GIS IN ENVIRONMENTAL HEALTH

Estimation of pesticide application in buffer zones around Danish addresses

AARHUS UNIVERSITY
HEALTH

GIS DAY 2023
28 NOVEMBER 2023

JÖRG SCHULLEHNER
ASSISTANT PROFESSOR

OUTLINE

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Residential proximity to agriculture and risk of childhood leukemia and central nervous system tumors in the Danish national birth cohort☆

Deven M. Patel[a], Steen Gyldenkærne[b], Rena R. Jones[a], Sjurdur F. Olsen[c], Gabriella Tikellis[d], Charlotta Granström[c], Terence Dwyer[d], Leslie T. Stayner[e], Mary H. Ward[a,*]

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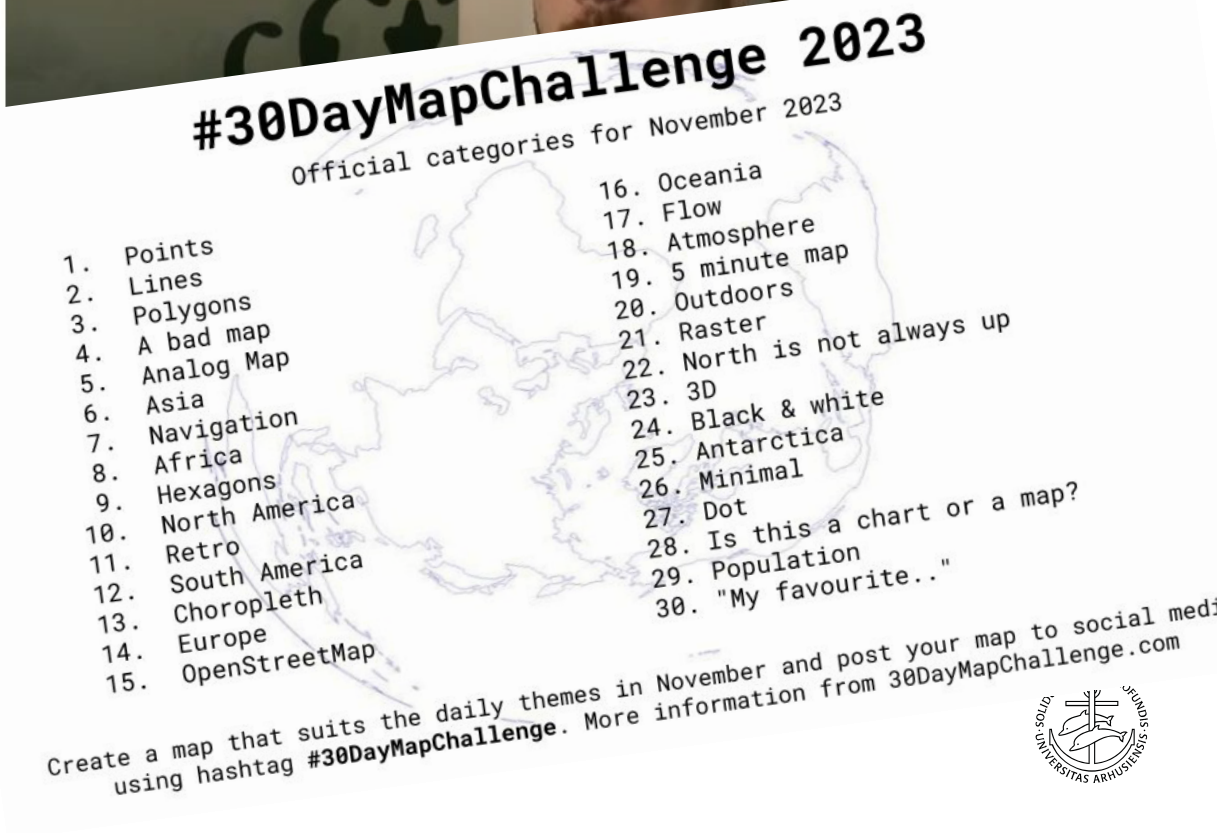
Sprøjtegifte i landbruget mistænkes for at være skyld i børneleukæmi

31. aug 2018 kl. 17.15 Del artikel



What we are working on now:

Estimating the actual *pesticide* exposure

PESTICIDES AND LEUKEMIA

- Most common cancer in children
- Multifactorial: interaction between genetic (inherited) susceptibility factors and exogenous exposures
- Chronic low-level pesticide exposure during pregnancy and early childhood could be risk factor
- Challenge: relatively rare outcome and low-levels of exposure

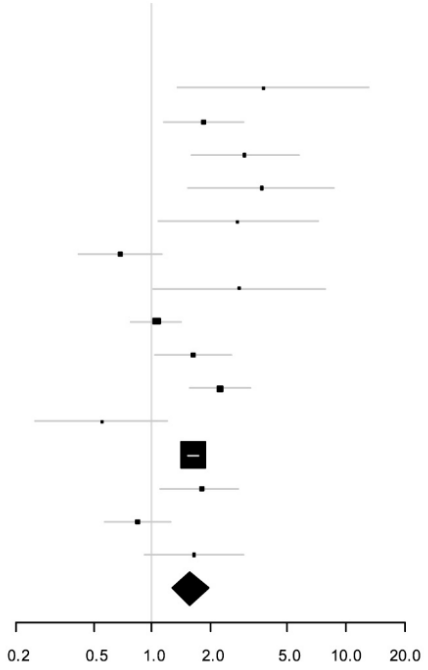
International Journal of Hygiene and Environmental Health
Volume 222, Issue 1, January 2019, Pages 49-67

Household exposure to pesticides and risk of leukemia in children and adolescents: Updated systematic review and meta-analysis

Geneviève Van Maele-Fabry [a], Laurence Gamet-Payrastre [b], Dominique Lison [a]

(a) Forest plot of studies related to residential pesticide exposure and all types of childhood leukemia

Study	OR (95% CI)	Weights (%)
Lowengart et al. (1987)	3.8 (1.37-13.02)	0.29
Buckley et al. (1989)	1.85 (1.16-2.99)	1.61
Leiss and Savitz (1995)	3 (1.6-5.7)	0.9
Alexander et al. (2001)	3.67 (1.54-8.74)	0.48
Soldin et al. (2009)	2.77 (1.08-7.14)	0.41
Spix et al. (2009)	0.69 (0.42-1.12)	1.5
Castro-Jiménez and Orozco-Vargas (2011)	2.8 (1.01-7.77)	0.35
Slater et al. (2011)	1.06 (0.78-1.42)	4.03
Ding et al. (2012)	1.63 (1.04-2.55)	1.8
Ferreira et al. (2013)	2.24 (1.57-3.2)	2.85
Maryam et al. (2015)	0.55 (0.25-1.2)	0.59
Bailey et al. (2015)	1.64 (1.53-1.75)	80.18
Zhang et al. (2015)	1.8 (1.1-2.8)	1.66
Hyland et al. (2018)	0.84 (0.57-1.26)	2.3
Ferri et al. (2018)	1.65 (0.92-2.96)	1.06
Total	**1.57 (1.27-1.95)**	**100**



Positive association confirmed for domestic use

Low-quality of evidence

Need for better studies

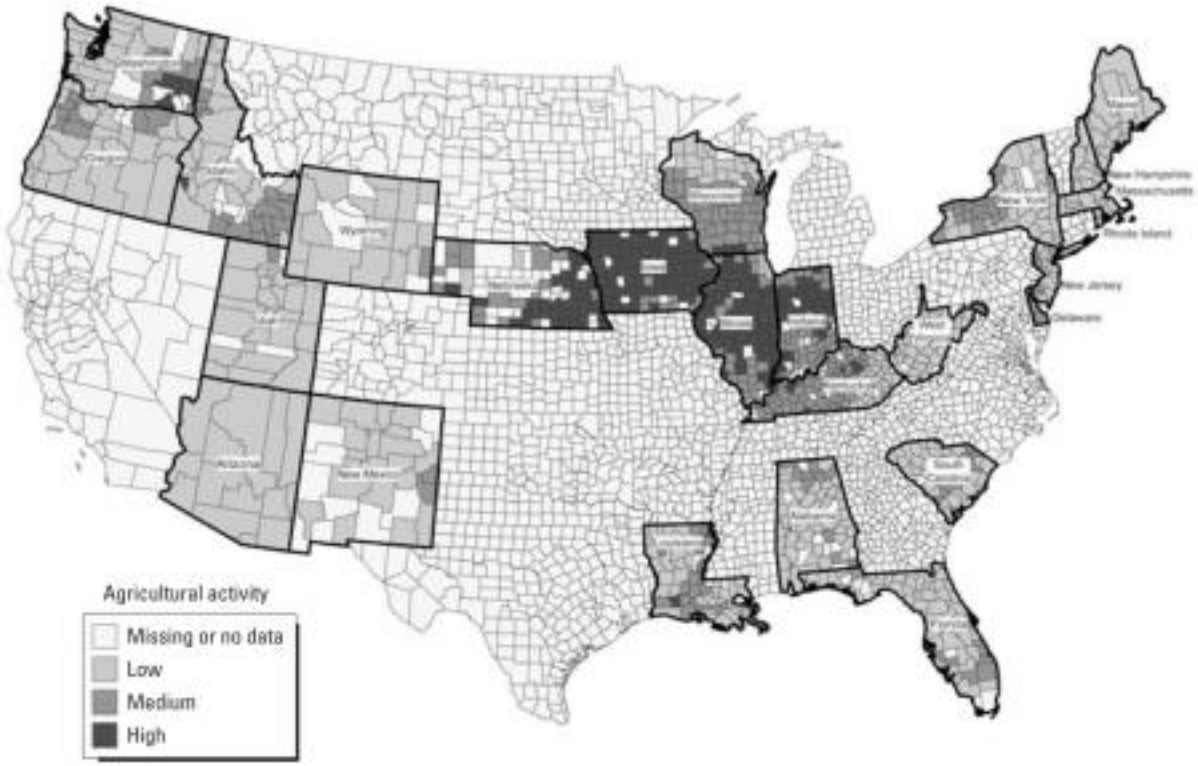
ENVIRONMENTAL EXPOSURE?

Research | Children's Health

Risk of Childhood Cancers Associated with Residence in Agriculturally Intense Areas in the United States

Susan E. Carozza,[1] Bo Li,[2] Kai Elgethun,[3] and Ryan Whitworth[4]

[1]Department of Epidemiology and Biostatistics, School of Rural Public Health, Texas A&M Health Science Center, College Station, Texas, USA; [2]National Center for Atmospheric Research, Boulder, Colorado, USA; [3]Department of Community and Environmental Health, Boise State University, Boise, Idaho, USA; [4]Centers for Health Promotion and Prevention Research, School of Public Health, University of Texas Health Science Center at Houston, Houston, Texas, USA



Booth *et al. Environmental Health* (2015) 14:82
DOI 10.1186/s12940-015-0070-3

ENVIRONMENTAL HEALTH

RESEARCH Open Access

Agricultural crop density and risk of childhood cancer in the midwestern United States: an ecologic study

Benjamin J. Booth[1,2*], Mary H. Ward[2], Mary E. Turyk[1] and Leslie T. Stayner[1]

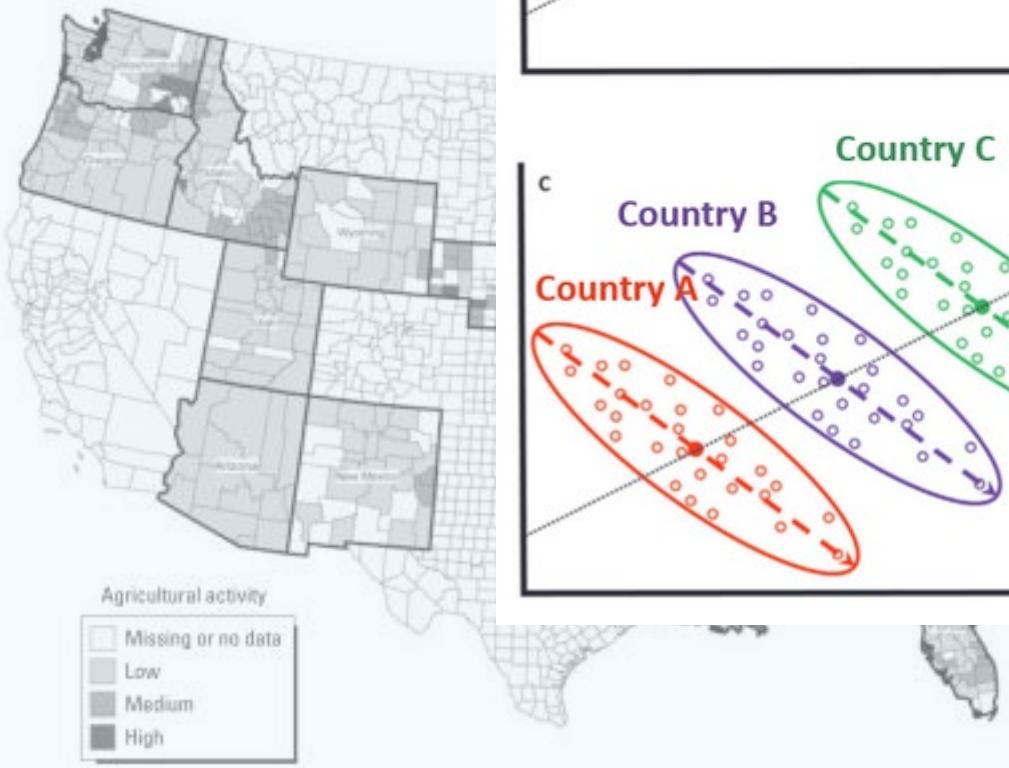
the associations observed in this study need to be confirmed by analytic epidemiologic studies using individual level exposure data and accounting for potential confounders that could not be taken into account in this ecologic study.

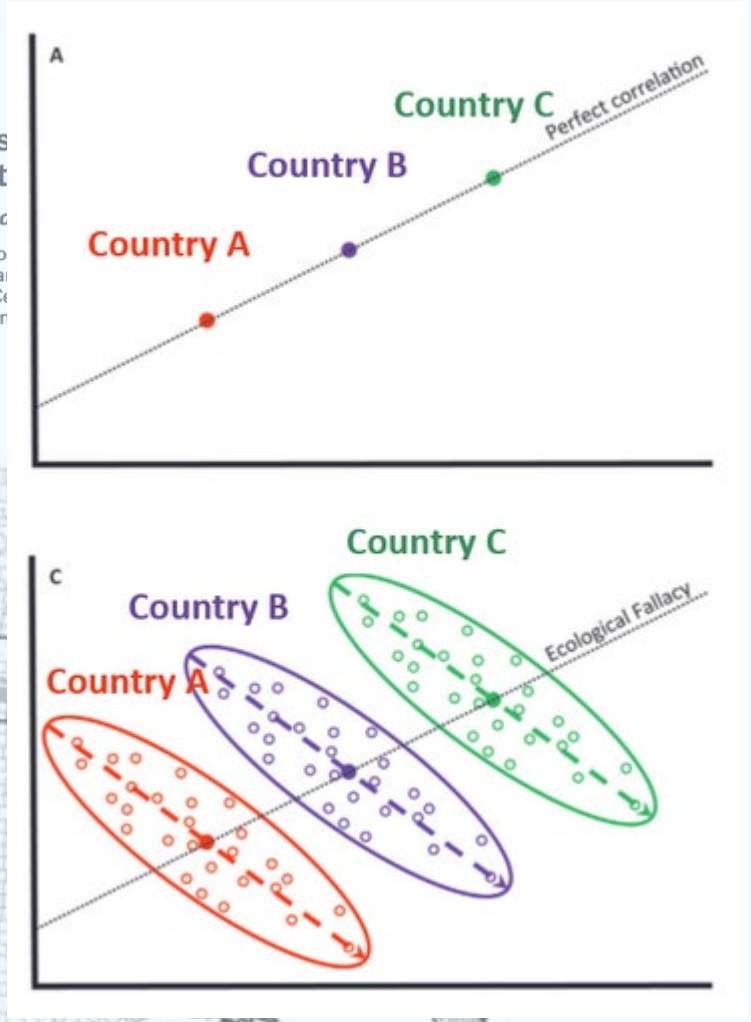
ENVIRONMENTAL EXPOSURE?

Risk of Childhood Cancers Ass
Intense Areas in the United St

Susan E. Carozza,[1] Bo Li,[2] Kai Elgethun,[3] and

[1]Department of Epidemiology and Biostatistics, Scho
Texas, USA; [2]National Center for Atmospheric Resea
Health, Boise State University, Boise, Idaho, USA; [4]C
University of Texas Health Science Center at Houston





Ecological fallacy:
Drawing conclusions about individuals based on aggregated data in a larger group

WHY DENMARK?

Scandinavian Journal of Public Health
OnlineFirst, June 6, 2023

https://doi.org/10.1177/14034948231178076

Sage Journals

Study Design Article

Perspectives on environment and health research in Denmark

Henriette T. Horsdal [1,2], Marianne G. Pedersen [1,3], Jörg Schullehner [2,4,5], Cecilie S. Østergaard [1,2,4], John J. Mcgrath [1,6,7], Esben Agerbo [1,3], Allan Timmermann [1,2,3], Ane Marie Closter [1,2,3], Jørgen Brandt [8], Jesper H. Christensen [8], Lise M. Frohn [8], Camilla Geels [8], Matthias Ketzel [8,9], Jibran Khan [2,8], Pia V. Ørby [2,8], Yulia Olsen [2,4], Gregor Levin [8], Jens-Christian Svenning [10], Kristine Engemann [10], Steen Gyldenkærne [8], Birgitte Hansen [5], Ole Hertel [2,11], Clive E. Sabel [2,4], Christian Erikstrup [2,12], Torben Sigsgaard [2,4], and Carsten B. Pedersen [1,2,3]

WHY DENMARK?

- >60% population near indirect agricultural exposures
- Danish National Birth Cohort:
  - 96,841 live births 1996-2003
  - Case-cohort analysis
    - 191 cases (61 leukemia, 59 CNS)
    - 9171 controls (~10% random sample)
- Geocoded residences during pregancy
- Danish General Agricultural Register
  - From 1996: location and area of subsidized crops (crops for sale & grassland)
  - 720,000 fields
  - Spatial resolution 2-5 m

ELSEVIER

Environment International
Volume 143, October 2020, 105955

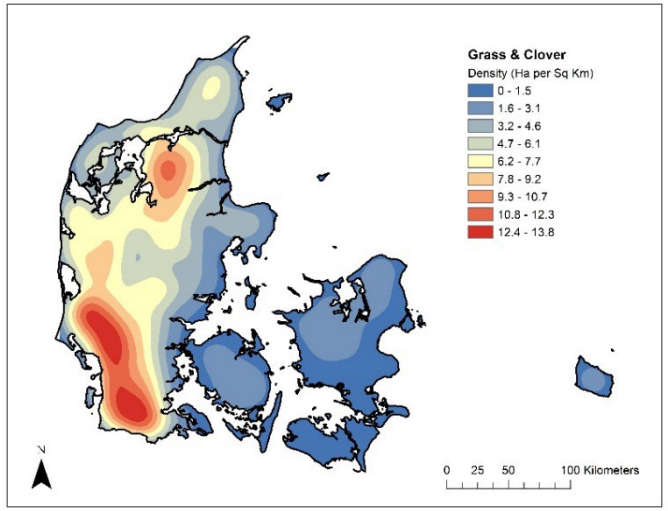
Residential proximity to agriculture and risk of childhood leukemia and central nervous system tumors in the Danish national birth cohort ☆

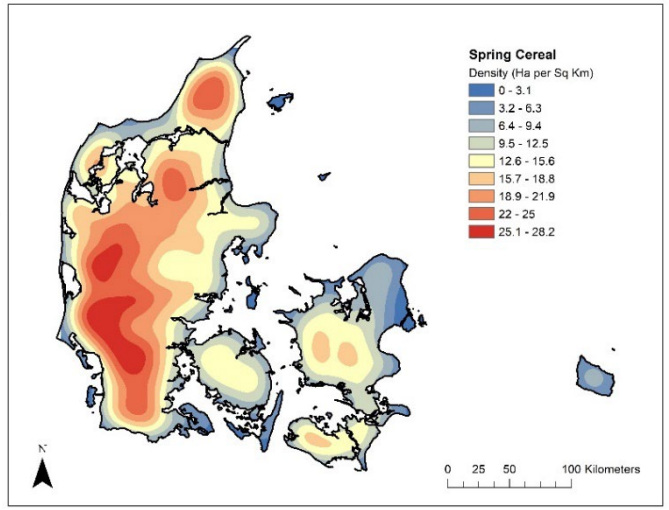
Deven M. Patel [a], Steen Gyldenkærne [b], Rena R. Jones [a], Sjurdur F. Olsen [c], Gabriella Tikellis [d], Charlotta Granström [c], Terence Dwyer [d], Leslie T. Stayner [e], Mary H. Ward [a]

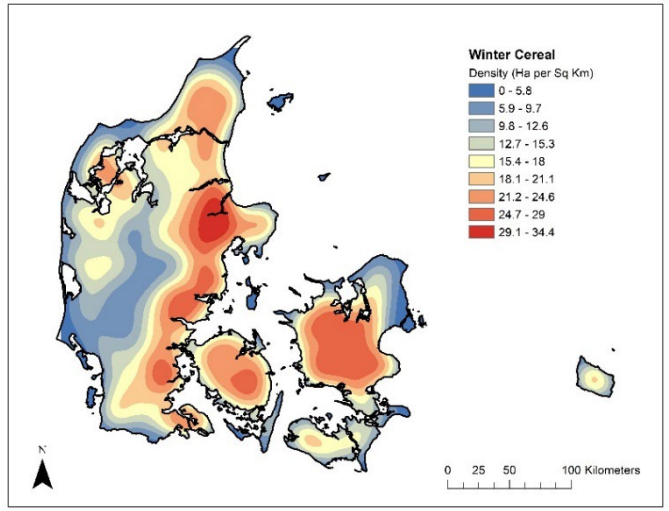
EXPOSURE TO CROPS

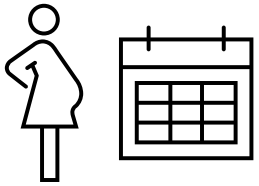
Area within buffer zones 250, 500, 1000, 2000m where these crops are grown

- Winter cereals
- Spring cereals
- Grass/clover
- Winter rapeseed
- Peas
- Maize
- Sugar beets
- Seed crops
- ~~Spring rapeseed, potatoes~~ (too few lived within 500m of these)
- ~~Other vegetables~~ (not included until 2000)







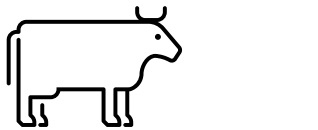
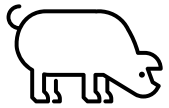
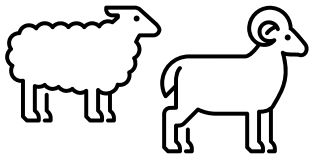
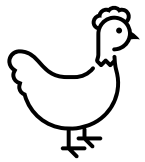
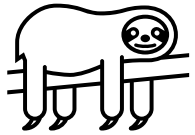


Planting cycel matched to each month of pregnancy

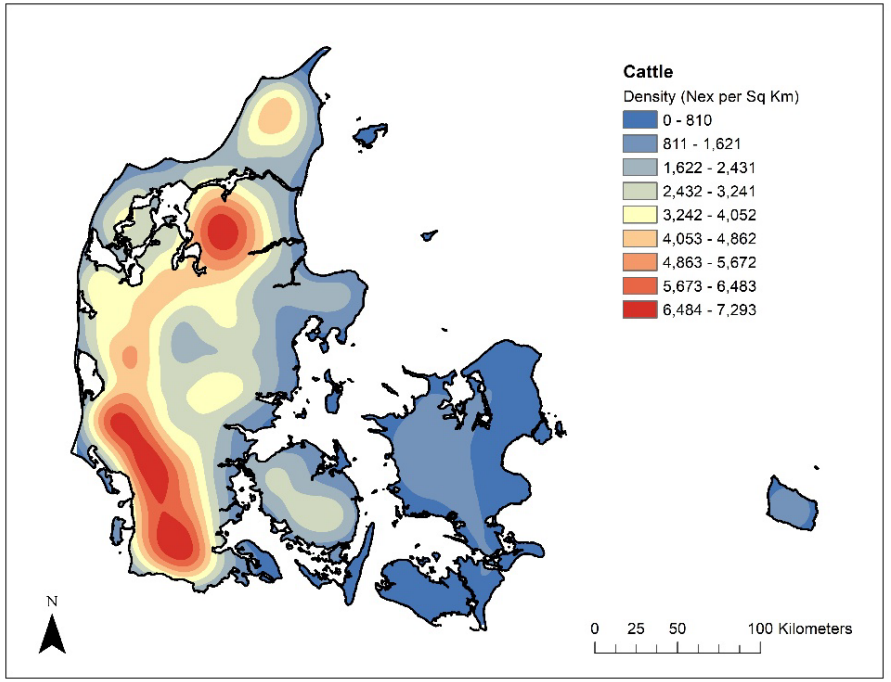
EXPOSURE TO ANIMALS

Central Husbandry Register

- 77,000 animal locations
  - Cattle
  - Pigs
  - Sheep/goat
  - Poultry
  - Others (mink, deer etc)

→ Sum animals Total nitrogen excretion N_{ex}



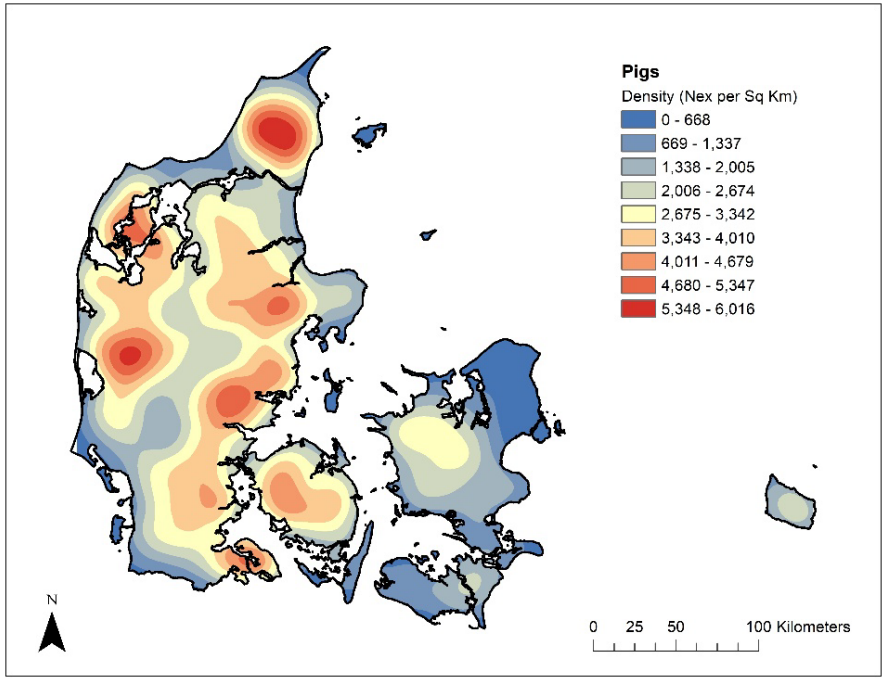


Table 3

Hazard ratios (HR) and 95% confidence intervals (95% CI) for childhood leukemia and CNS tumors associated with crop area (total, by type) within 500 m of the home during pregnancy, unadjusted and adjusted for total animal nitrogen excretion (Nex) [1] within 1000 m of the home.

			Leukemia			CNS tumors		
Crop Type	Range (hectares)	N	Cases	Unadjusted for Total Animals[2]	Adjusted for Total Animals[3]	Cases	Unadjusted for Total Animals[2]	Adjusted for Total Animals[3]
			n	HR (95% CI)	HR (95% CI)	n	HR (95% CI)	HR (95% CI)
No Crops	No Crops	3479	17	Ref	Ref	19	Ref	Ref
Total Crops	> 0– < 6.9	1962	11	1.2 (0.5–2.5)	1.3 (0.6–2.9)	12	1.2 (0.6–2.5)	1.1 (0.5–2.4)
	6.9–23.9	1957	14	1.5 (0.7–3.0)	1.9 (0.8–4.4)	15	1.5 (0.7–3.0)	1.2 (0.5–2.8)
	24–66	1964	19	2.0 (1.02–3.8)	2.6 (1.02–6.8)	13	1.3 (0.6–2.6)	1.0 (0.4–2.8)
Winter Cereals	0– < 1.5	1961	10	1.1 (0.5–2.3)	1.2 (0.5–2.7)	13	1.3 (0.6–2.6)	1.1 (0.5–2.5)
	1.5– < 8.3	1961	20	2.1 (1.09–4.0)	2.4 (1.1–5.3)	17	1.7 (0.9–3.3)	1.3 (0.6–2.9)
	8.3–566	1961	14	1.4 (0.7–3.0)	1.7 (0.7–4.3)	10	1.0 (0.5–2.1)	0.8 (0.3–2.0)
Spring Cereals	0– < 0.8	1961	14	1.5 (0.7–3.0)	1.6 (0.8–3.4)	15	1.5 (0.7–2.9)	1.3 (0.6–2.7)
	0.8– < 5.0	1961	16	1.7 (0.8–3.3)	1.8 (0.8–4.1)	14	1.4 (0.7–2.8)	1.1 (0.4–2.6)
	5.0–46	1961	14	1.5 (0.7–3.0)	1.5 (0.6–3.9)	11	1.1 (0.5–2.3)	0.8 (0.3–2.1)
Grass/clover	0	2214	8	0.7 (0.3–1.7)	0.9 (0.4–2.2)	14	1.2 (0.6–2.5)	1.1 (0.5–2.4)
	> 0– < 1.1	1708	16	1.9 (0.96–3.8)	2.7 (1.2–6.2)	9	1.0 (0.5–2.3)	0.9 (0.4–2.2)
	1.1–32	1961	20	2.1 (1.1–4.0)	3.1 (1.2–7.7)	17	1.7 (0.9–3.2)	1.5 (0.5–3.9)
Winter rapeseed	> 0–15	2445	17	1.4 (0.7–2.8)	1.5 (0.6–3.6)	18	1.4 (0.7–2.7)	1.2 (0.5–2.8)
Seed crops	> 0–24	1800	9	1.1 (0.5–2.6)	1.2 (0.5–3.1)	11	1.3 (0.6–2.8)	1.1 (0.4–2.7)
Sugar beets	> 0–20	1600	15	1.9 (0.96–3.9)	2.2 (0.9–5.3)	8	1.0 (0.4–2.2)	0.7 (0.3–2.1)
Peas	> 0–12	1698	17	2.0 (1.03–4.0)	2.4 (1.02–5.4)	15	1.7 (0.9–3.4)	1.5 (0.6–3.5)
Maize	> 0–20	1130	13	2.3 (1.1–4.9)	2.8 (1.1–6.9)	4	0.7 (0.2–2.1)	0.5 (0.1–1.8)

[1] Nex values were calculated by multiplying numbers of each animal type by animal-specific nitrogen excretion rates.

[2] Adjusted for child gender and maternal age.

[3] Adjusted for child gender, maternal age, and total animal Nex within 1000 m of the home.

Minister advarer: Godkendte pesticider risikerer at give børn leukæmi

Kemikalier | 31. august 2018 kl. 16:29 | 21

Intet straksforbud

Resultaterne blev onsdag præsenteret på en konference i Canada og er ifølge de oplysninger, som forskerne har givet til Miljøministeriet, behæftet med usikkerhed og kan ændres, når yderligere analyser er udført.

Politik

Arbejdsgruppe skal se på leukæmi og pesticider

Foreløbige resultater i en ny igangværende international undersøgelse viser, at der kan være en sammenhæng mellem visse pesticider og børneleukæmi. En ny dansk arbejdsgruppe skal følge undersøgelsen tæt

2. sep. 2018 kl. 15:00

SSV

2. SEPTEMBER 2018 09:35

SKREVET AF: FREDERIK THALBITZER

S vil have straksforbud mod pesticid efter leukæmi-mistanke

Minister ad
pesticider r
børn leukæ

Kemikalier | 31. august 2018 kl. 16

Intet straksforbud

Resultaterne blev onsdag p
ifølge de oplysninger, som f
behæftet med usikkerhed o
udført.

2. SEPTEMBER 201

S vil hav
mistank

Samfund

S udsætter forbud mod sprøjtegift, der mistænkes for at give børn leukæmi

17. jul 2019 kl. 21.12

Del artikel

De foreløbigt kendte resultater indikerer, at børn kan have en øget risiko for at udvikle børneleukæmi, hvis deres mødre under graviditeten har boet i nærheden af marker sprøjtet med pesticiderne. Foto: Henning Bagger / Scanpix Denmark

af **Redaktionen**

Socialdemokratiet foreslog i 2018 et øjeblikkeligt forbud mod pesticiderne. Nu haster det ikke for miljøministeren.

For et år siden ønskede Socialdemokratiet hurtigst muligt at forbyde en række sprøjtemidler, der mistænkes for at give børn leukæmi.

æmi og

l undersøgelse viser,
r og børneleukæmi.

SSV

AARHUS UNIVERSITY
HEALTH

SOLIDUM PETIT IN PROFUNDIS
UNIVERSITAS ARHUSIENSIS

BUT WHAT ABOUT PESTICIDES?

$$App\_rate_{Corr,AI,x} = \frac{\sum App\_rate_{AI\_2012\_2013,CropType} * A_{CropType,x}}{AI_{sold,x}} \quad (1)$$

where

$App\_rate_{Corr,AI,x}$ = Corrected application rate per hectare in year x for active ingredients (1996–2003), g AI ha^{-1}

$App\_rate_{AI\_2012\_2013,Croptype}$ = Reported average application rate per ha for year 2012 and 2013 by crop type, g AI ha^{-1}

$A_{CropType,x}$ = Area with the crop type in year x, ha

$AI_{sold,x}$ = Amount of AI sold in year x, g

$$App\_AI_{Buffer,x,y} = \sum_{1}^{n} App\_rate_{Corr,AI,x} * A_{CropType,Buffer,x} * AI_{Frac,y} \quad (2)$$

where

$App\_AI_{Buffer,m,y}$ = Applications in the buffer in year x and month y, g AI

$A_{CropType,Buffer,x}$ = Area of crop type in the buffer in year x, ha

$AI_{Frac,y}$ = Fraction of active ingredients applied to crop type in month y, dimensionless

n = crop types with applications of AI

We found elevated risk of childhood leukemia in offspring of mothers with the highest tertiles of applications of the herbicides *fluroxypyr/bromoxynil/ioxynil, phenmedipham, and tribenuron-methyl and the fungicide tebuconazole*; adjustment for total animal Nex within 1000 m increased the risk estimates slightly (HRs were > 2.0) but **none were statistically significant**.

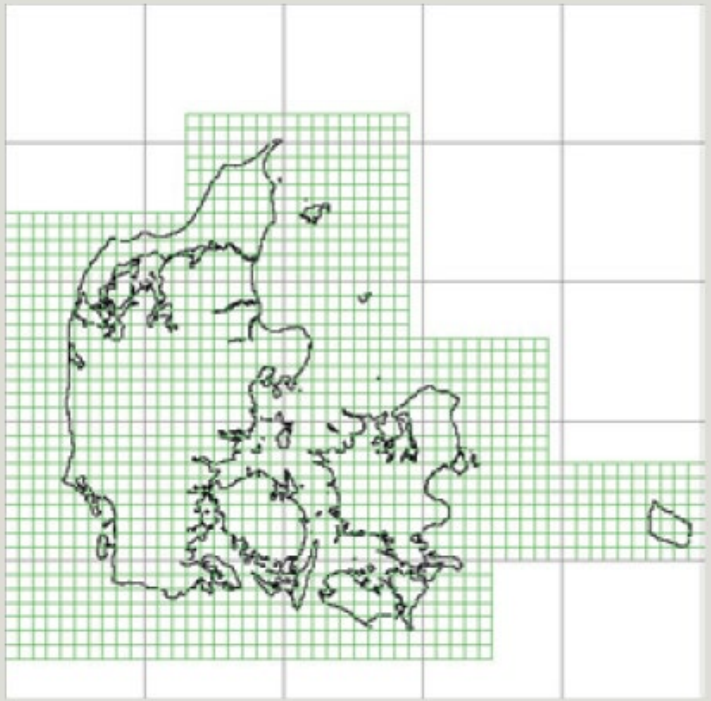
Our findings suggest that **living in areas of Denmark with a high density of agricultural crops during pregnancy was associated with increased risk of childhood leukemia in the offspring** although the reasons for this association are not clear. A few of the nine herbicides and one fungicide that were used on a high proportion of crop fields showed similar patterns of elevated leukemia risk, but the correlated use and other limitations of the pesticide use metrics **prohibit conclusions about specific pesticides.**

IMPROVING THE EXPOSURE MEASURES

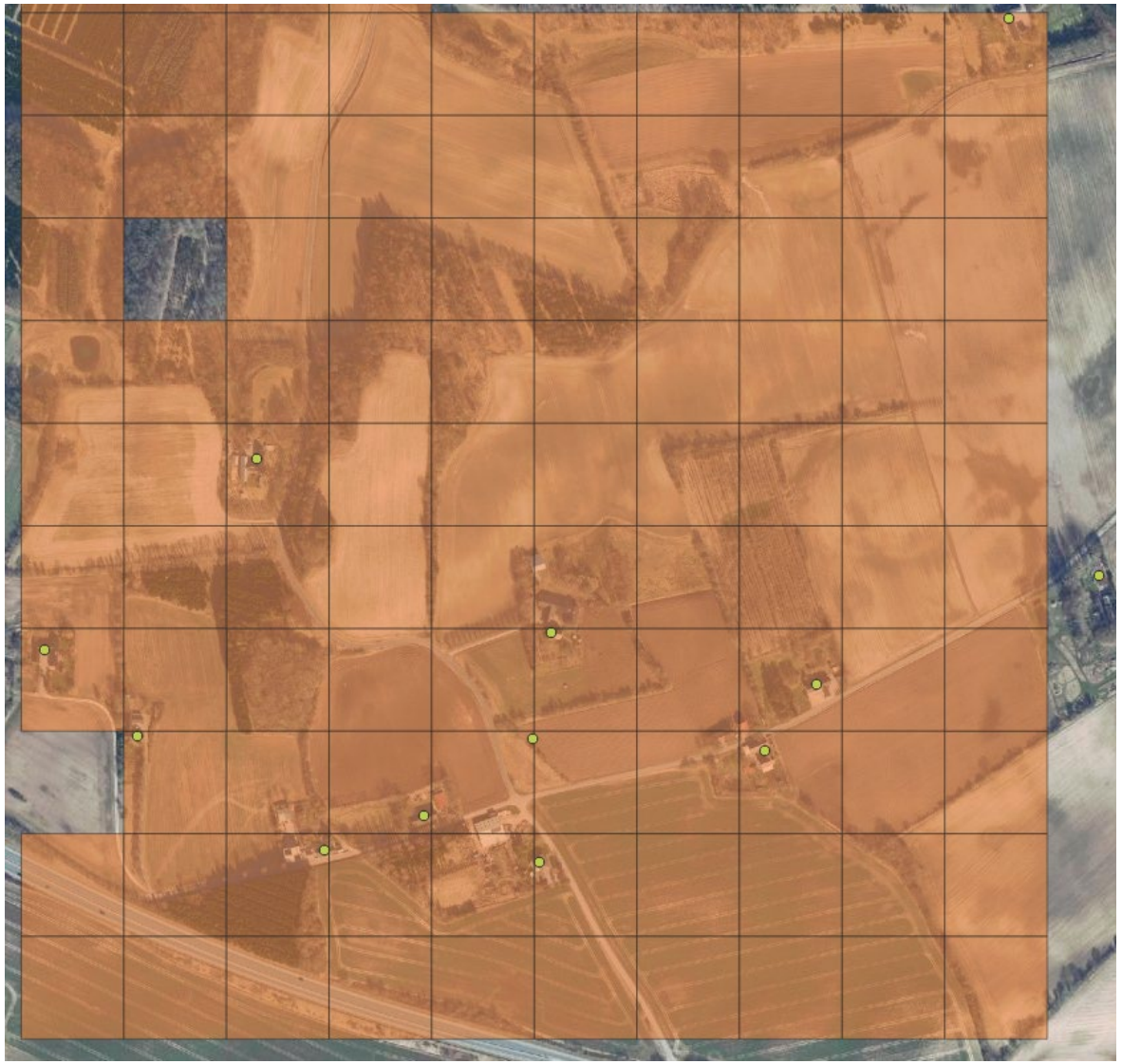
Based on application journals, AU ENVS has estimated for planning years 2010-2021

applied kg of active ingredient by CAS-no. for each

- Month
- 100x100 m grid cell in the Danish Kvadratnet



Figur 1
100 km- og 10 km-nettene, vist med grå hen-holdsvis grøn.



BUFFER ZONES

For each of > 2 million addresses in DK

- Calculate the percentage of area of the DKN_100m_ETRS89 cells within
  - 100 m
  - 250 m
  - 500 m
  - 1000 m
- Sum kg of each pesticide for each month, weighted by % grid cell within circular buffer

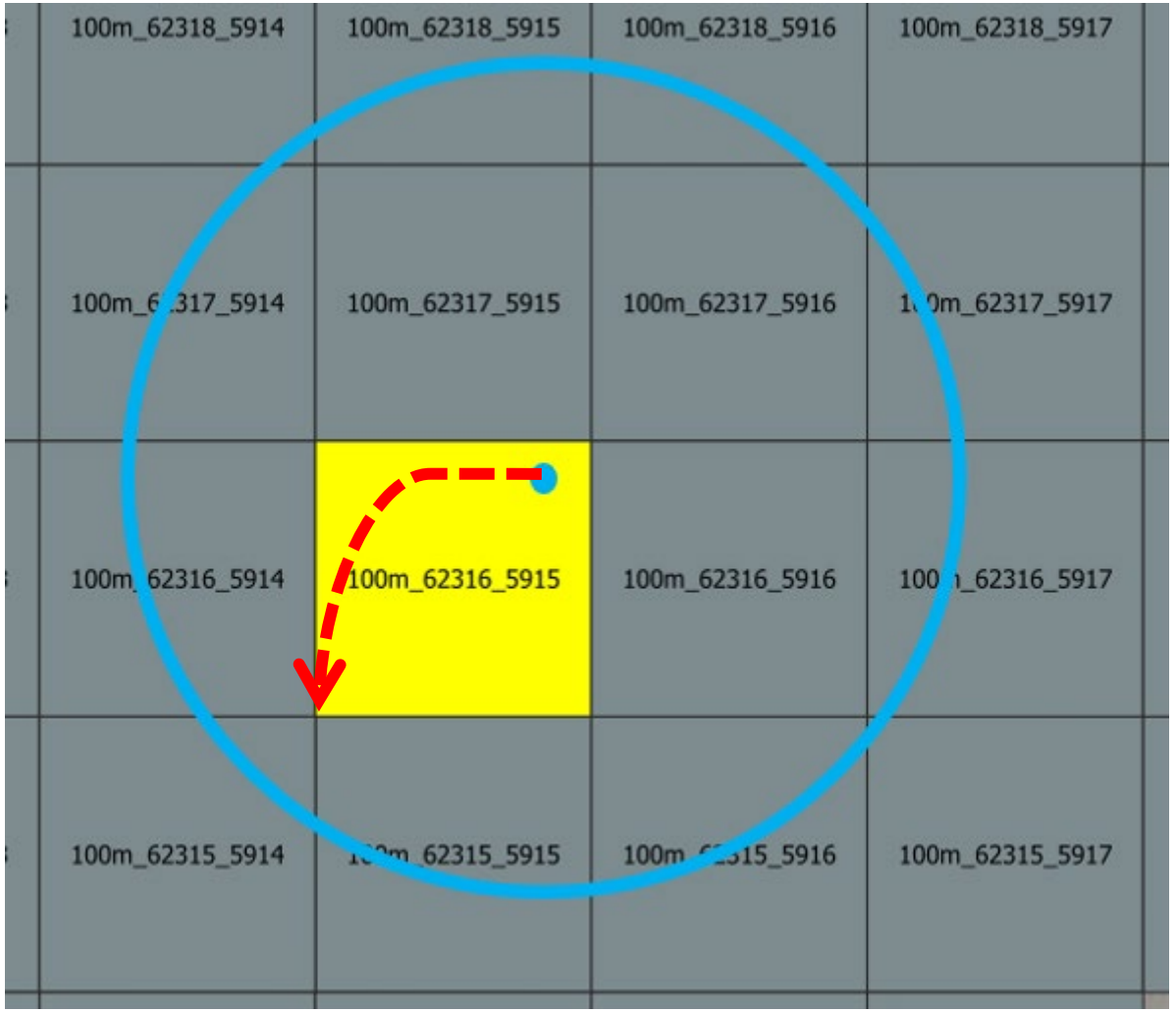
NEED FOR SPEED

Fastest (laziest?) to do by geometry in R:

- Construct relevant DKN_100m_ETRS89 cells for each address
- Calculate overlap geometrically

→ 1 year pesticide data set, all households ~ 3h

Could it have been done in QGIS? Other tools?



NEXT STEPS

We now have

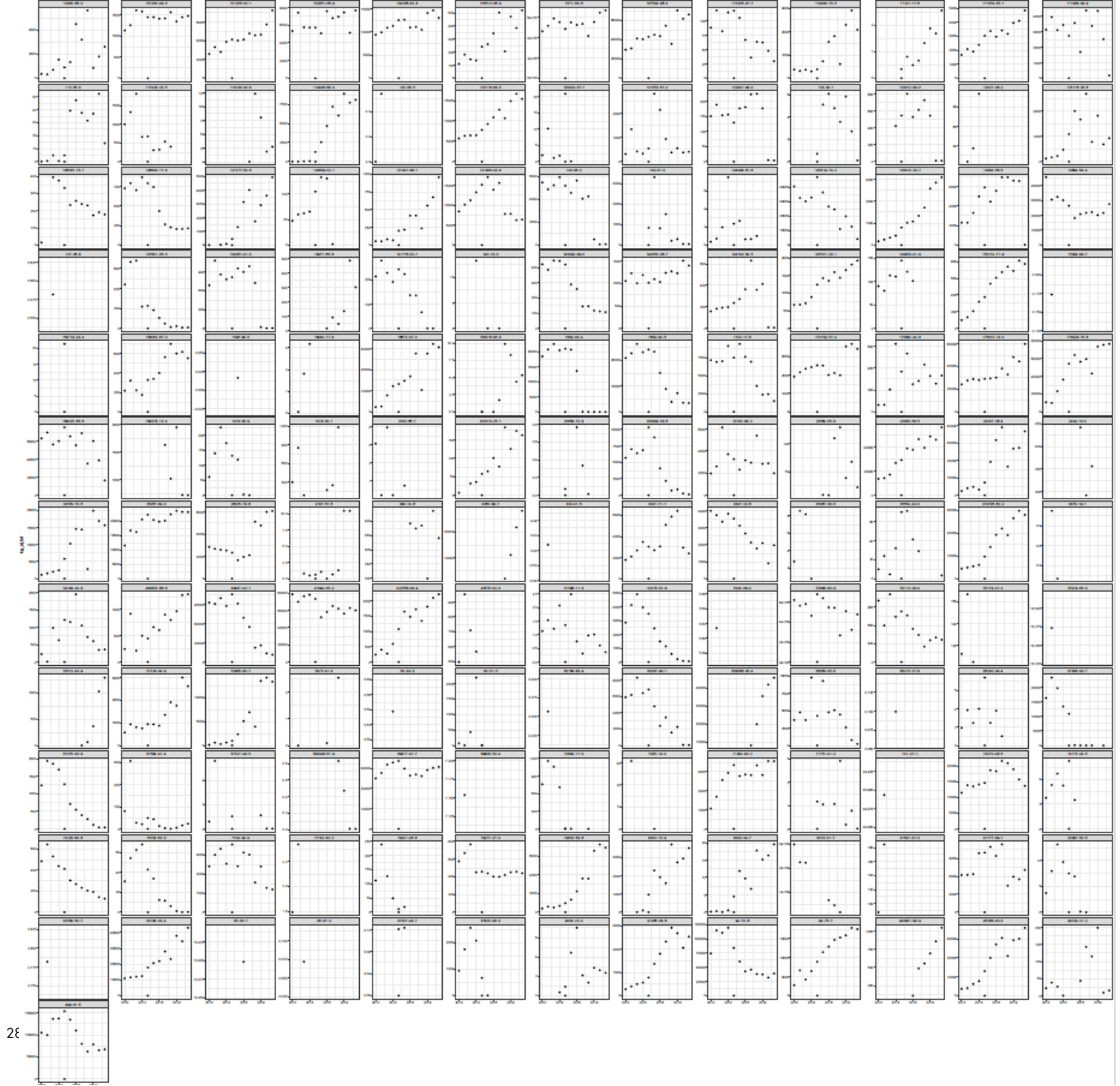
- pesticide application (kg_{ai}) within buffer zones
- Number of animals within buffer zones

A bit too much data to get started:

→ Aggregation of pesticides

Most comprehensive nationwide exposure dataset for pesticide application

→ Lots of epidemiology to come



AARHUS UNIVERSITY HEALTH

TAK

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Bluesky: @jorgs.bsky.social

BERTHA - Big Data Centre for Environment and Health

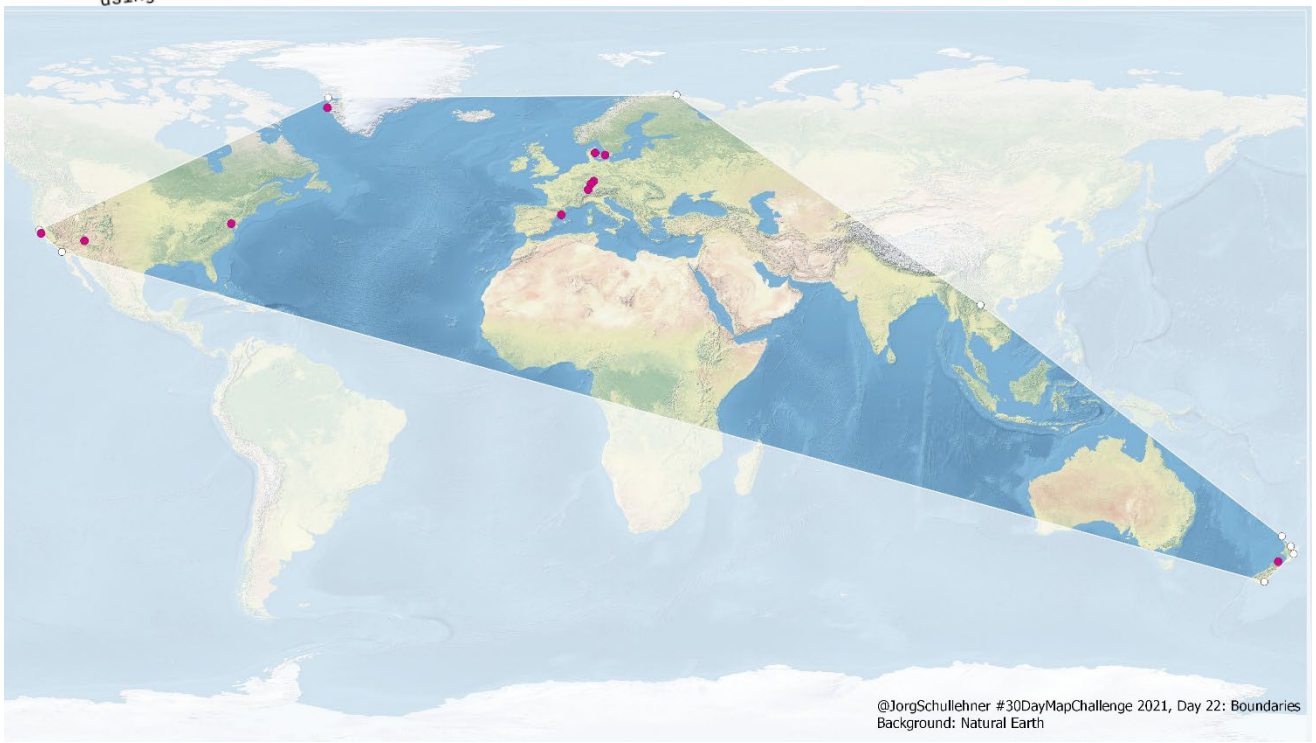
Novo Nordisk Foundation Challenge Programme (grant NNF17OC0027864).

#30DayMapChallenge 2023

Official categories for November 2023

1. Points
2. Lines
3. Polygons
4. A bad map
5. Analog Map
6. Asia
7. Navigation
8. Africa
9. Hexagons
10. North America
11. Retro
12. South America
13. Choropleth
14. Europe
15. OpenStreetMap
16. Oceania
17. Flow
18. Atmosphere
19. 5 minute map
20. Outdoors
21. Raster
22. North is not always up
23. 3D
24. Black & white
25. Antarctica
26. Minimal
27. Dot
28. Is this a chart or a map?
29. Population
30. "My favourite.."

Create a map that suits the daily themes in November and post your map to social media using hashtag **#30DayMapChallenge**. More information from 30DayMapChallenge.com



Edit Profile

Jörg Schullehner

@jorgs.bsky.social

17 followers **28** following **7** posts

Environmental Health | Water Quality | GIS | Assistant Professor @Aarhus University

Course **GIS in Health Sciences**

ECTS: 3
Graduate school: Faculty of Health
Status: Course is open for application
Cancellation deadline: 26/02/2024

Course leader: Jörg Schullehner
Graduate program: PH
Semester: Spring 2024
Start date: 11/03/2024

Language: English
Course fee: 3,600.00 DKK
Application deadline: 12/02/2024
Administrator: Lena Melchior Villadsen

Course **Advanced GIS in Health Sciences**

ECTS: 5
Graduate school: Faculty of Health
Status: Course is open for application
Cancellation deadline: 07/10/2024

Course leader: Jibran Khan
Graduate program: PH
Semester: Fall 2024
Start date: 21/10/2024

Language: English
Course fee: 6,000.00 DKK
Application deadline: 23/09/2024
Administrator: Anne Fabricius

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