Neonicotinoids & Other Pesticides in Nebraska Streams

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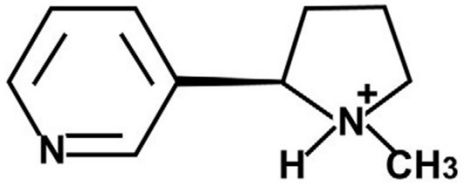
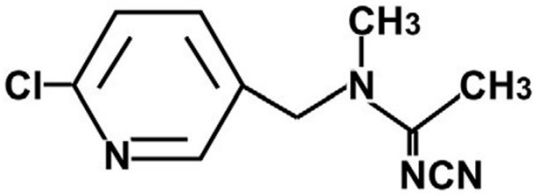
NEBRASKA
DEPT. OF ENVIRONMENT AND ENERGY

Nicotinic acetylcholine receptors (nAChRs)

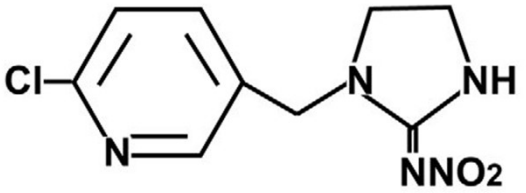
A. Nicotine

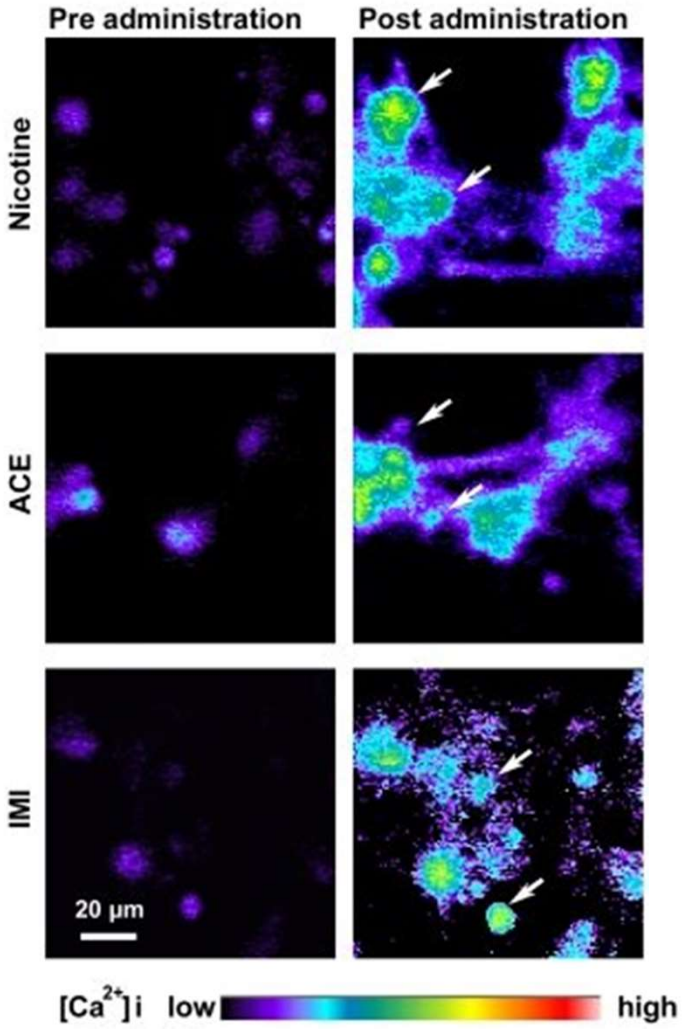


B. Neonicotinoid ACE

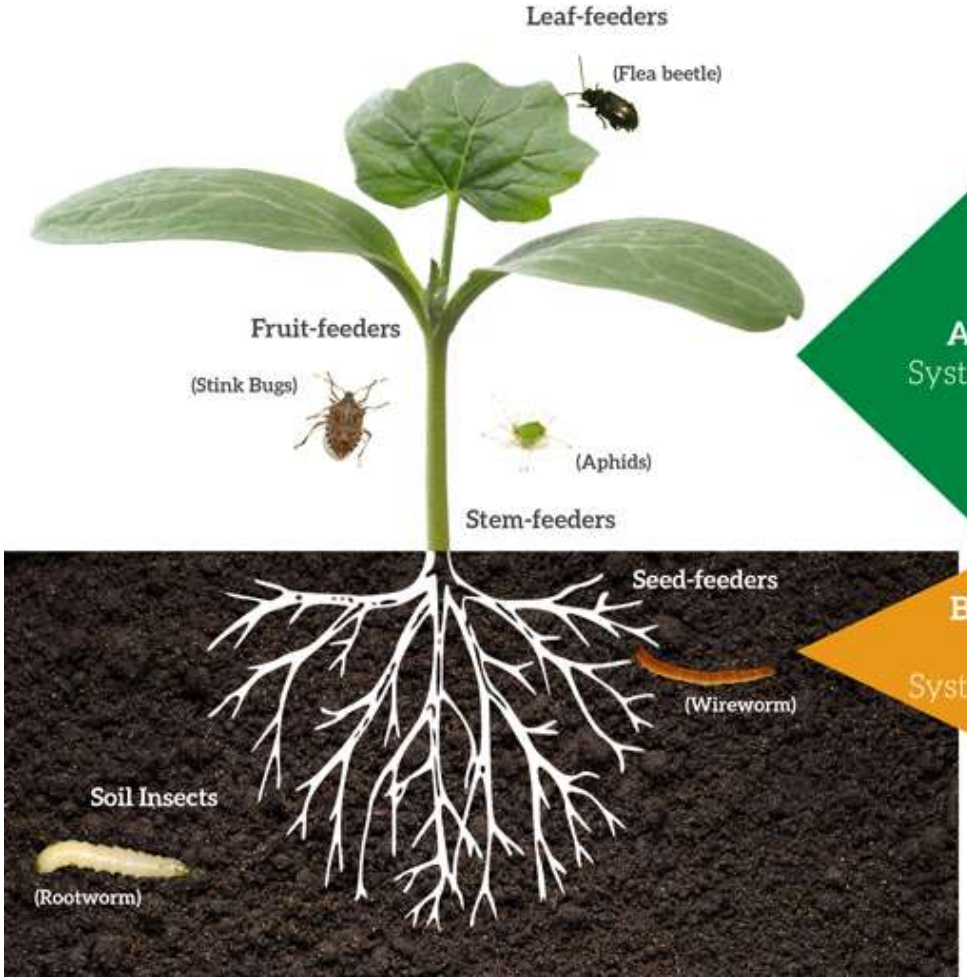


C. Neonicotinoid IMI



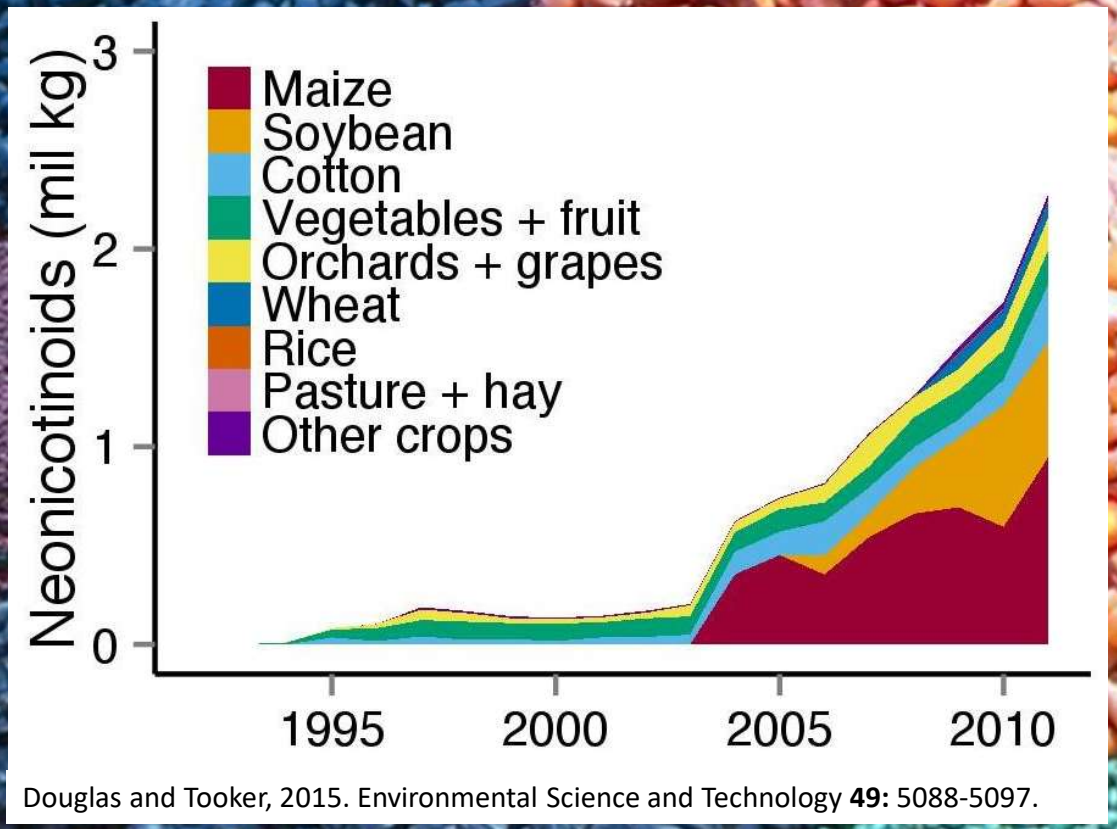


Figures from Kimura-Kuroda et al. 2012

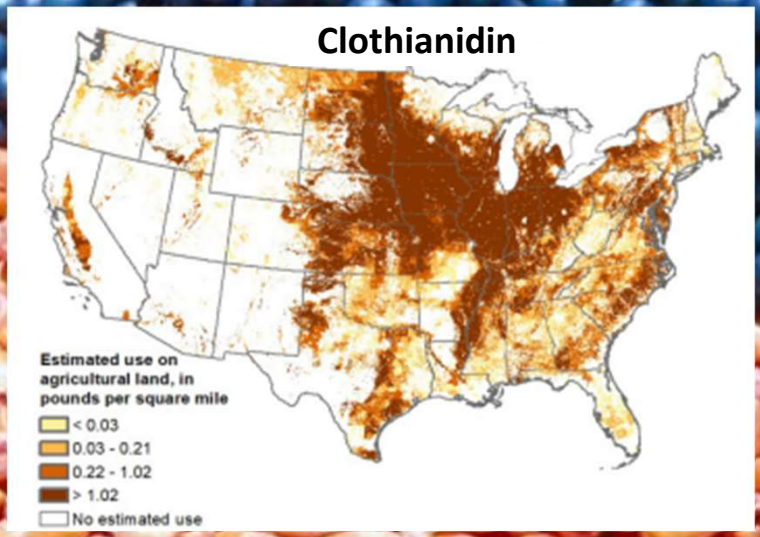


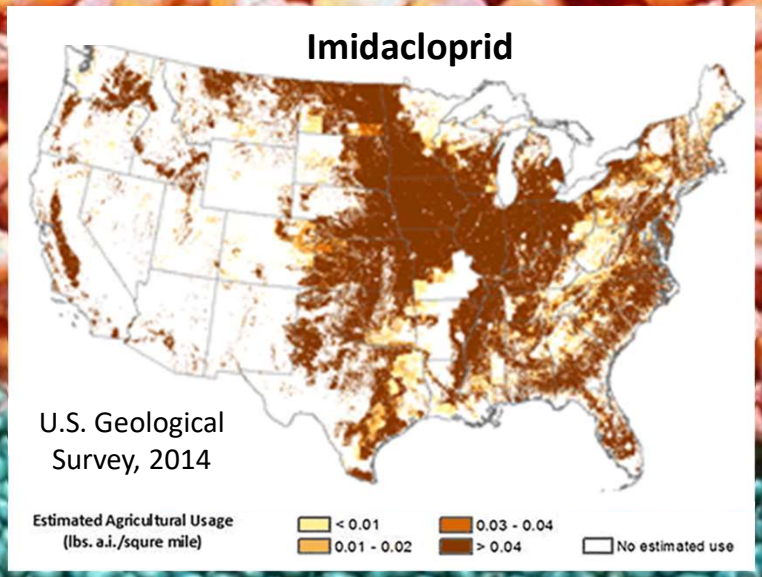
	Chewing Pests	Sucking Pests
Above Ground Systemic Activity	Cutworm	Aphids
	Armyworm	Thrips
	Flea Beetle	White Flies
	Sugarcane Beetle	Alfalfa Hopper
	BLB	Chinch Bugs
	Billbugs	Leafhopper
	Cabbage Root Fly	Stinkbug
	Cornstalk Borers	Gall Weevil
Below Ground Contact and Systemic Activity	Rootworm	
	Seedcorn Maggot	
	White Grubs	
	Wireworms	

Seminis

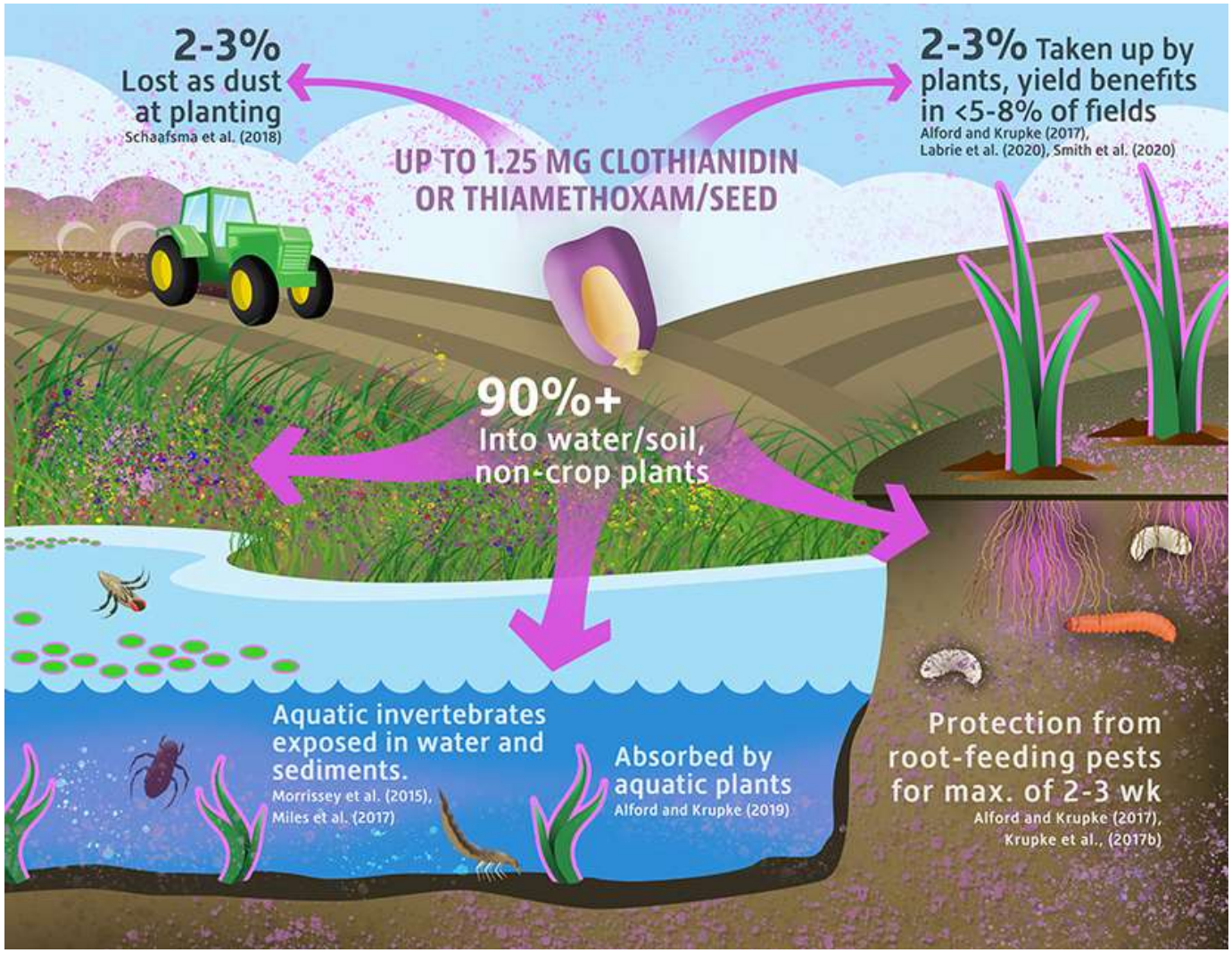


Douglas and Tooker, 2015. Environmental Science and Technology **49:** 5088-5097.





U.S. Geological Survey, 2014



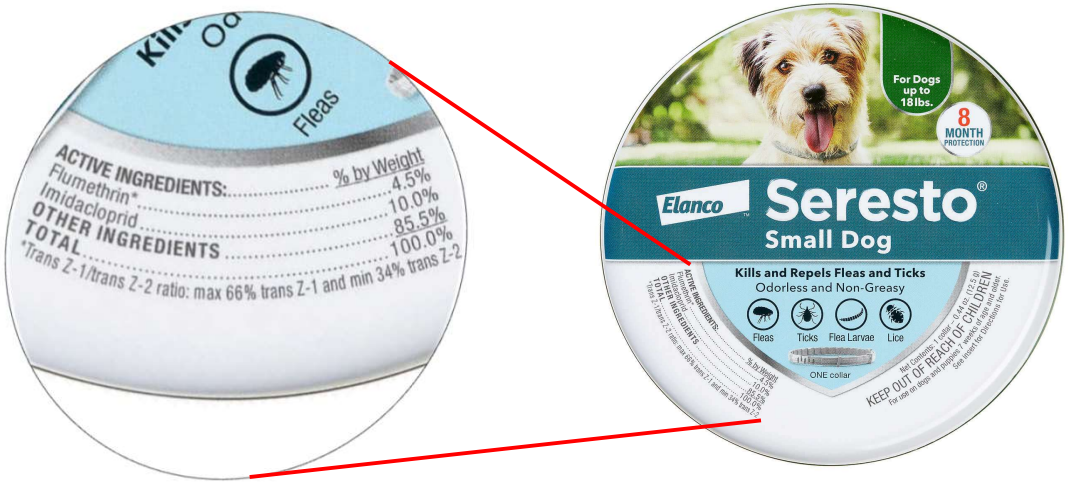
Hrupke and Tooker, 2020. Frontiers in Sustainable Food Systems. https://doi.org/10.3389/fsufs.2020.595855.

Colorado State Extension

Greenhouse grower

Table 1. Neonicotinoid active ingredients and common products used in California's home landscapes.	
Active ingredient	**Representative products registered for home use in outdoor settings**
acetamiprid	some Ortho 'Insect Killer' products
clothianidin	some Bayer Advanced products, Green Light Grub Control with Arena
dinotefuran	Green Light Tree and Shrub Insect Control with Safari 2G
imidacloprid	many Bayer Advanced products, some Ortho 'Tree and Shrub' products, Monterey Once a Year Insect Control
thiamethoxam	Maxide Dual Action Insect Killer

Andrew M. Sutherland 2014. http://www.ipm.ucdavis.edu/RETAIL/retail-newsletter.html.



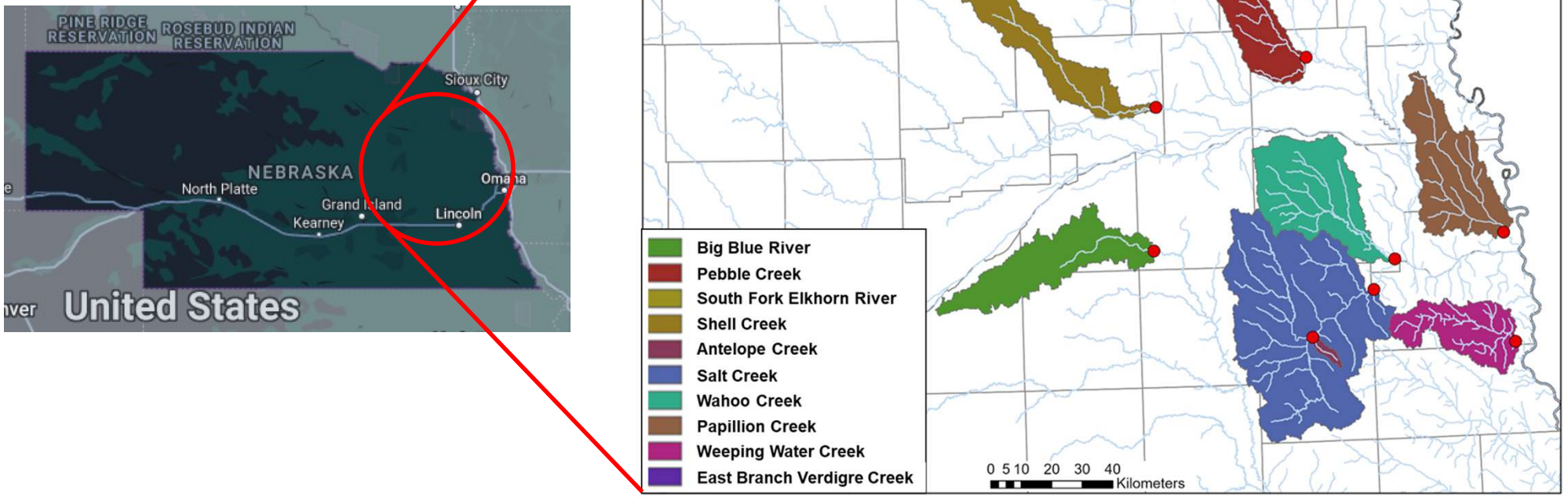
Properties of the big three neonics

Compound	Solubility	Soil persistence	Mobility	Mammal toxicity	Fish toxicity	Aquat. invert toxicity*
Clothianidin	Moderate	Very high	Moderate	Moderate	Low	(0.05 µg/L) Moderate-high
Imidacloprid	High	High	Moderate	Moderate	Moderate	(0.01 µg/L) High
Thiamethoxam	High	Moderate	High	Moderate	Low	(0.74 µg/L) Low-High

*Differences in toxicity are from different organisms tested, chronic vs. acute, water column vs. sediment dwelling

The uncertainties

1. What is in the water?
2. Ag vs Urban vs Grasslands?
3. Water vs. sediments?
4. Temporal effects and runoff?
5. Effects of the toxic cocktail?


PINE RIDGE RESERVATION
ROSEBUD INDIAN RESERVATION
Sioux City
NEBRASKA
North Platte
Omaha
Grand Island
Kearney
Lincoln
United States
Big Blue River
Pebble Creek
South Fork Elkhorn River
Shell Creek
Antelope Creek
Salt Creek
Wahoo Creek
Papillion Creek
Weeping Water Creek
East Branch Verdigre Creek
0 5 10 20 30 40
Kilometers

Stream	Latitude	Longitude	Watershed area (km2)	Cultivated Crops (%)	Urban Develop. (%)	Other land uses (%)
Big Blue River at Surprise	41.1024	-97.3075	907.7	90.41	4.73	4.87
Pebble Creek sw of Scribner	41.6590	-96.6841	533.5	88.90	4.54	6.56
Shell Creek ne of Columbus	41.5260	-97.2818	760.1	85.16	4.28	10.57
Wahoo Creek at Ashland	41.0536	-96.3678	1076.8	84.29	5.07	10.64
Weeping Water Creek se of Union	40.7938	-95.9113	624.8	81.37	4.90	13.73
East Branch Verdigre Creek	42.3460	-98.0930	104.7	80.62	4.22	15.16
Salt Creek at Greenwood	40.9651	-96.4547	2724.9	51.72	12.60	35.69
Papillion Creek at Fort Crook	41.1177	-95.9378	993.9	41.97	47.06	10.96
Antelope Creek at State Fair Park	40.8314	-96.7000	37.4	0.05	94.34	5.61
South Fork Elkhorn River	42.2414	-98.3982	740.1	6.95	1.75	91.3

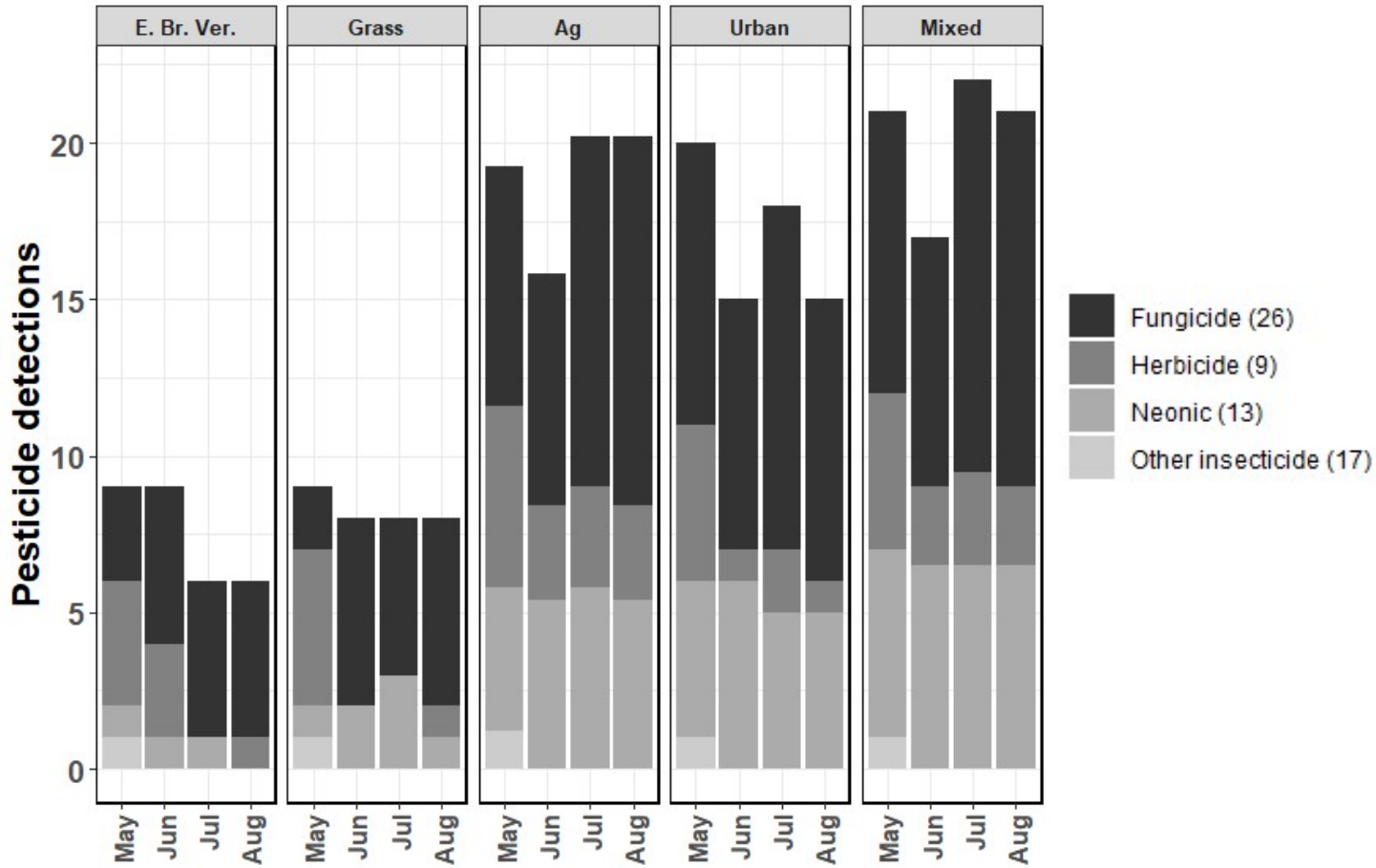
1. Water sampled monthly May-Aug 2022

2. Sediment and benthic invertebrates sampled June and Aug

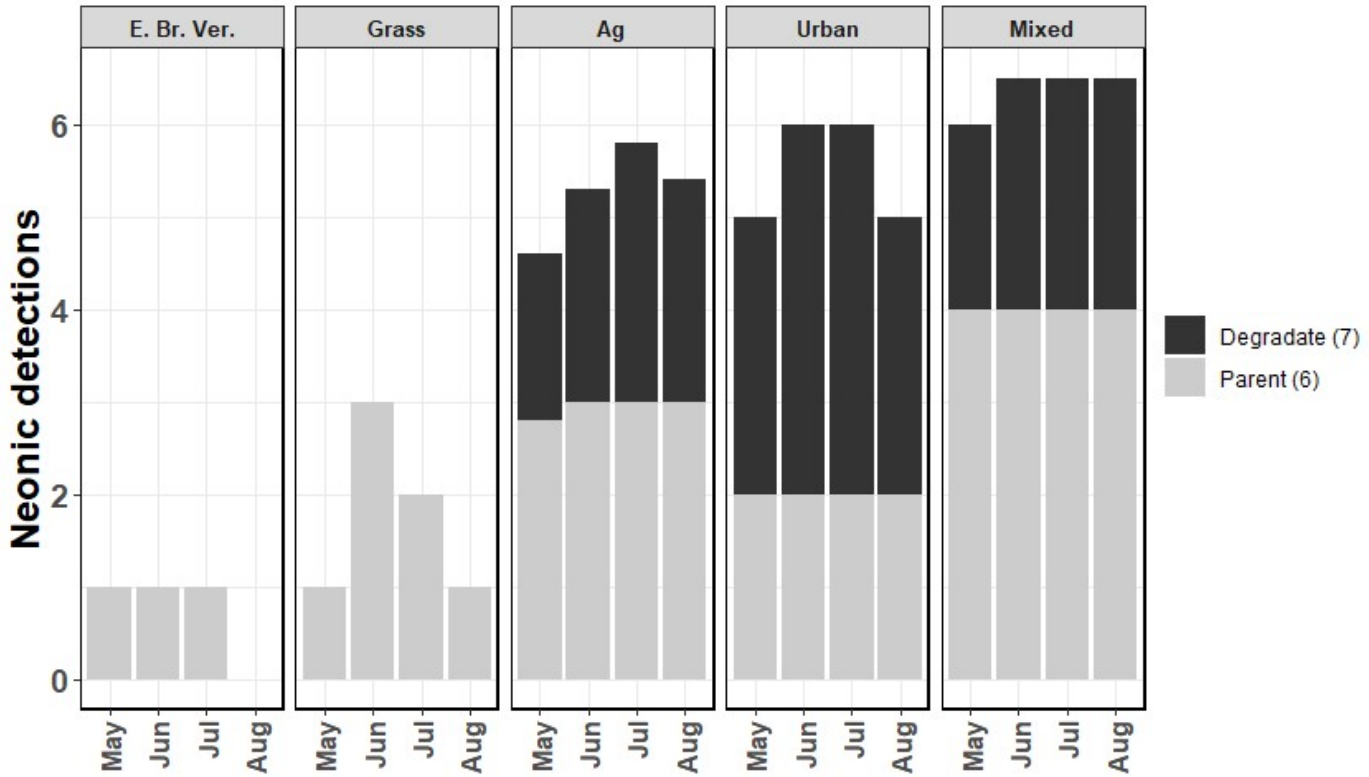
3. Analyzed for 65 compounds

- Neonic parents and degradates
- Pyrethroid insecticides
- Azole fungicides
- Strobilurin fungicides
- Organophosphates and other herbicides

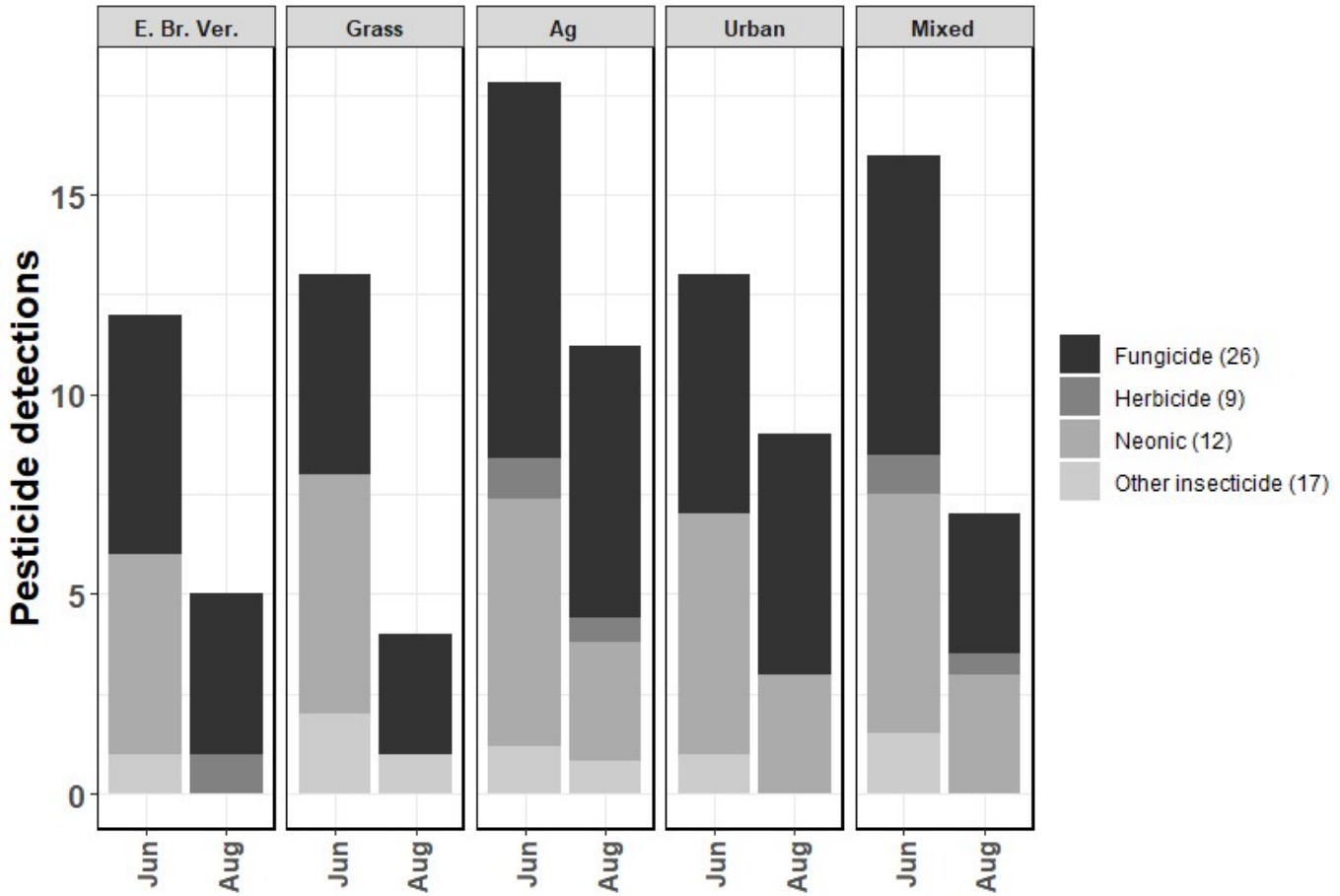
What is out there: water



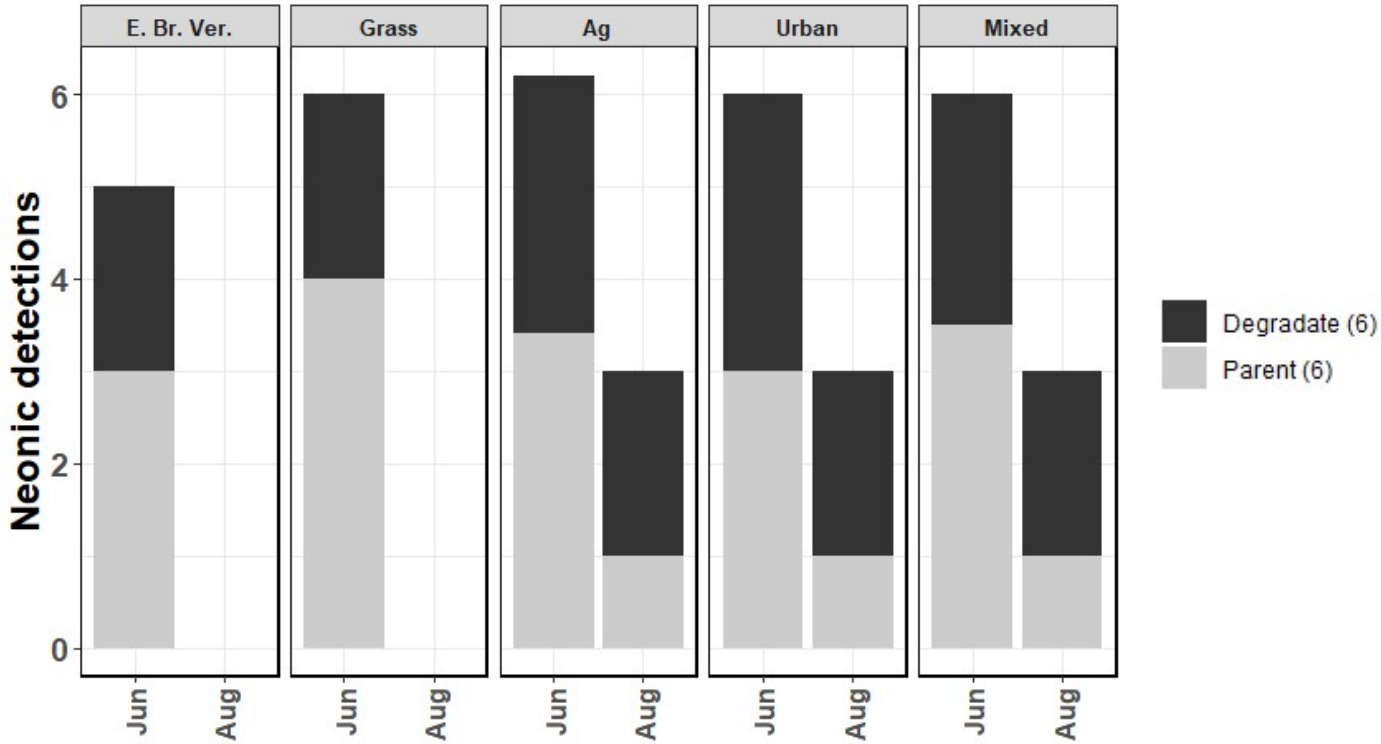
What is out there: neonics in water



What is out there: sediment

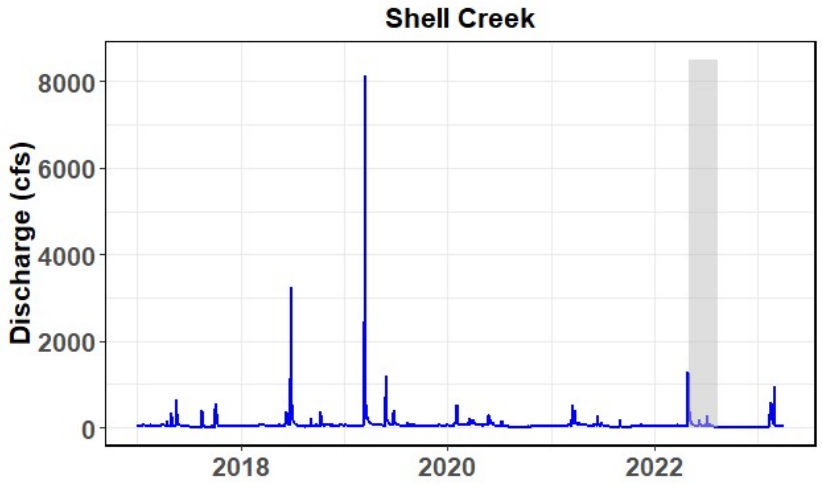


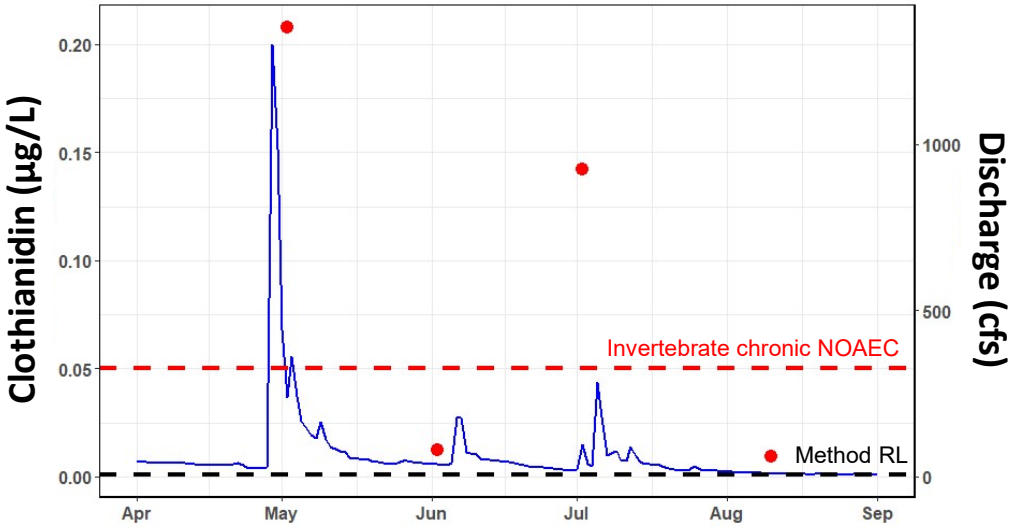
What is out there: neonics in sediment

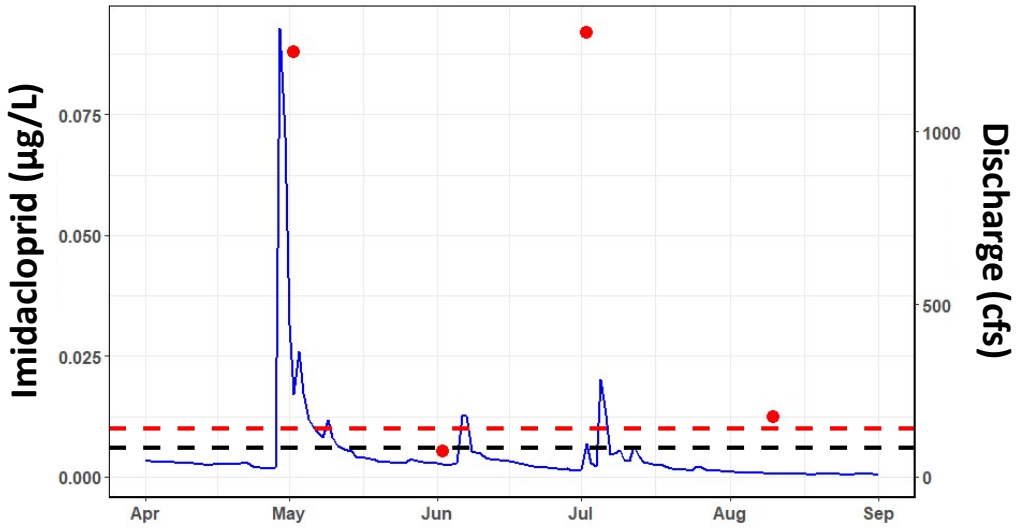


Temporal effects: Shell Creek

85% crops
Large rain in May

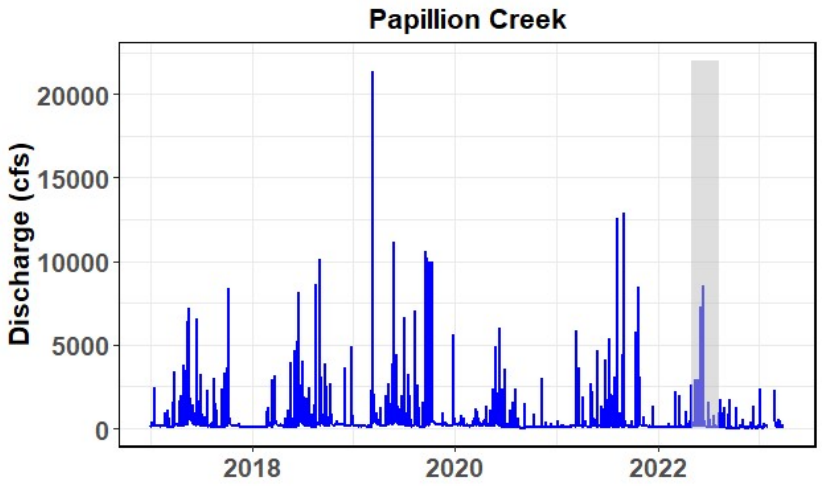


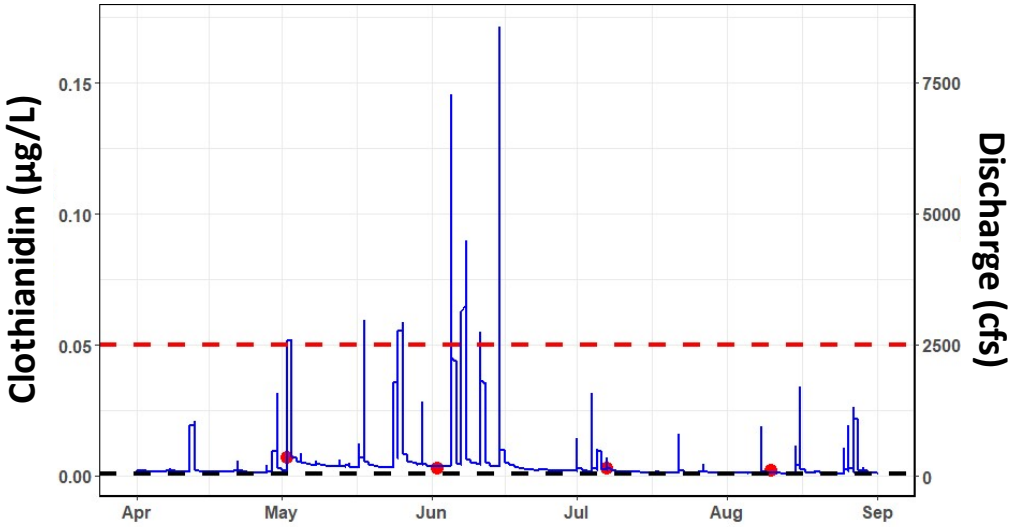


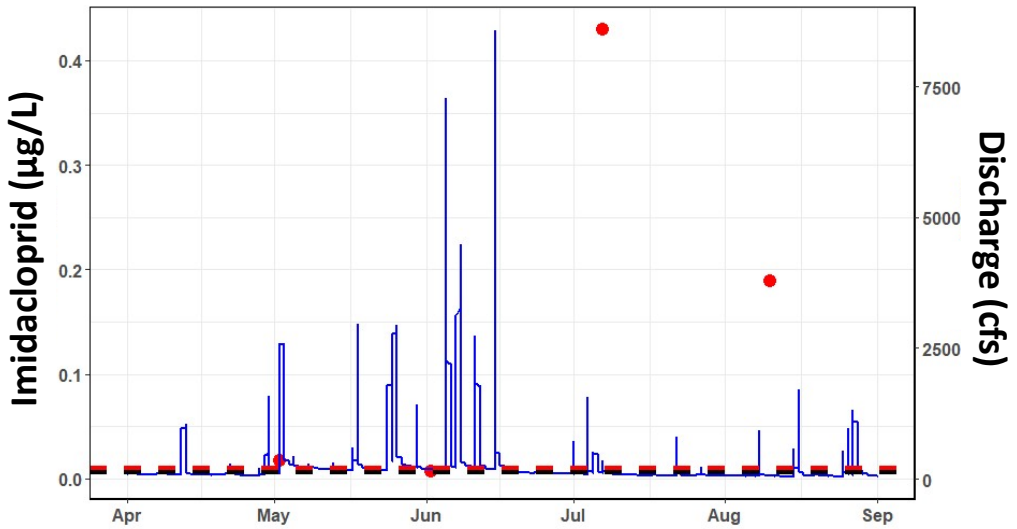


Temporal effects: Papillion Creek

47% urban
42% crops







Water mixture toxicity

Stream	5/2/2022	6/2/2022	7/7/2022	8/5/2022	Compounds of concern
Shell Creek	**13.22**	0.26	**12.29**	**1.44**	Clothianidin, Imidacloprid
Weeping Water Creek	**13.12**	**6.01**	**1.11**	**1.96**	Clothianidin, Imidacloprid
Big Blue River Rep 1	**5.67**	0.94	**5.29**	**1.53**	Clothianidin, Imidacloprid
Big Blue River Rep 2	**5.40**	0.23	**5.36**	**1.61**	Clothianidin, Imidacloprid
Salt Creek	**2.19**	**4.51**	**5.62**	**1.57**	Imidacloprid
Papillion Creek	**1.73**	0.76	**43.04**	**18.92**	Imidacloprid
Antelope Creek Rep 1	<0.01	**3.41**	**13.90**	**2.97**	Imidacloprid
Antelope Creek Rep 2	<0.01	**3.88**	**14.62**	**3.17**	Imidacloprid
Wahoo Creek	0.01	**1.22**	0.12	0.07	Imidacloprid
Pebble Creek	<0.01	0.08	0.15	**2.81**	Imidacloprid
South Fork Elkhorn River	<0.01	0.20	0.05	0.03	
East Branch Verdigre Creek	0.00	0.11	0.03	0.00	

Toxic Unit =
∑ concentration /
invert chronic NOAEC

Values > 1.00 exceed
21-day chronic NOAEC

Chronic effects include
survival, growth,
reproduction, emergence

Takeaways

- Always multiple pesticides, water & sediments
- Fungicides had most detects
- Ag & urban watersheds had similar detects (~15-20)
- Water detects persisted, sediments had fewer in August than June
- Runoff effects were evident and repeated
- Chronic toxicity in both ag & urban watersheds
  - Clothianidin and imidacloprid in ag
  - Imidacloprid in urban/mixed
  - ***Toxicities extended in duration = more likely chronic effects manifested***

Neonicitinoids and strobilurin fungicides

Compound	CAS#	Water MDL (µg/L)	Sediment MDL (ng/L)
Acetamiprid	135410-20-7	0.003	0.045
Clothianidin	210880-92-5	0.003	0.046
Dimethoate	60-51-5	0.003	0.03
Dinotefuran	165252-70-0	0.002	0.027
Imidacloprid	138261-41-3	0.003	0.039
Metalaxyl	57837-19-1	0.003	0.013
Thiacloprid	111988-49-9	0.006	0.016
Thiamethoxam	153719-23-4	0.004	0.017
Azoxystrobin	131860-33-8	0.012	0.111
Picoxystrobin	117428-22-5	0.004	0.025
Pyraclostrobin	175013-18-0	0.002	0.029

Compound	CAS#	Water MDL (µg/L)	Sediment MDL (ng/L)
Trifloxystrobin	141517-21-7	0.003	0.073
Sulfoxaflor	946578-00-3	0.003	0.018
Indoxacarb	144171-61-9	0.005	0.083
Imidacloprid urea	120868-66-8	0.008	NM
Imidacloprid olefin	115086-54-9	0.004	NM
Imidacloprid desnitro	115970-17-7	0.008	NM
Thiamethoxam urea	902493-06-5	0.002	0.016
6-Chloronicotinic acid	5326-23-8	0.021	NM
6-Chloronicotinic aldehyde	23100-12-1	0.004	NM
6-Chloro-N-methylnicotinamide	54189-82-1	0.002	0.049

Pyrethroids and organophosphates

Compound	CAS#	Water MDL (µg/L)	Sediment MDL (ng/L)
Acetochlor	34256-82-1	0.017	0.488
Atrazine	1912-24-9	0.017	0.178
Bifenthrin	82657-04-3	0.007	1.09
Boscalid	188425-85-6	0.022	2.284
Carbofuran	1563-66-2	0.027	0.266
Chlorpyrifos	2921-88-2	0.014	1.36
Cyhalothrin lambda	91465-08-6	0.003	0.907
Cypermethrin	52315-07-8	ND	2.881
Cyprodinil	121552-61-2	0.024	1.037
Deethyl-atrazine (DEA)	6190-65-4	0.007	0.446
Deltamethrin	52918-63-5	0.008	3.827
Desisopropyl-atrazine (DIA)	1007-28-9	0.043	0.82
Diazinon	333-41-5	0.021	0.804
Fludioxonil	131341-86-1	0.012	1.166

Compound	CAS#	Water MDL (µg/L)	Sediment MDL (ng/L)
Malathion	121-75-5	0.015	0.844
Methidathion	950-37-8	0.019	0.843
Metolachlor	51218-45-2	0.018	0.511
Metribuzin	21087-64-9	0.012	0.514
Parathion ethyl	56-38-2	0.015	0.918
Parathion methyl	298-00-0	0.014	3.165
Pendimethalin	40487-42-1	0.008	0.301
Permethrin	52645-53-1	0.009	1.145
Propazine	139-40-2	0.027	0.382
Pyrimethanil	53112-28-0	0.012	0.955
Quinoxyfen	124495-18-7	0.013	1.269
Tebuconazole	107534-96-3	0.008	3.196
Tefluthrin	79538-32-2	0.01	1.365
Triadimefon	43121-43-3	0.02	0.823

Azole fungicides

Compound	CAS #	Water MDL (µg/L)	Sediment MDL (ng/L)
Difenoconazole	119446-68-3	0.01	2.0
Metconazole	125116-23-6	0.01	2.0
Propiconazole	60207-90-1	0.01	2.0
Prothioconazole	178928-70-6	0.01	2.0
Desthio-Prothioconazole	120983-64-4	0.01	2.0
Tebuconazole	107534-96-3	0.01	2.0
Thiabendazole	148-79-8	0.01	2.0
Ipconazole	125225-28-7	0.01	2.0
Abamectin	71751-41-2	0.1	5.0