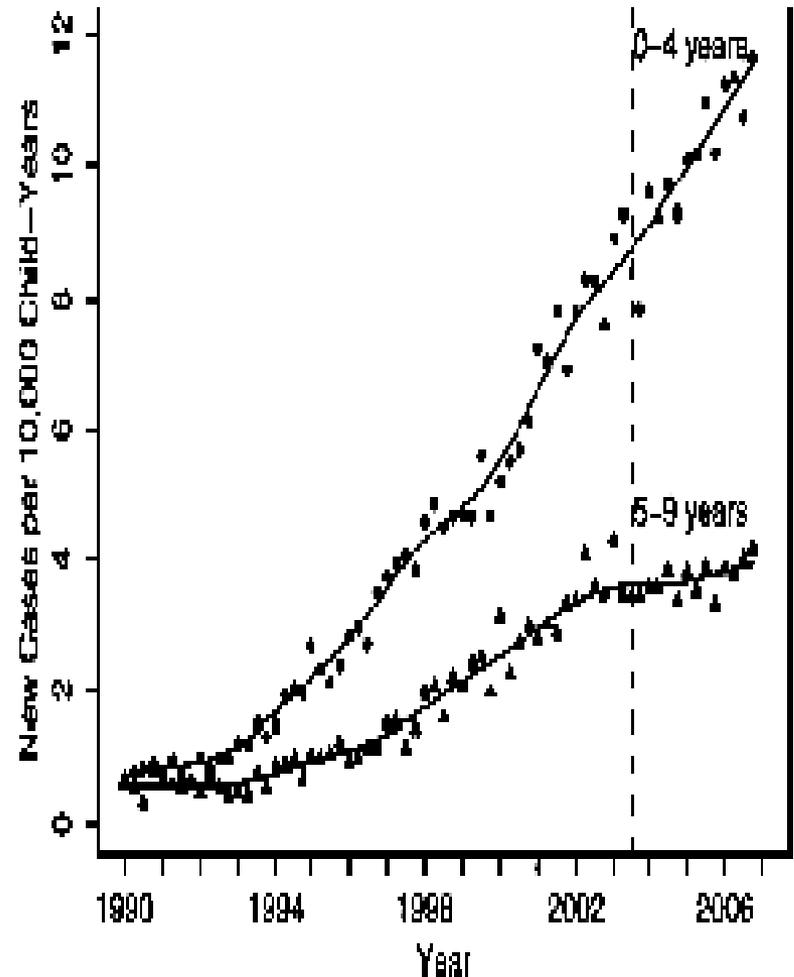
- There is experimental evidence of immune suppression in bees and fish by neonicotinoids
- There have been outbreaks of infectious diseases in honey bees, bumble bees, fish, amphibians, bats and birds in the past two decades
- The disease outbreaks started in countries and regions where neonicotinoid insecticides were used for the first time, and later they spread to other countries



Nicotine Causes Many Adverse Effects On The Normal Development Of A Child

Kimura-Kuroda J et al. (2012) PLoS ONE 7(2): e32432. doi:10.1371/journal.pone.0032432

- Perinatal exposure to nicotine is a known risk factor for sudden infant death syndrome, low-birth-weight infants, attention deficit/hyperactivity disorder (ADHD), autism
- The Graph on the Right →:
The rise of autism in California since the introduction of the neonicotinoid insecticides in the early 1990s



A Generation in Jeopardy

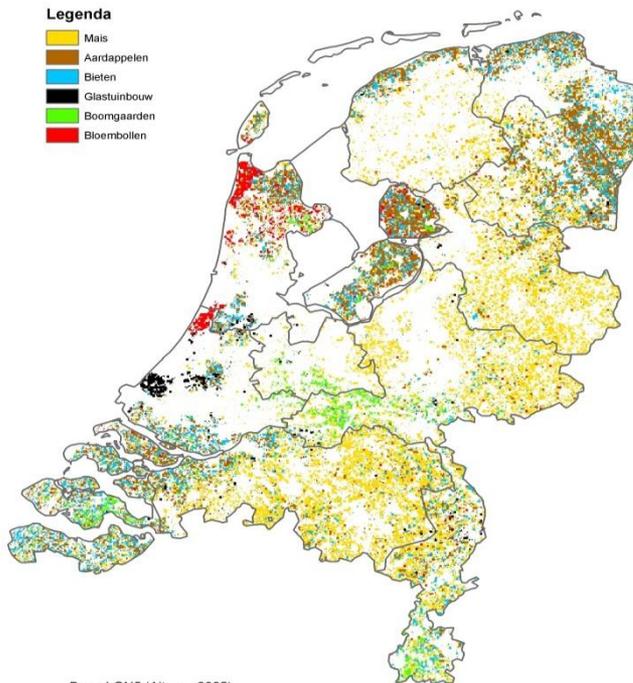
How pesticides are undermining our children's health & intelligence

PESTICIDE ACTION NETWORK NORTH AMERICA , OCTOBER 2012

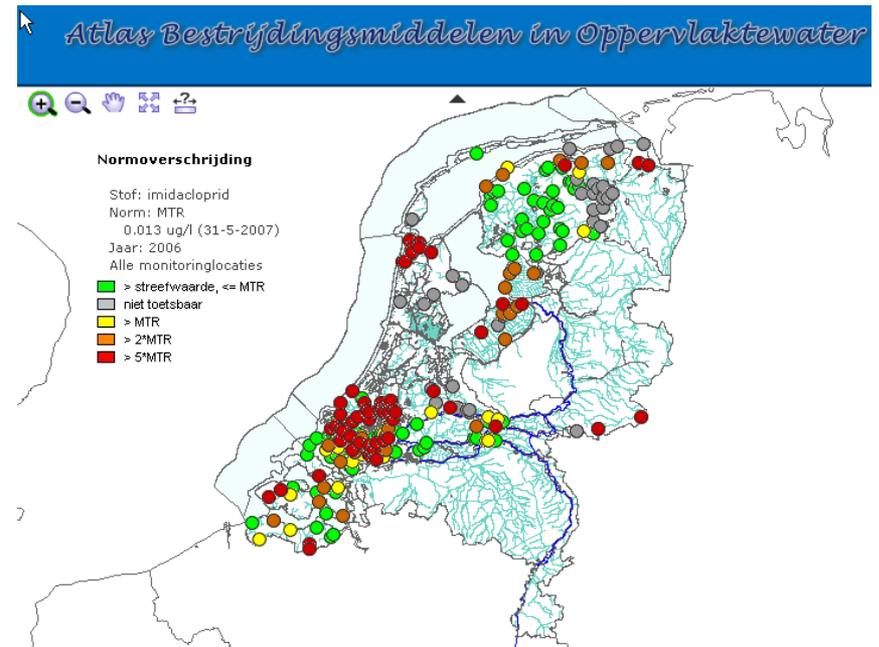


The Widely Used Neonicotinoid Insecticide Imidacloprid Has Caused Major Contamination Of Dutch Surface Water Since 2004

Red dots (right hand side) : Maximal Permissible Risk Level (MRL) Exceeded At Least Five Times
In 2005, MRL Exceeded 25,000 Times at Noordwijkerhout (Flower Bulb Cultivation)



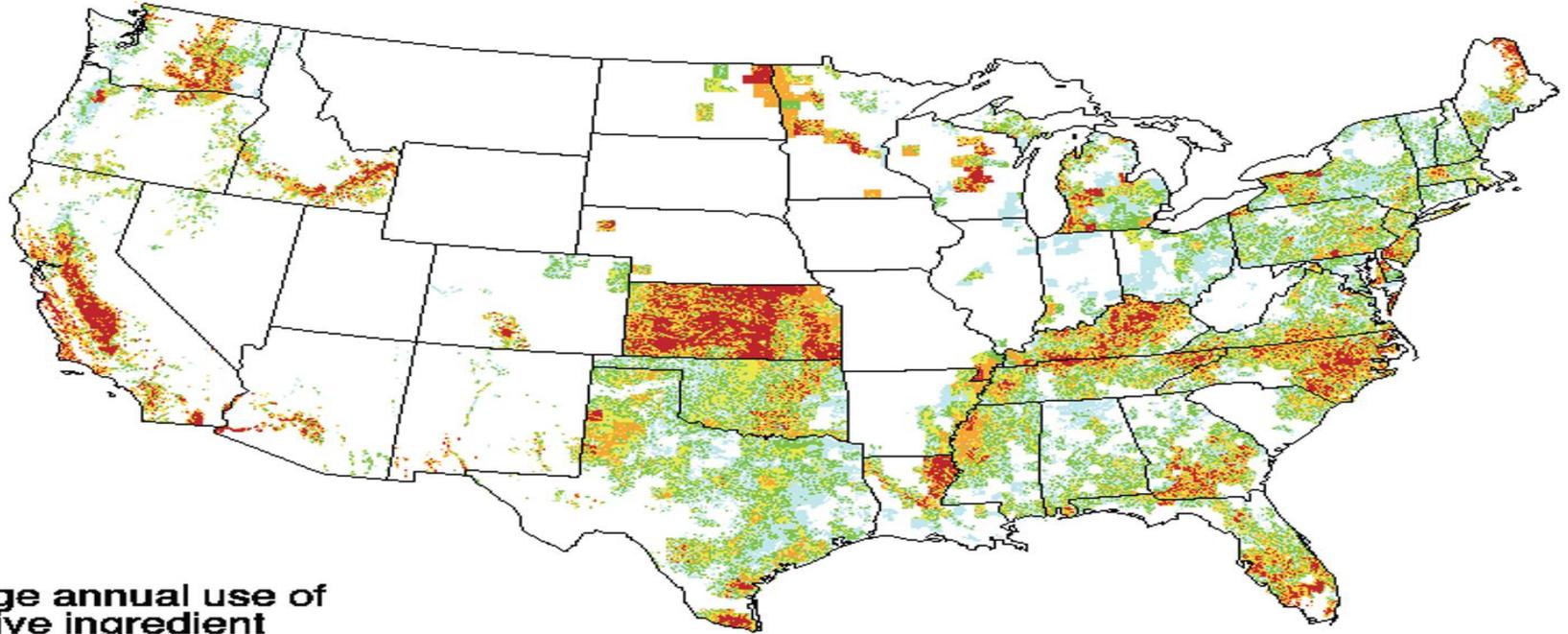
Bron: LGN5 (Alterra, 2005)



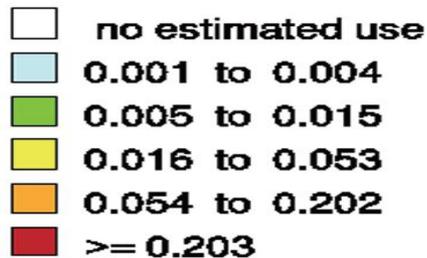
Imidacloprid

Estimated Annual Agricultural Use In The US In 2002

US Geological Survey National Water-Quality (NAWQA) Program



average annual use of active ingredient per square mile of agricultural land in county)



Crops	Total pounds applied	Percent national us
sorghum	95355	26.36
potatoes	59336	16.40
tobacco	43392	11.99
lettuce	35573	9.83
cotton	18147	5.02
grapes	17093	4.72
tomatoes	15211	4.20
citrus fruit	13295	3.68
apples	11268	3.11
pecans	10001	2.76

One Of The Most Obvious Services Insects Render, Albeit Unknowingly, Is Pollination

May Berenbaum (Entomologist, University of Illinois) NZZ Folio 07/01 - Theme: Käfer und Co

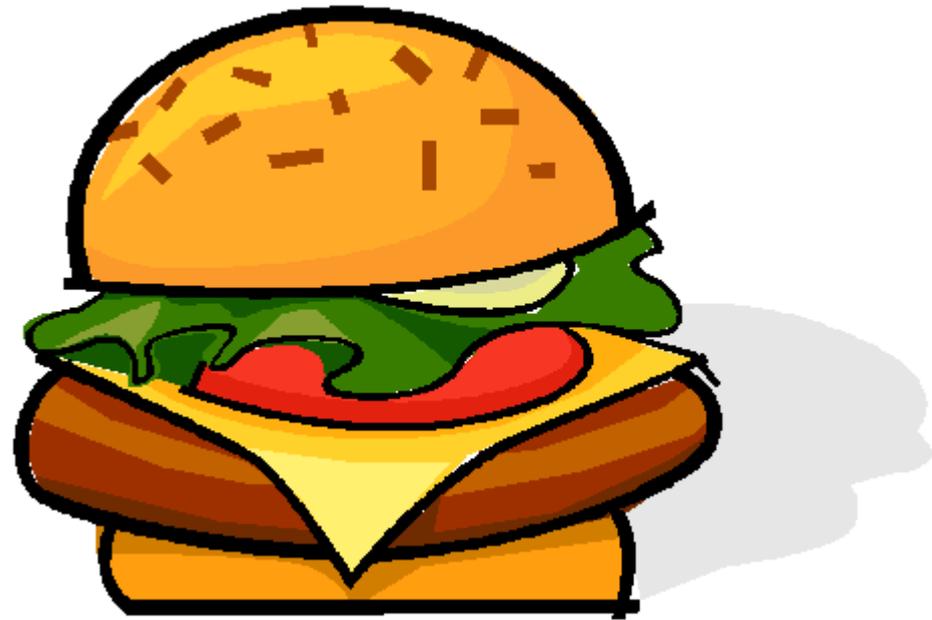
- Because plants for the most part can't move around, most rely on animal partners to bring males and females together for mating
- Insects provide that service (in the form of pollen transport) for a remarkable number of plants, particularly species that have become important to human economies and lifestyles.
- **About one-third of the Western diet results directly from the pollination activities of insects.**



From Big Mac to McBun

May Berenbaum (Entomologist, University of Illinois) NZZ Folio 07/01 - Theme: Käfer und Co

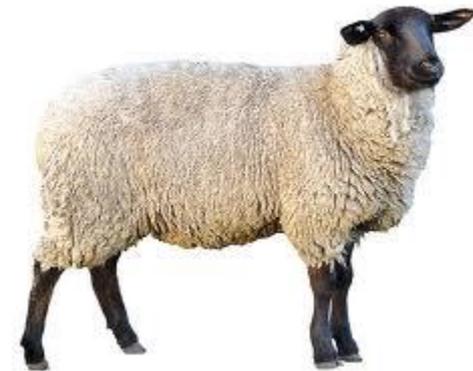
- A McDonald's Big Mac burger in an insect-free world would have no meat, no lettuce, no cheese, no pickle, no onion, and no ketchup; basically, it would be a McBun.



Our Fiber Needs Are Met In Large Part As A Result Of Insect Activity

May Berenbaum (Entomologist, University of Illinois) NZZ Folio 07/01 - Theme: Käfer und Co

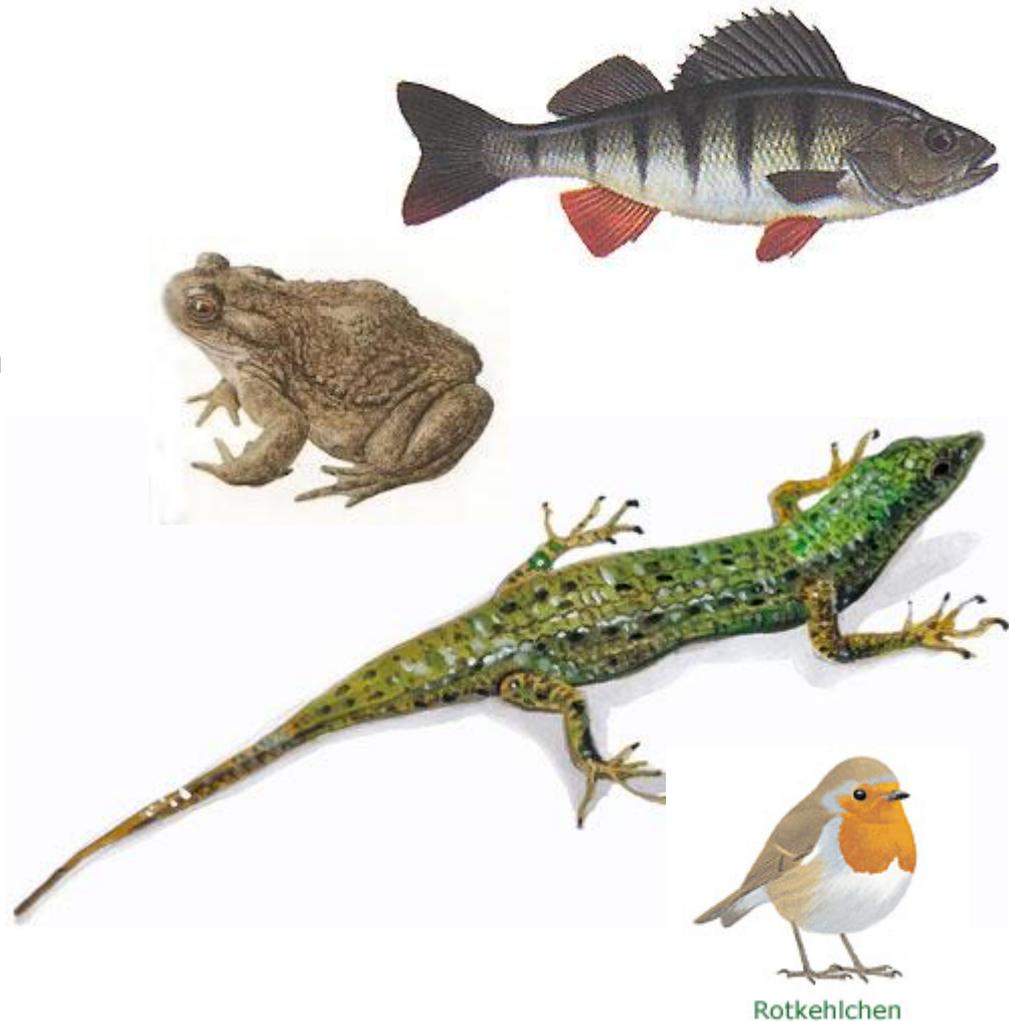
- The cotton plant is insect – pollinated
- Wool and leather come for the most part from sheep and cattle that have eaten insect-pollinated legumes in their diet.
- Silk, of course, is a natural fiber produced directly by an *insect*— *Bombyx mori*, the Japanese silkworm



Most Vertebrates Rely Heavily On Insects In Their Diet

May Berenbaum (Entomologist, University of Illinois) NZZ Folio 07/01 - Theme: Käfer und Co

- Approximately 40 to 90% of the diet of **freshwater fish** consists of insects
- Among the **amphibians**, frogs, toads, and salamanders depend on insects; about 75% of the diet of the common toad is made up of insects
- Among the **reptiles**, insects are the food of choice for lizards, chameleons, green glass snakes, and horned toads.
- About one-third of the diet of **game birds and songbirds** are insects and their relatives



Rotkehlchen

Most Orders Of Mammals Contain Insect-Eating Species

May Berenbaum (Entomologist, University of Illinois) NZZ Folio 07/01 - Theme: Käfer und Co

- spiny anteaters, duck-billed platypuses, opossums, cuscuses, caenolestid rat opossums, bandicoots, marsupial moles, hedgehogs, moles, tenrecs, solenodons, shrews, most bats, anteaters, armadillos, pangolins, some mice, and raccoons all consume insects on a regular basis.
- Even among the primates, our closest relatives, insect-eating is the norm; lemurs, aye-eyes, lorises, tarsiers, marmosets, and several of the great apes are to various degrees entomophagous.
- Both gorillas and chimpanzees fashion sticks into tools to help them extract termites and ants from their nests.

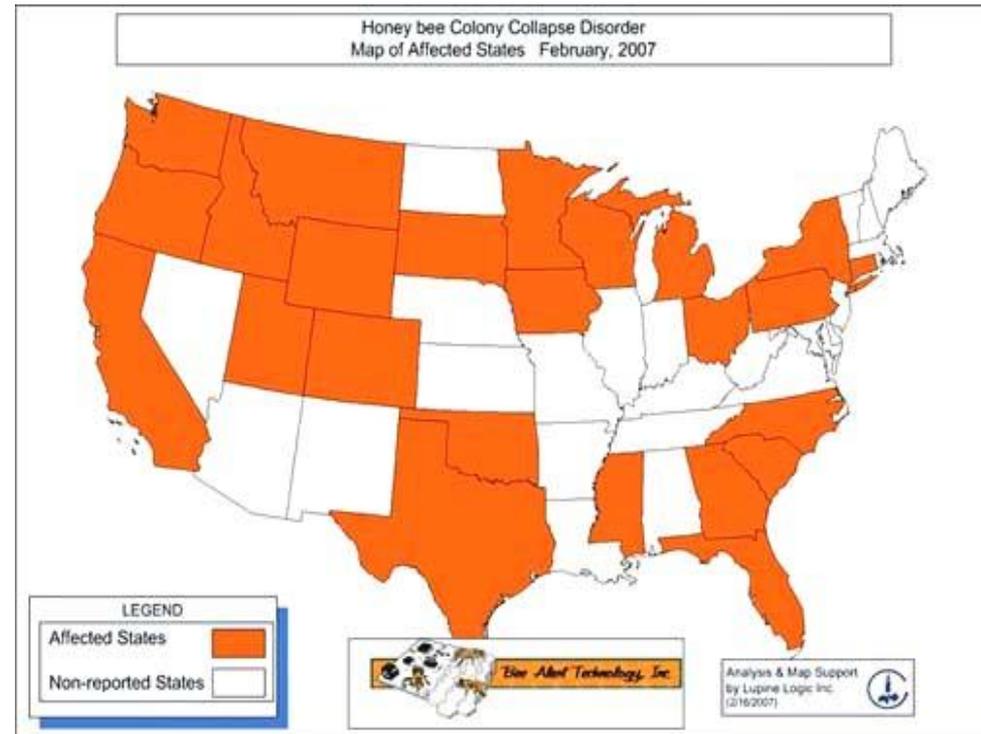


Honey Bee Declines in the US and Europe Are Linked To Infections

Cédric Alaux et al. Environ Microbiol. (2010) 12(3): 774–782

Pettis, JS et al. (2012) Naturwissenschaften DOI 10.1007/s00114-011-0881-1

- Neonicotinoids are weakening the insects' immune systems, and thus allowing infections to spread through a hive
- One thing common to bee colonies that go on to collapse is a greater variety and higher load of parasites and pathogens than other colonies



Imidacloprid Is Weakening The Immune Systems of Freshwater Fish

Sánchez-Bayo F, Goka K. *Aquat Toxicol* 2005; 74(4):285-93

- While studying Japanese medaka fish in experimental paddy fields, Sánchez-Bayo and Goka observed physiological stress in juvenile medaka and massive infections of the weaker fish by a *Trichodina* ectoparasite where rice was treated with imidacloprid, compared with medaka in control rice fields



The Collapse of Wild Salmon Populations in the Proximity of Salmon Farms is Linked to Infections

Sánchez-Bayo F, Goka K. *Aquat Toxicol* 2005; 74(4):285-93

- In 1994 there was an epidemic of parasitic salmon lice *Lepeophtheirus salmonis* in salmon farms sited on the Atlantic coast of Canada
- The first epidemic of *L. salmonis* involving the wild pink salmon populations on the Pacific coast of British Columbia occurred suddenly in spring 2001.
- It became apparent that in areas without salmon farms, the prevalence of infestation was low whereas there was collapse in the wild salmon populations in the proximity of farms



The Massive Bumble Bee Declines in the US and Europe Are Linked To Infections

Cameron, S.A. et al. (2011) Proc. Natl Acad. Sci. USA 108, 662-667

- Comparing results with museum records of bumble bees showed that the relative abundances of four species had declined historically by up to 96%. Geographical ranges had contracted by 23-87%, some within the past two decades.
- Those species that had declined had significantly higher infection levels of the pathogen *Nosema bombi*
- Exposure to neonicotinoid insecticides is likely to have occurred and may have weakened immune systems, such that they became more susceptible to pathogens

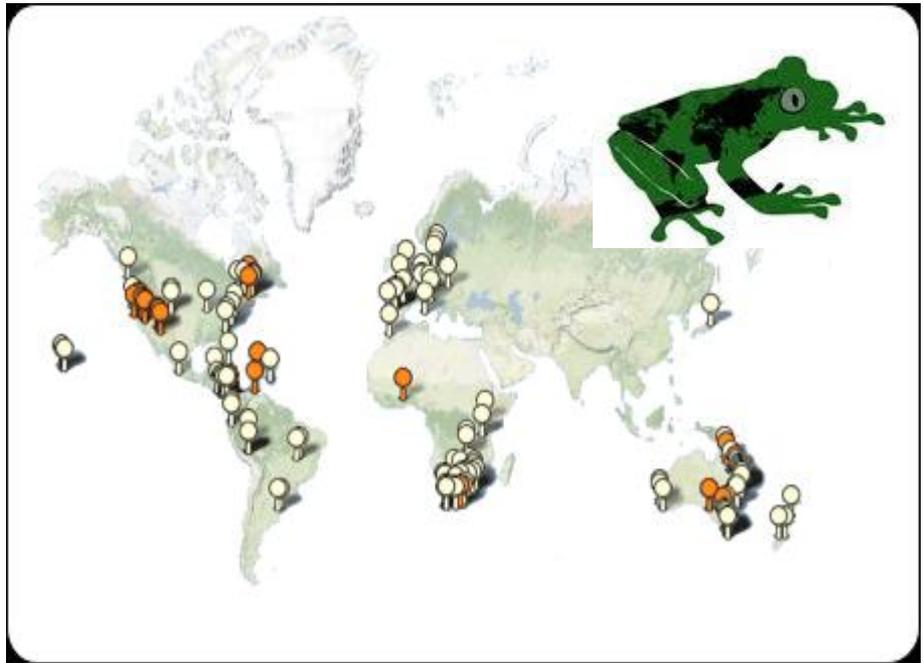


The Massive Declines in Amphibian Populations Are Linked To Infections

The Chytrid Fungus Is Devastating Frog Populations

Symposium held at the Zoological Society of London: 20/21 November 2008. Halting the global declines in amphibians.
Research & Practice

- Two species of once common frogs that had inhabited the thousands of lakes and ponds in California's Sierra Nevada are being wiped out by *chytridiomycosis*
- Exposure to small doses of neonicotinoid insecticides is likely to have occurred and may have weakened the amphibian immune systems, such that they became more susceptible to pathogens

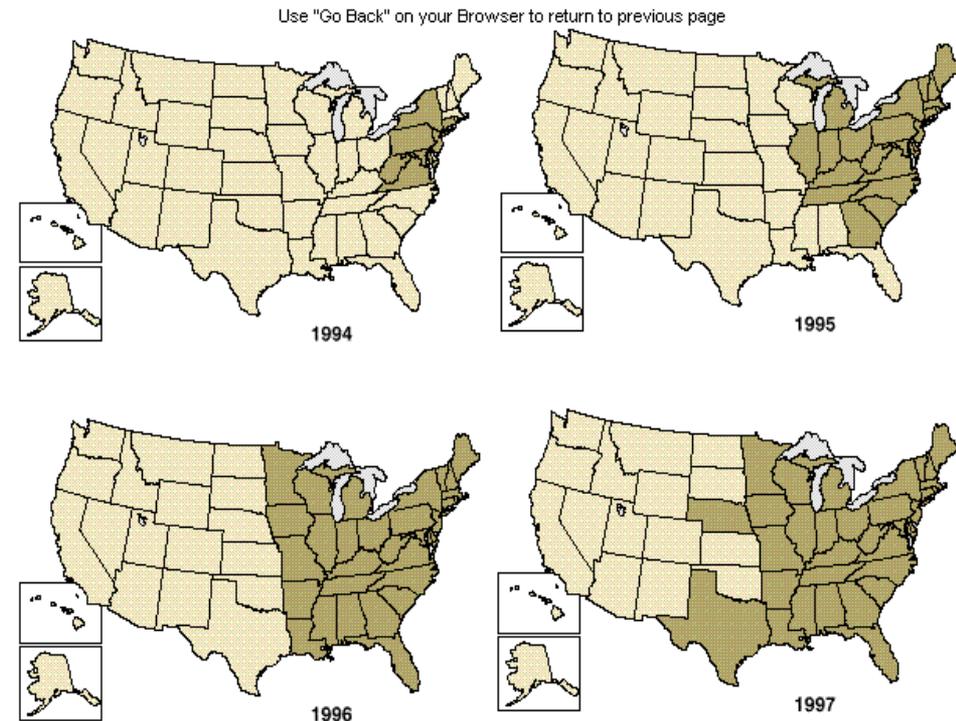


Declines Due To Pathogens In Birds In the US

Fischer JR, Stallknecht DE, Luttrell P, et al. Emerg Infect Dis 1997; 3(1):69-72.



- A mycoplasmal conjunctivitis was first reported in wild house finches (*Carpodacus mexicanus*) in February 1994 in suburban Washington, DC.
- It was identified as *Mycoplasma gallisepticum*, a pathogen of poultry that had not previously been associated with wild songbirds.
- In the first three years it killed an estimated 225 million finches. There was a dramatic spread of disease to house finches in the mid-West and South East



EXPLANATION
Spread of house finch conjunctivitis
■ States where disease has been detected

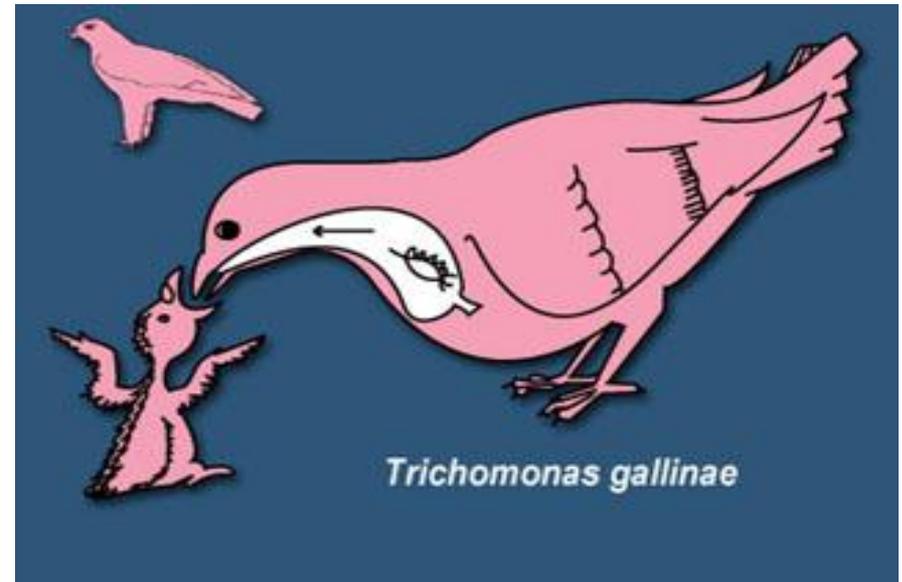
Reported geographic spread of house finch inner eyelid inflammation (conjunctivitis) since the initial 1994 observation. (Data adapted from reports in the scientific literature and personal communications between the National Wildlife Health Center and other scientists.)

Declines Due To Pathogens In Birds In Europe

Robinson RA, Lawson B, Toms MP, et al. PLoS One 2010; 5(8):e12215.

Lawson B, Malnick H, Pennycott TW, et al. Vet J 2011; 188(1):96-100

- In Europe epidemics caused by a variety of novel pathogens in wild birds began in early 2000
- Greenfinch (*Carduelis chloris*) numbers in Europe have been devastated by infections with *Trichomonas gallinae*, a protozoal organism which invades the bird's crop and mucosal lining of the beak. Deaths started in the UK around 2005
- At the same time, chaffinches (*Fringilla coelebs*) appeared in gardens with white, crusty growths on their legs and feet caused by a *papilloma virus*. The mortality is said to be about 20%, so the disease kills more slowly than with the Greenfinch *Trichomonas* infections



Declines Due To Pathogens In Birds In Europe

Friedrich-Loeffler-Institute. Federal Research Institute for Animal Health. News 16/09/2011

- In September 2011, mass deaths of Blackbirds (*Turdus merula*) were reported in the Rhine-Neckar area of Germany
- The Bernhard-Noct Institute for Tropical Diseases and the Friedrich-Loeffler Institute examined four birds and confirmed that it was the tropical **Usutu Virus** from Africa
- It was first seen in Austria in 2001, followed by reports from Italy, Hungary and Switzerland. In birds it first causes apathy, then signs of a central nervous system disorder, with unnatural movements of the head
- **An estimated 300,000 blackbirds were killed by the disease**



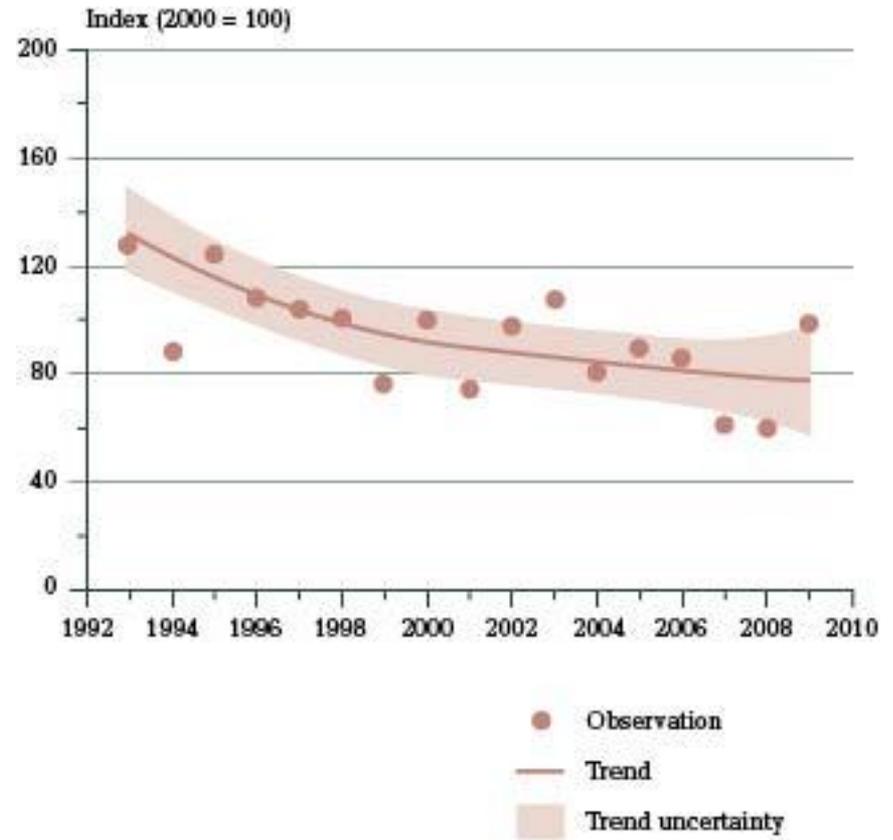


The Systemic Insecticides: A Disaster in the Making

Tennekes, H.A. (2010) ETS Nederland BV, Zutphen, The Netherlands.
Available from: <http://www.disasterinthemaking.com/>.

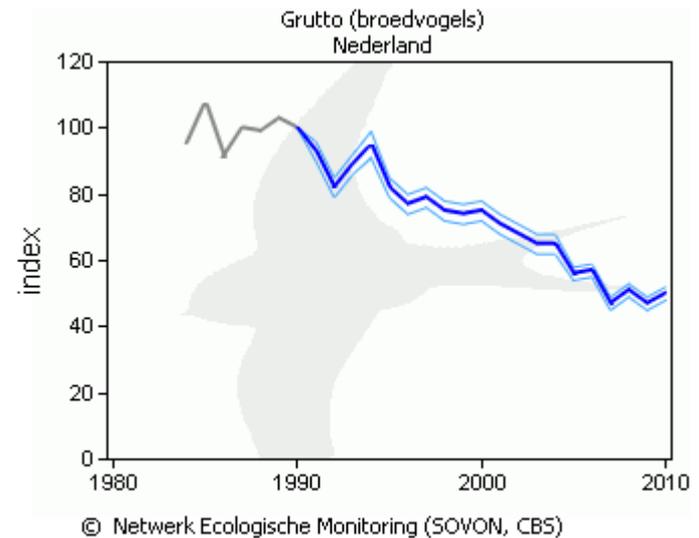
- Dr Henk Tennekes, an independent Dutch toxicologist, first warned of the dangers of the systemic neonicotinoids in his book: ***The Systemic Insecticides: A Disaster in the Making***
- Dr Tennekes says that his book: ***“catalogues a tragedy of monumental proportions regarding the loss of invertebrates and subsequent losses of the insect-feeding (invertebrate-dependent) bird populations in all environments in the Netherlands.***
- *The disappearance can be related to agriculture in general, and to the neonicotinoid insecticide imidacloprid in particular, which is a major contaminant of Dutch surface water since 2004.”*
- The relationship exists because of crucial (and catastrophic) disadvantages of the neonicotinoid insecticides: the damage to the central nervous system of insects is virtually irreversible and cumulative.
- Tennekes showed that even minute quantities can have devastating effects in the long term.
- They leach into groundwater and contaminate surface water and persist in soil and water, chronically exposing aquatic and terrestrial organisms to these insecticides.
- ***“So, what, in effect, is happening is that these insecticides are creating a toxic landscape, in which many beneficial organisms are killed off.”***

The Number Of **Butterflies** In The Netherlands Is Presently At The Lowest Point Ever Recorded



The Decline of Grassland Birds In The Netherlands

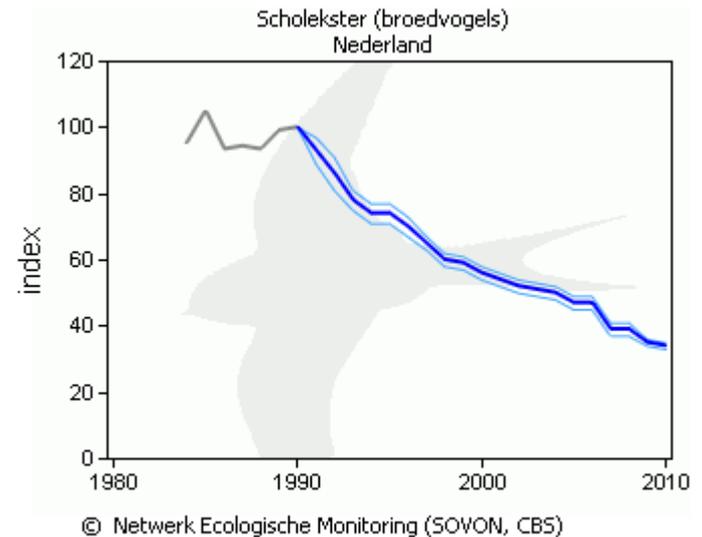
Black-tailed Godwit



- The breeding population in Germany was halved over the last 15 years

The Decline of Grassland Birds In The Netherlands

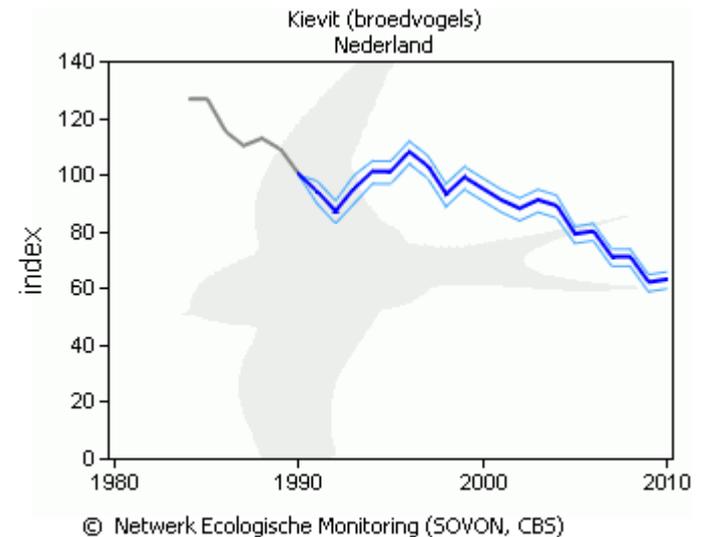
Oystercatcher



- Sharp decline observed in Germany as well

The Decline of Grassland Birds In The Netherlands

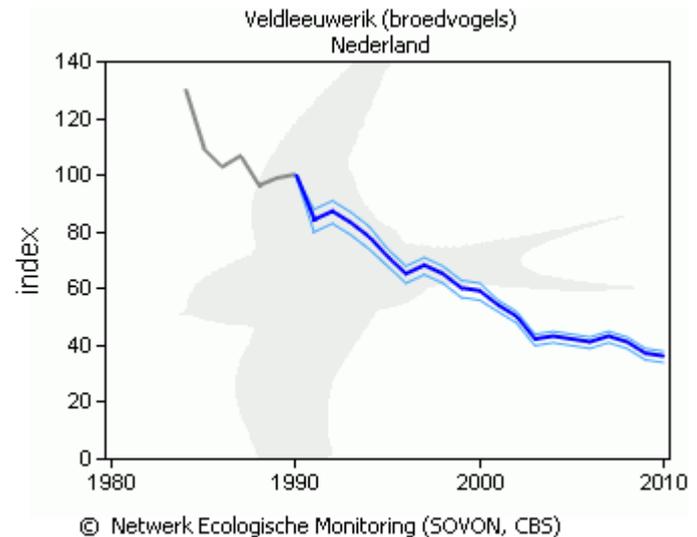
Northern Lapwing



- Dramatic decline of breeding population in Germany since the 1970s

The Decline of Grassland Birds In The Netherlands

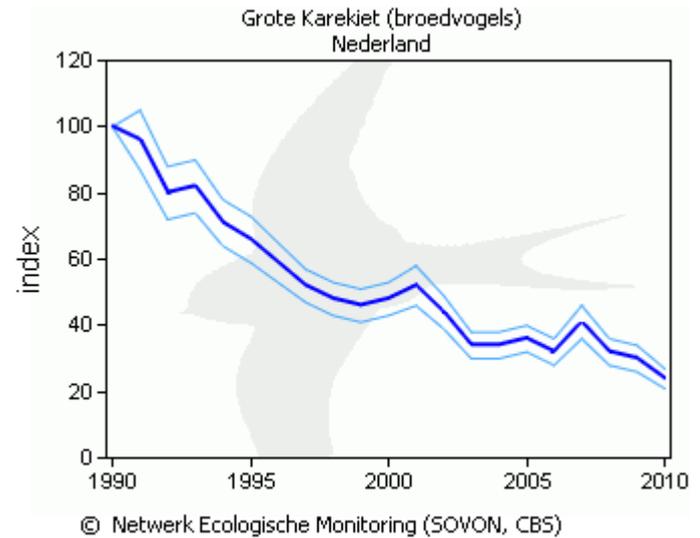
Skylark



- Substantial decline of breeding population of once common Skylarks in Germany since the 1960s

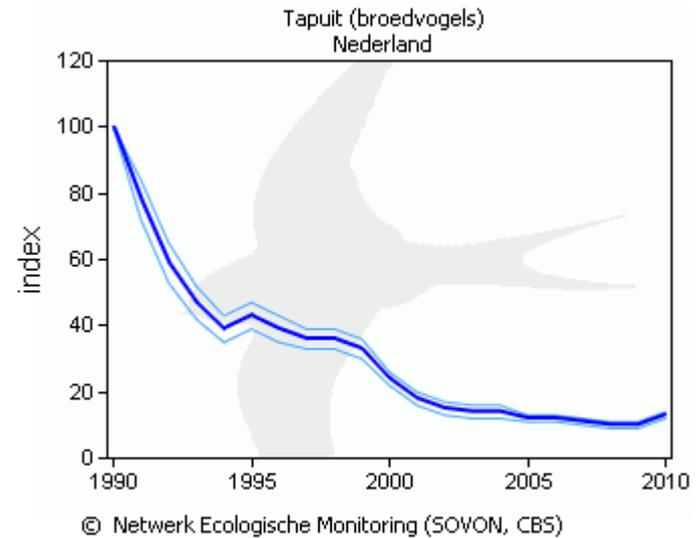
The Decline of Marsh Birds In The Netherlands

Great Reed Warbler



The Decline of Heath Land Birds In The Netherlands

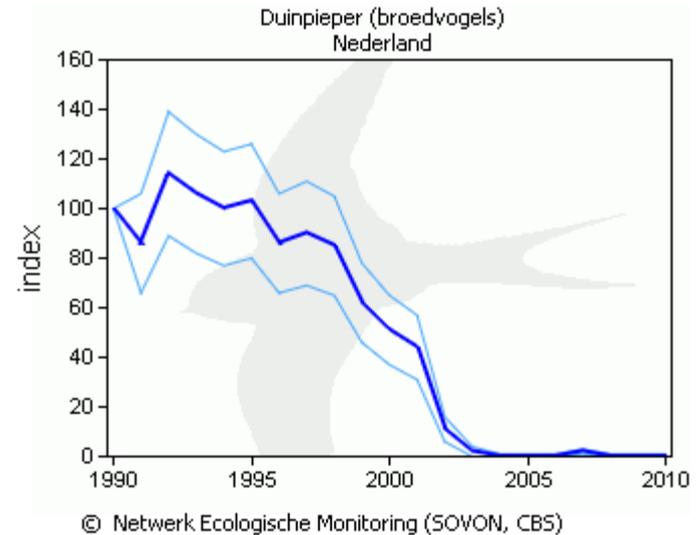
Northern Wheatear



- On the brink of extinction in Germany

The Decline of Heath Land Birds In The Netherlands

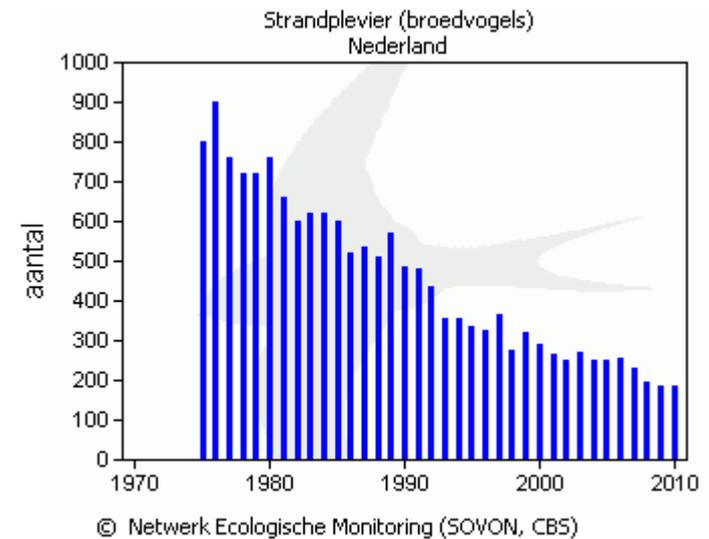
Tawny Pipit



- On the brink of extinction in Germany

The Decline of Coast Birds In The Netherlands

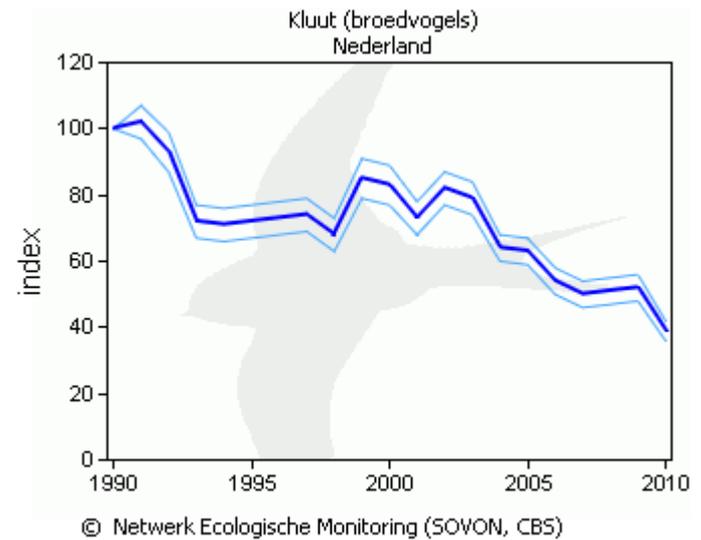
Kentish Plover



- On the brink of extinction in Germany

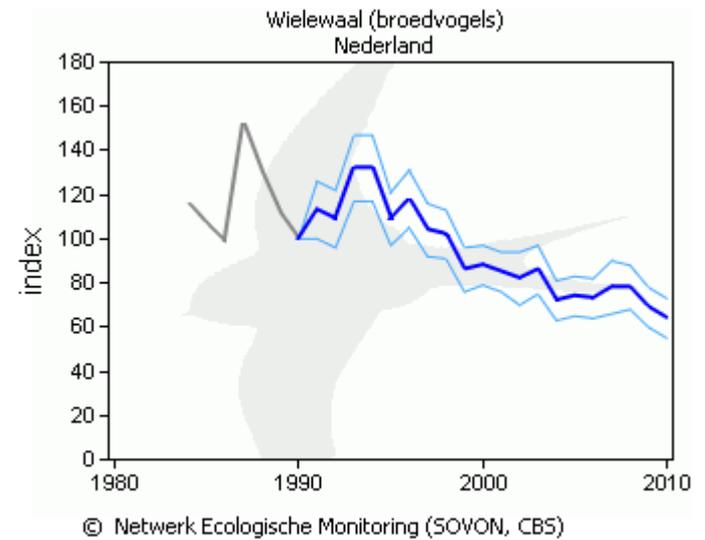
The Decline of Coast Birds In The Netherlands

Pied Avocet



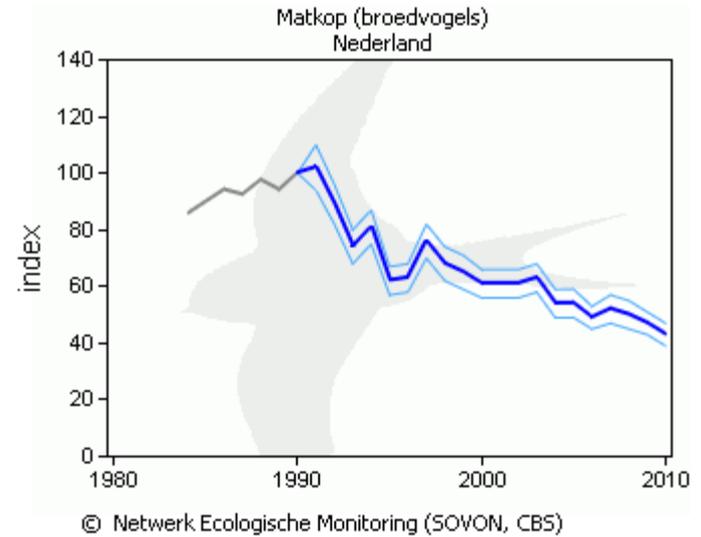
The Decline of Woodland Birds In The Netherlands

Golden-Oriole



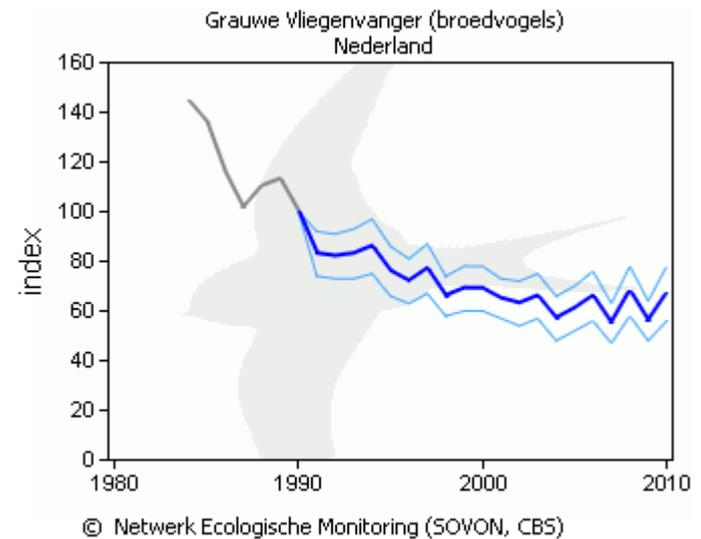
The Decline of Woodland Birds In The Netherlands

Willow Tit



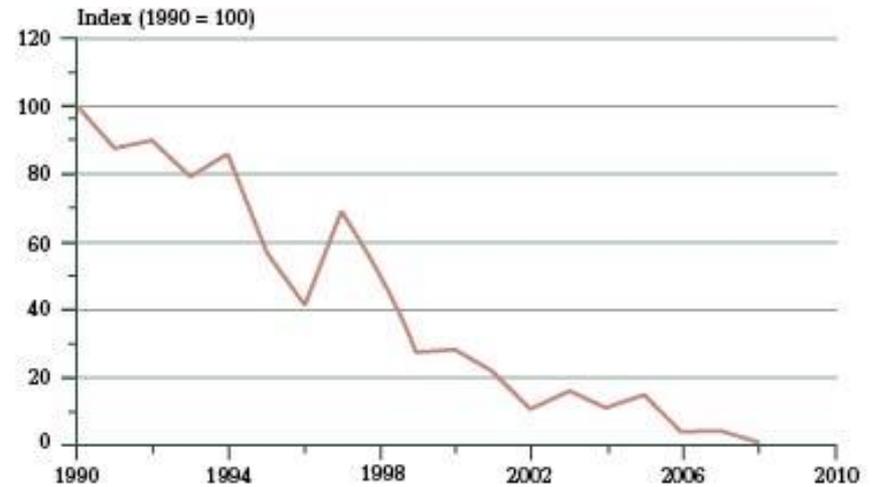
The Decline of Woodland Birds In The Netherlands

Spotted Flycatcher



The Decline of Farmland Birds In The Netherlands

Corn Bunting

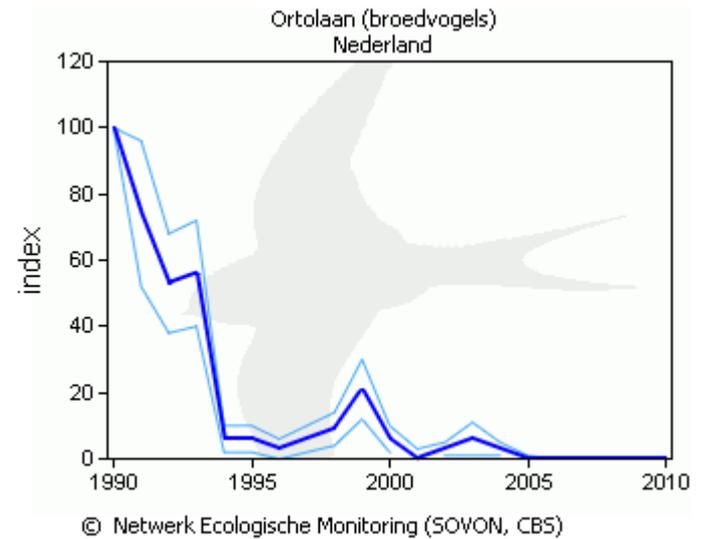


Source: NEM (SOVON, CBS)
CBS/nov09/1389
www.compendiumvoordelastomgeving.nl

- Threatened in Germany

The Decline of Farmland Birds In The Netherlands

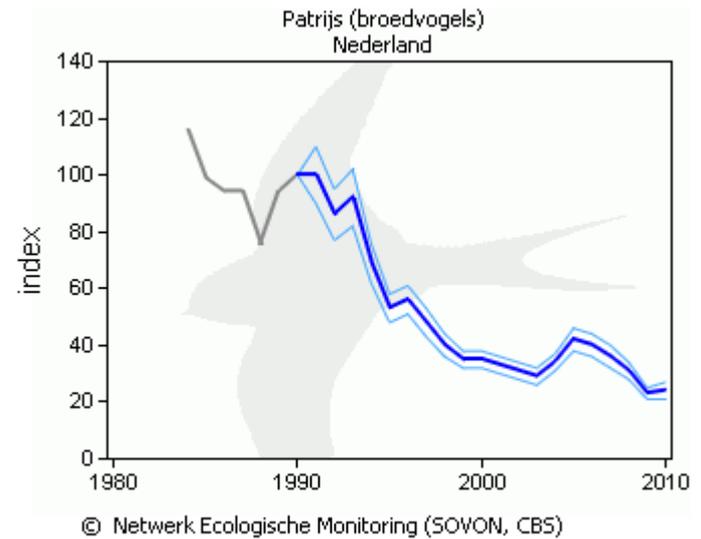
Ortolan Bunting



- Threatened In Germany

The Decline of Farmland Birds In The Netherlands

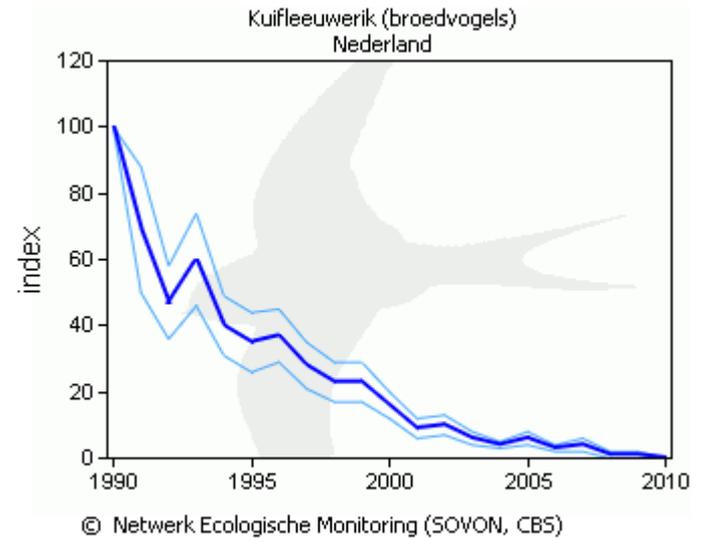
Grey Partridge



- Threatened in Germany

The Decline of Farmland Birds In The Netherlands

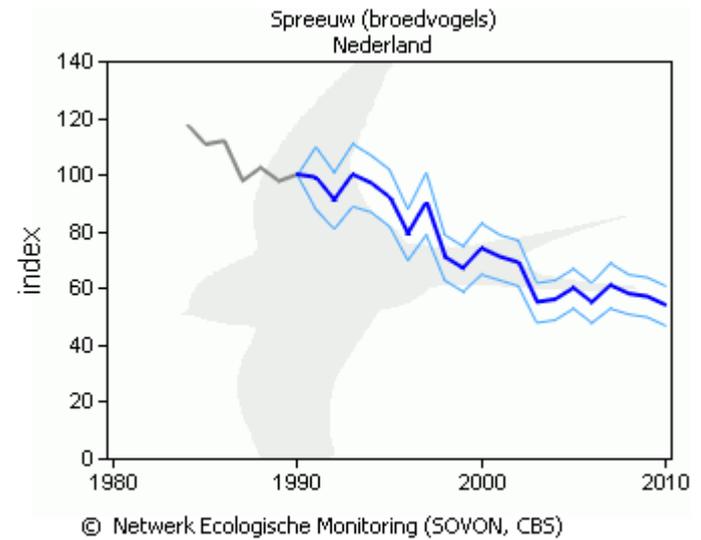
Crested Lark



- On the brink of extinction in Germany

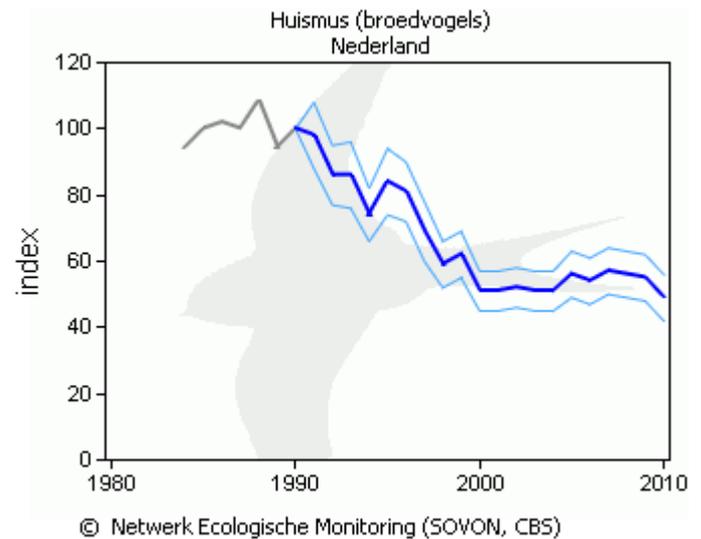
The Decline of Settlement Birds In The Netherlands

Starling



The Decline of Settlement Birds In The Netherlands

House Sparrow





Summary

- Neonicotinoid insecticides act by causing **virtually irreversible blockage of postsynaptic nicotinic acetylcholine receptors (nAChRs)** in the central nervous system of insects.
- The damage is cumulative, and with every exposure more receptors are blocked. In fact, **there may not be a safe level of exposure.**
- The nAChRs play roles in many cognitive processes and neonicotinoids account for worker bees neglecting to provide food for eggs and larvae, and for a breakdown of the bees' navigational abilities. **Very small quantities of neonicotinoid insecticides are sufficient to cause collapse of bee colonies**
- Food residues of neonicotinoids may **adversely affect human health, especially the developing brain**
- **Neonicotinoid insecticides** are persistent and mobile in soil, soluble in water and stable to breakdown by water at neutral pH, and - as a result of these properties - the compounds **may leach from soils.**
- Since 2004 **major contamination of Dutch surface water with imidacloprid** has been detected by the Water Boards, particularly in the western part of the country. Surface water contamination with imidacloprid has also been recorded in agricultural regions of California
- Consequently, **high concentrations of imidacloprid are diffusing through the environment**, killing or debilitating non-target insects and other arthropods, **decimating invertebrate prey for higher organisms.**

A Disaster In The Making

Neonicotinoids Break Food Chains

- **Invertebrate-dependent bird species in the Netherlands have been declining on a massive scale in recent times, in all kinds of habitats** (grasslands, marshes, heathlands, at the coast, woodlands, settlements, farmlands):
- Skylark, Yellow Wagtail, Oystercatcher, Black-tailed Godwit, Northern Lapwing, Common Redshank, Meadow Pipit, Willow Tit, Spotted Flycatcher, Wood Warbler, Pied Flycatcher, Wood Nuthatch, Willow Warbler, Marsh Tit, Grey-faced Woodpecker, Wryneck, Common Crossbill, Golden-Oriole, Northern House Martin, Barn Swallow, Common Swift, Starling, House Sparrow, Common Redstart, Great Reed Warbler, Bearded Tit and Spotted Crake
- Ground and surface water contamination with persistent insecticides that cause irreversible and cumulative damage to aquatic and terrestrial (non-target) insects must lead to an environmental catastrophe.
- The data presented here show that **an environmental catastrophe is actually taking place before our eyes**, and that

IT MUST BE STOPPED



<http://smallbluemarble.org.uk/>

a UK based independent charity dedicated to pesticide safety assessment

- The aims of small blue marble are to:
- conduct unbiased research into the effects of pesticides – the true ecotoxicological risks associated with pesticides, deficiencies in pesticide safety assessment and the longer term risks of many pesticides
- publish the results among the scientific community for peer review
- share this information with the public in an accessible form
- enable the public and other stakeholders to express informed and on-going views about the impact of pesticides on our planet
- equip today's children to be better guardians (than we have been) of tomorrow's world

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