German Federal Institute for Risk Assessment

German Environment Agency

From soils into pigs – accumulation of PFAS in wild boar livers illustrated by data from Germany

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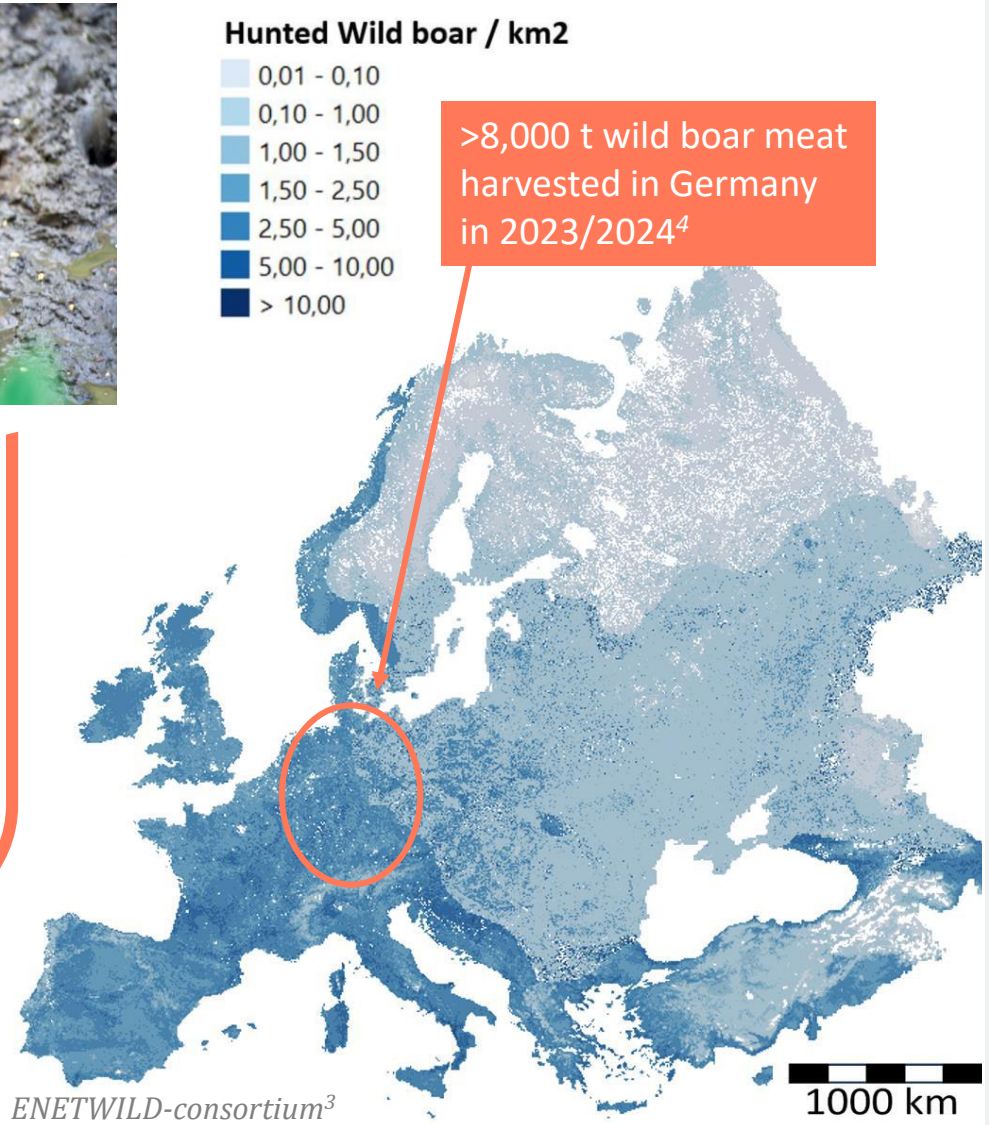
Conference „PFAS in soil – forever pollution, forever concern?“
25 – 26 March 2025 in Berlin, Germany

The wild boar [1,2]
Sus scrofa

Class:	Mammal
Weight:	40–150 kg
Distribution:	All continents except Antarctica
Home range:	Generally <20 km², sometimes 50 km²
Diet:	Omnivore • Plant origin: Ground vegetation, tubers, roots and seeds • Animal origin: Worms, insects, mice, bird eggs and carrion
Behaviour:	Foraging for food on the ground and in the soil
Age expectancy:	2–3 years (due to hunting)



ENETWILD-consortium[3]

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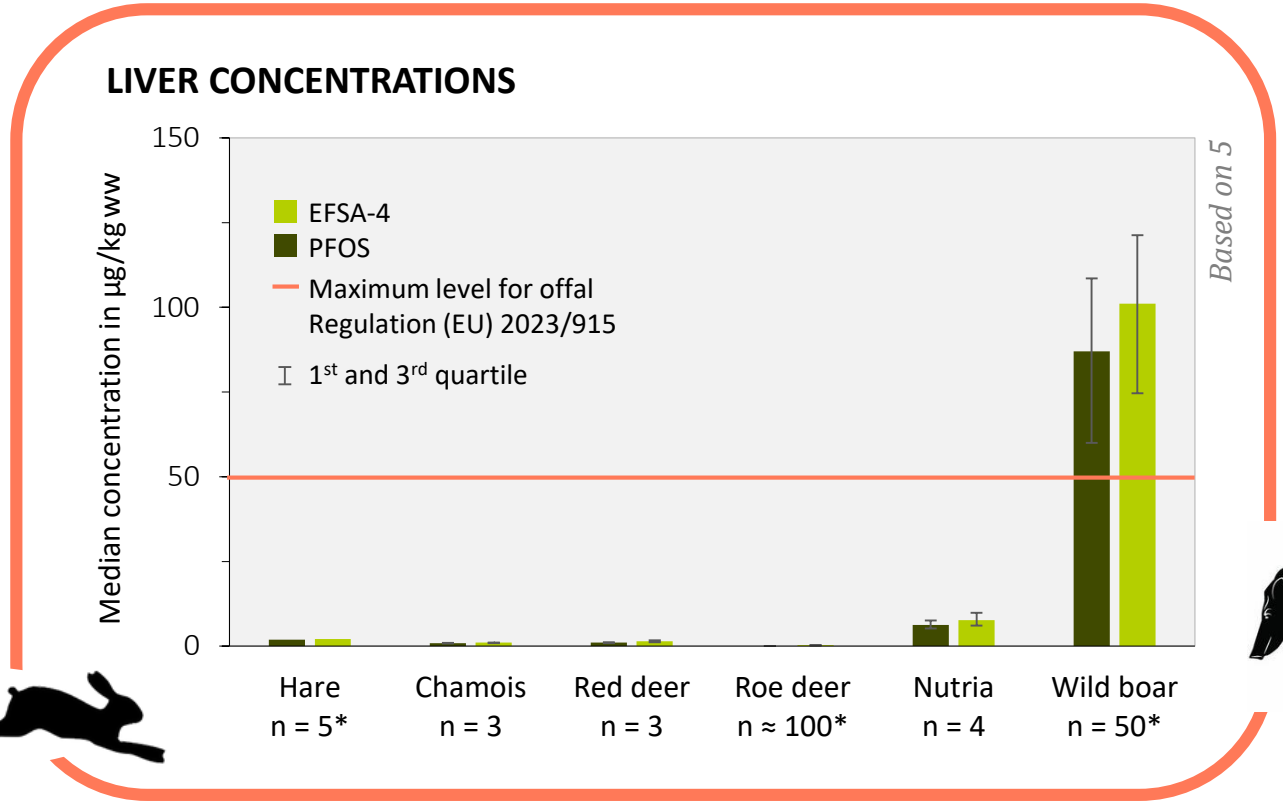
PFAS levels in wild boar can be significantly higher compared to other game animals



Relatively short half-lives in rabbits: PFOS 88 days[6]

Long half-lives in domestic pigs: PFOS 1.7 years[7]

Comparable to humans: PFOS 5.4–8.7 years[8]

PFAS accumulation in the food chain

* Analysed in pool samples of 3–10 individuals

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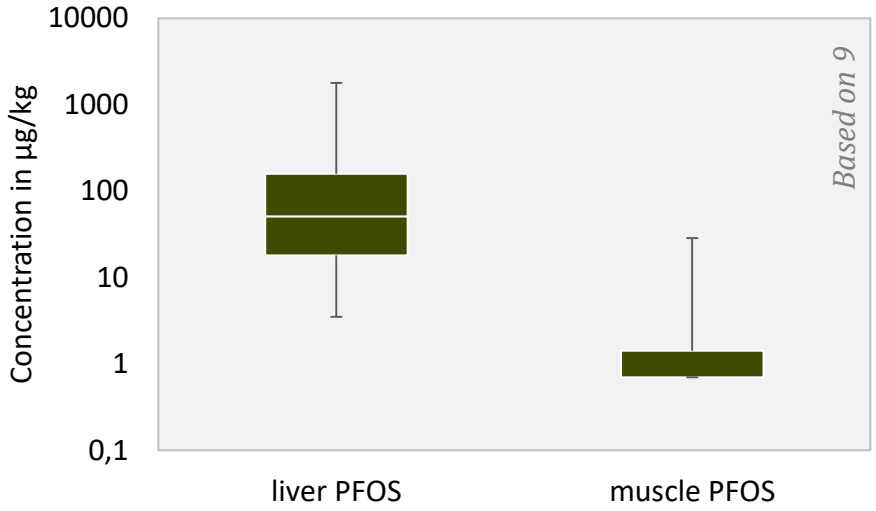
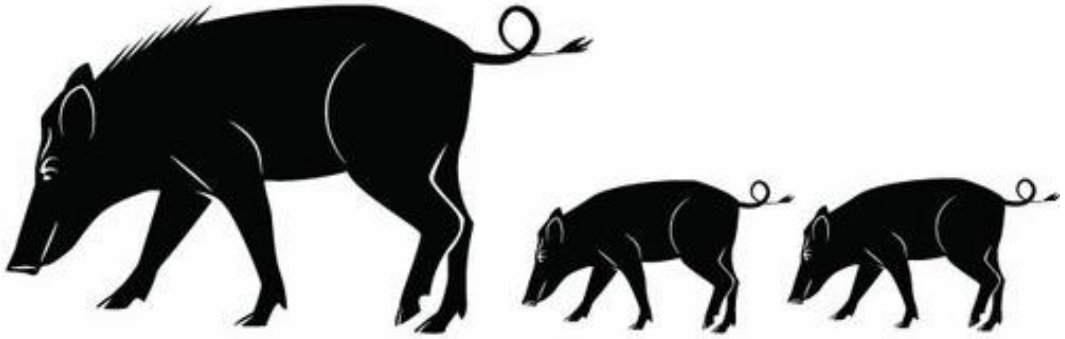
PFAS in livers are higher concentrated than in other tissue



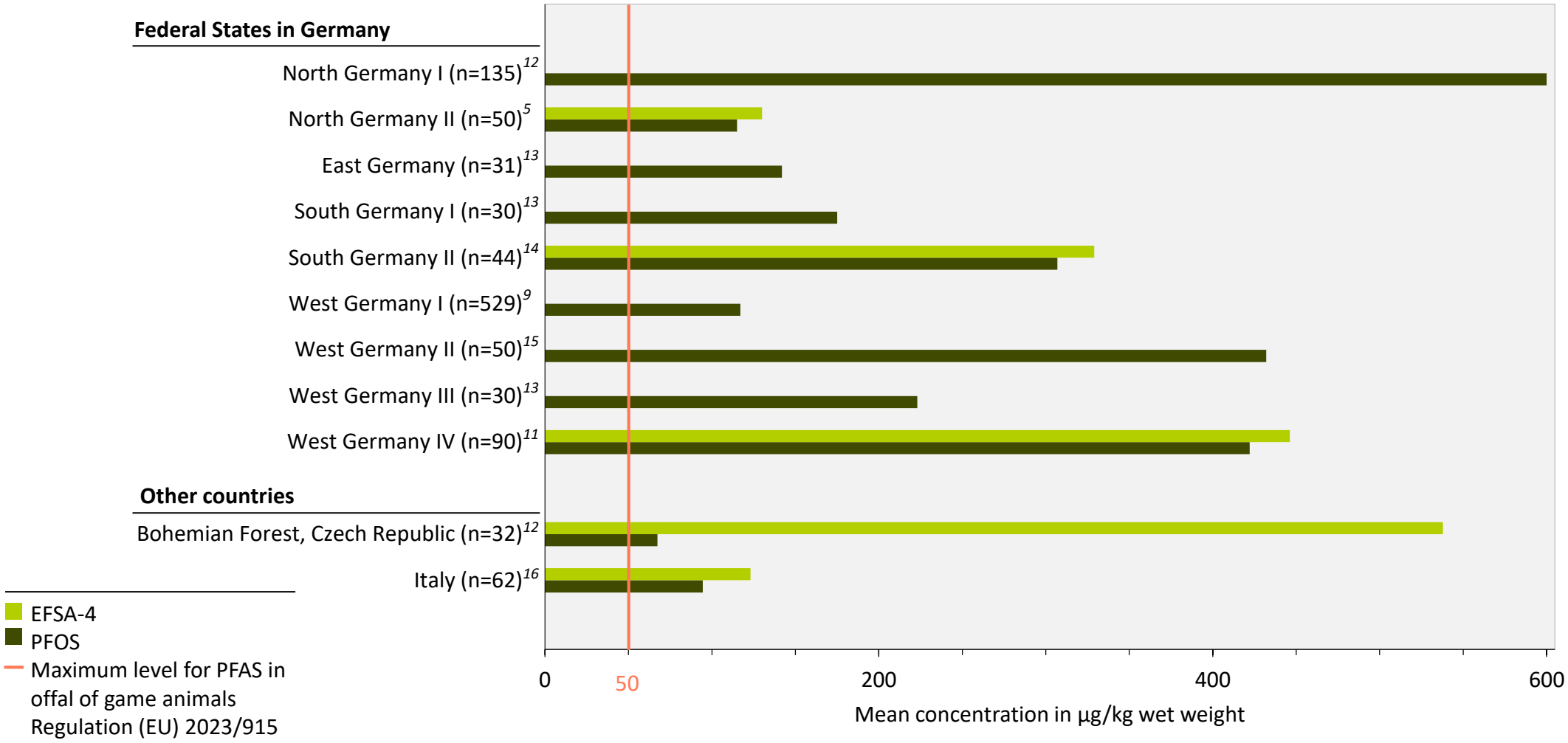
- Only 1–3% of PFOS liver concentrations determined in the muscle of wild boars (n=529) *Dervied from 9*
- Approximately 60% of EFSA-4 liver concentrations in the kidney (n=23) *Derived form 10*

Only marginal differences between sex and age of the animals detected

- PFAS transfer may occur via *in utero* gestation and lactation.[11]
- Overall, only marginal differences between piglets, male and female wild boars detected.[10,11]

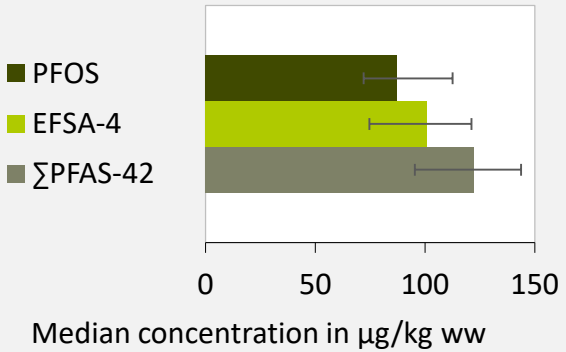


Maximum levels for PFAS exceeded in wild boar livers



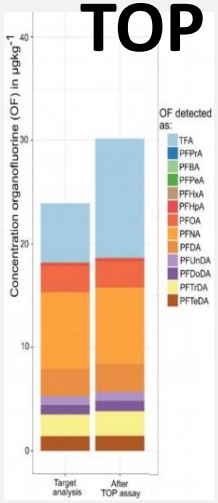
Additional PFAS detectable in wild boar livers using complementary screening approaches

Extended target analyses



Based on 17

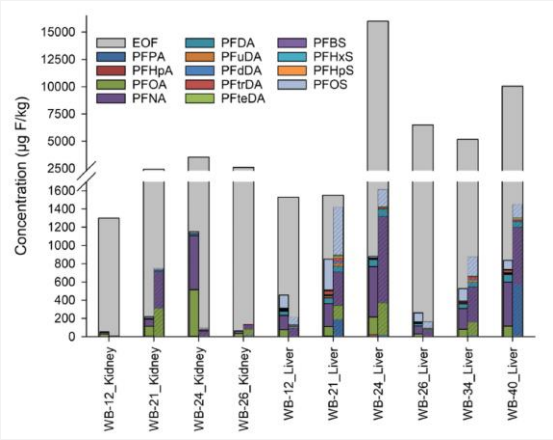
TOP assay



Total Oxidisable Precursors

Based on 17

EOF



Extractable Organo-Fluorine

10

- PFOS is the main contributor to the PFAS contamination.
- More than 25 additional PFAS were detected in wild boars, including HFPO-DA and DONA.[17]

The Federal Environment Ministry advises against consuming wild boar liver

1. Maximum levels exceeded for EFSA-4 PFAS in wild boar liver.
2. The Tolerable Weekly Intake (TWI) is exceeded in the long term by eating a 125-gram portion of wild boar liver with an average PFAS concentration once per year.

BfR Opinion 036/2024: The consumption of wild boar liver contributes to a high intake of PFAS[18]

Federal Ministry
for the Environment, Nature Conservation,
Nuclear Safety and Consumer Protection

Consumer tips on health and food safety

- The consumer tip against eating wild boar liver in Germany is independent of the age of the animal.[19]

Internal PFAS exposure of wild boars at hot-spots – a case study (1)

PFAS Contamination Patterns in Wild Boar Liver Samples and Soil Samples from a PFAS Hot Spot Area – Distinct, yet Indicative

Tobias Frische[1], Annegret Biegel-Engler[1], Marc Guckert[2], Jan Koschorreck[1], Raphaela Osterauer[3], Christina Riemenschneider[4], Jana Rupp[5], Reiner Söhlmann[6]
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[3]State Institute for Environment Baden-Wuerttemberg (LUBW) [4]State Institute for Chemical and Veterinary Analysis of Food (CVUA)
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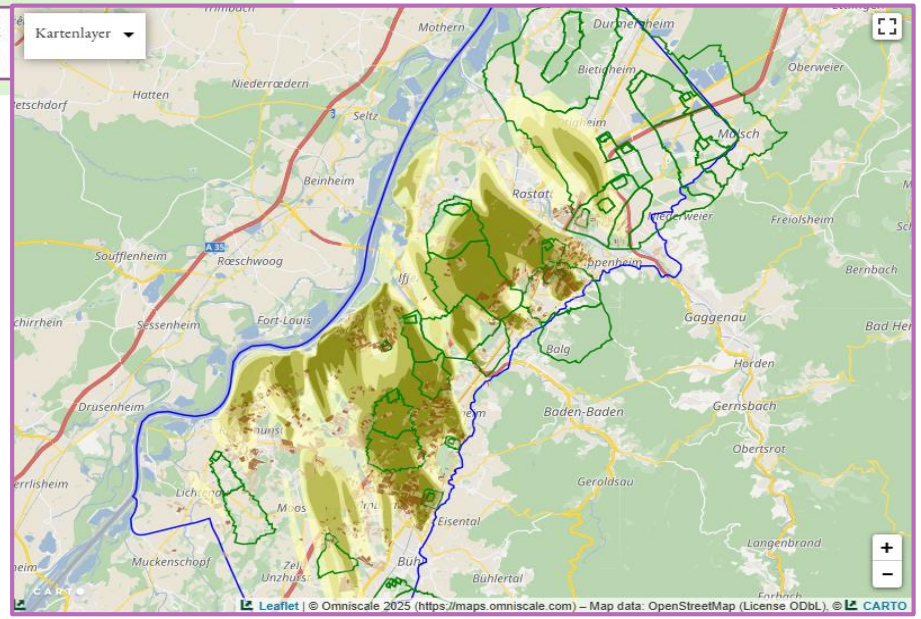
FLUOROS 2023
International Symposium on Per- and Polyfluoroalkyl Substances – PFAS
Idstein, Germany
August 31 – September 1, 2023



source: https://www.lubw.baden-wuerttemberg.de/wasser/pfc-karten-online

- **"Environmental forensic study",** i.e. combined analysis of already available/ published data
- Rastatt/ Baden-Baden (Germany) hot-spot area, about 200 km²

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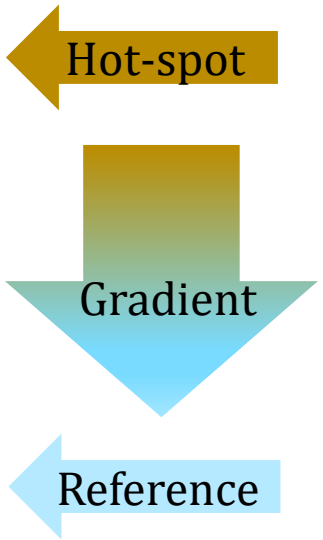
Internal PFAS exposure of wild boars at hot-spots – a case study (2)

Wild boar liver tissue sample collectives (WBL) – description and data source		
WBL hot-spot	9 samples from wild boars culled in the centre of the hot-spot area	Rupp et al. (2023)
WBL regional <40 km	17 samples from wild boars culled in the region with less than 40 km hot-spot area – assumed to be the maximum potential home range of wild boars	CVUA (2019, and personal communication)
WBL regional 40-100 km	15 samples from wild boars culled in the region with 40-100km distance to the hot-spot area	
WBL regional >100 km	15 samples from wild boars culled in the region with more than 100km distance to the hot-spot area	
WBL reference >400 km	11 samples from wild boars culled in a region with more than 400 km distance to the hot-spot area – considered as reference region (i.e. only diffuse airborne "background" PFAS contamination)	Rupp et al. (2023)

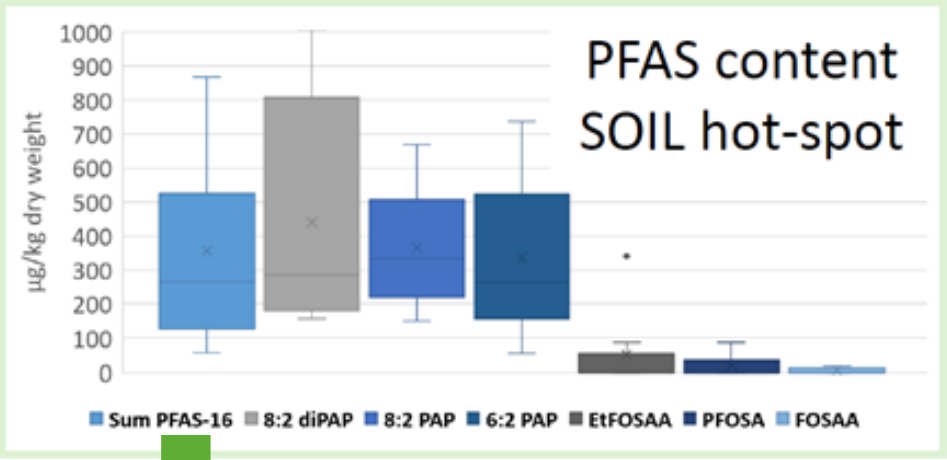


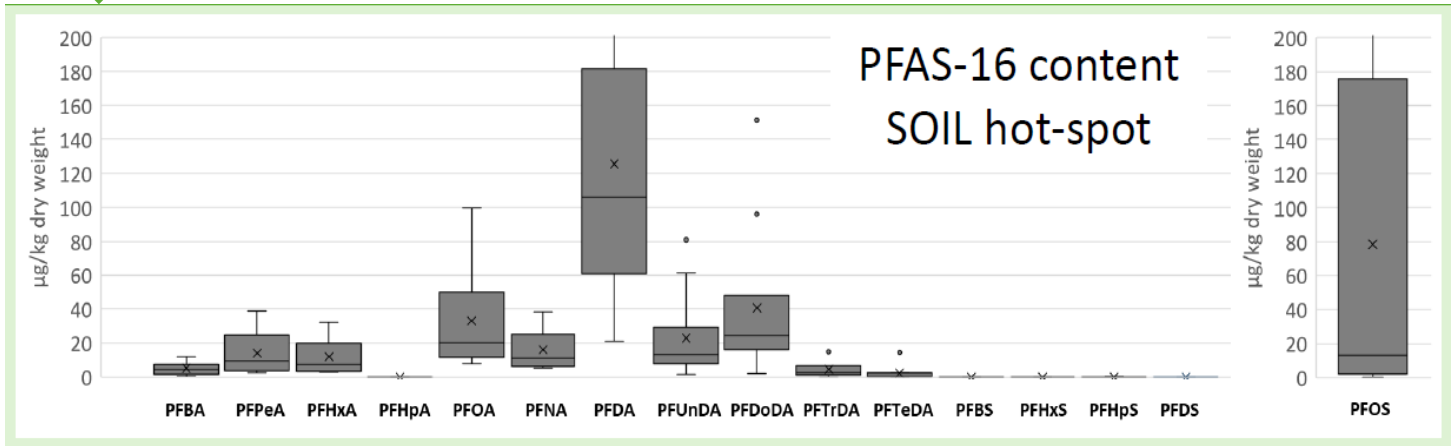
- PFAS-content of **wild boar liver (WBL) samples** from hot-spot area compared to sample collectives with increasing distance

- Target analysis included up to 42 PFAS, **focus on those 16 PFAS dominating in WBL samples (PFAS-16)**

PFAS-16 compounds	
11 PFCAs	Perfluorobutanoic acid (PFBA)
	Perfluoropentanoic acid (PFPeA)
	Perfluorohexanoic acid (PFHxA)
	Perfluoroheptanoic acid (PFHpA)
	Perfluorooctanoic acid (PFOA)
	Perfluorononanoic acid (PFNA)
	Perfluorodecanoic acid (PFDA)
	Perfluorundecanoic acid (PFUnDA)
	Perfluorododecanoic acid (PFDoDA)
	Perfluorotridecanoic acid (PFTrDA)
	Perfluorotetradecanoic acid (PFTeDA)
5 PFSAs	Perfluorobutanesulfonic acid (PFBS)
	Perfluorohexanesulfonic acid (PFHxS)
	Perfluoroheptanesulfonic acid (PFHpS)
	Perfluorooctanesulfonic acid (PFOS)
	Perfluorodecanesulfonic acid (PFDS)

Internal PFAS exposure of wild boars at hot-spots – a case study (3)



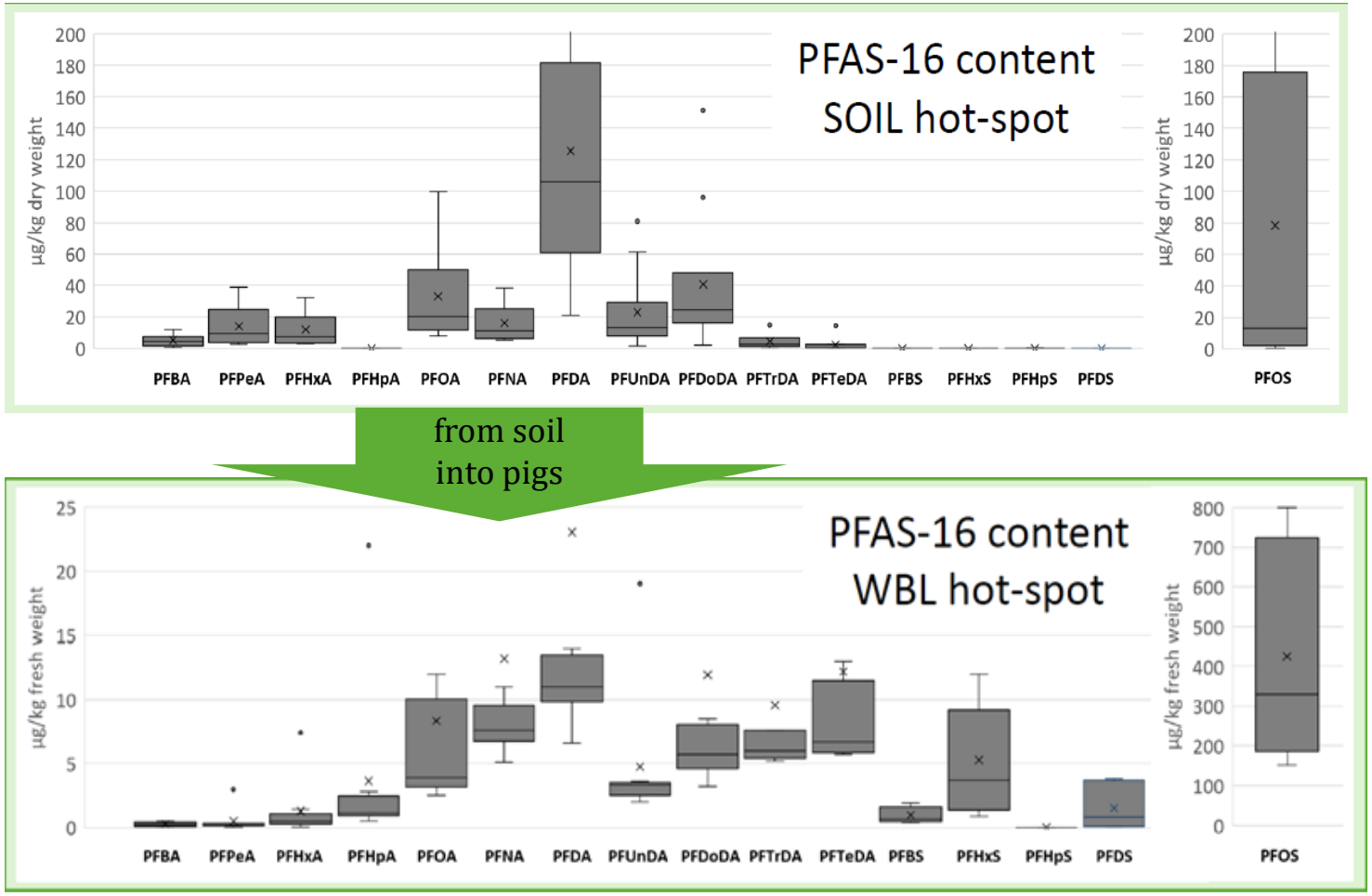


Soil samples from the hot-spot area with high total PFAS load (1248 µg/kg dry weight, median sum of 41 PFAS targets)

- Six precursor compounds make up 79% of total PFAS
- Sum of PFAS-16 makes up 21% of total PFAS, especially long-chain PFCAs and PFOS

Original data: Kotthoff et al. (2020)

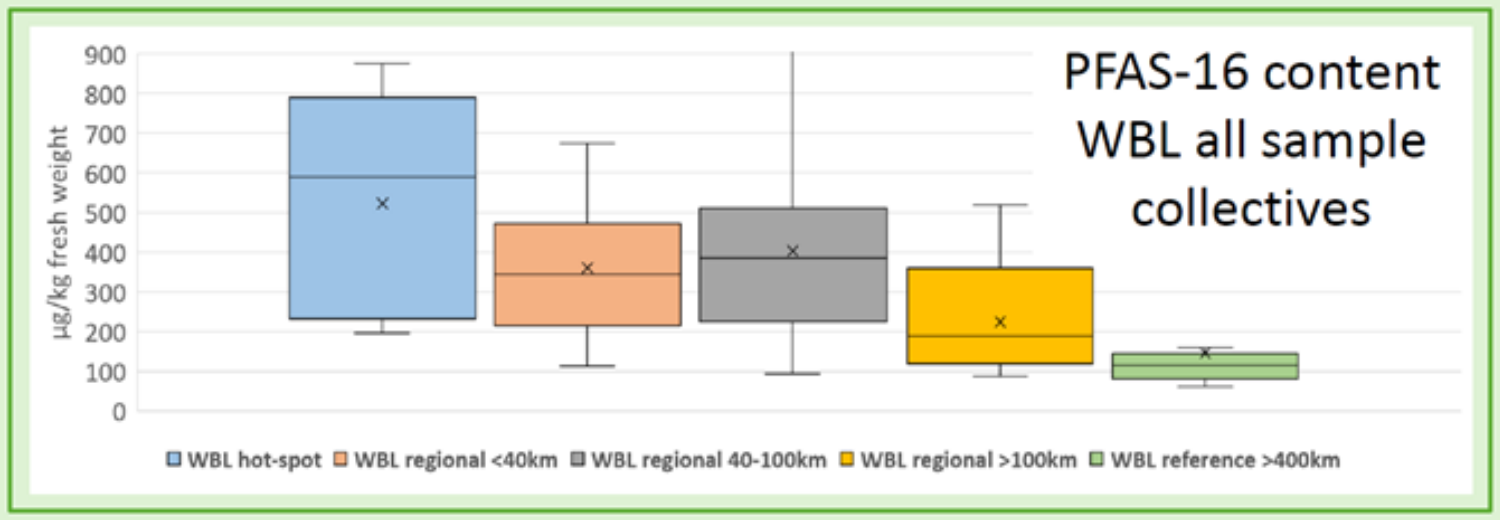
Internal PFAS exposure of wild boars at hot-spots – a case study (4)



Wild boar liver samples from the hot-spot area with high total PFAS load (590 µg/kg fresh weight, median sum content of 42 PFAS targets)

- PFAS-16 make up 99.5% of total PFAS content, especially long-chained PFAS
- PFOS contributes 83% to the sum of PFAS-16 content
- detected precursors negligible

Internal PFAS exposure of wild boars at hot-spots – a case study (5)



Increasing distance from hot-spot

PFOS:PFOA ratio				
hot-spot	<40 km	40-100 km	>100 km	>400 km (ref.)
67 (9-172)	43 (11-130)	60 (15-247)	13 (2-88)	35 (8-96)

Wild boar liver content decreasing with increasing distance to hot-spot area (at least indicated)

- Highest median PFAS-16 content in samples from hot-spot area
- Sample cohorts > 100 km and > 400 (reference) with clearly lower median PFAS-16 content and lower PFOS/PFOA-ratio
- Strong scattering in data (typical)

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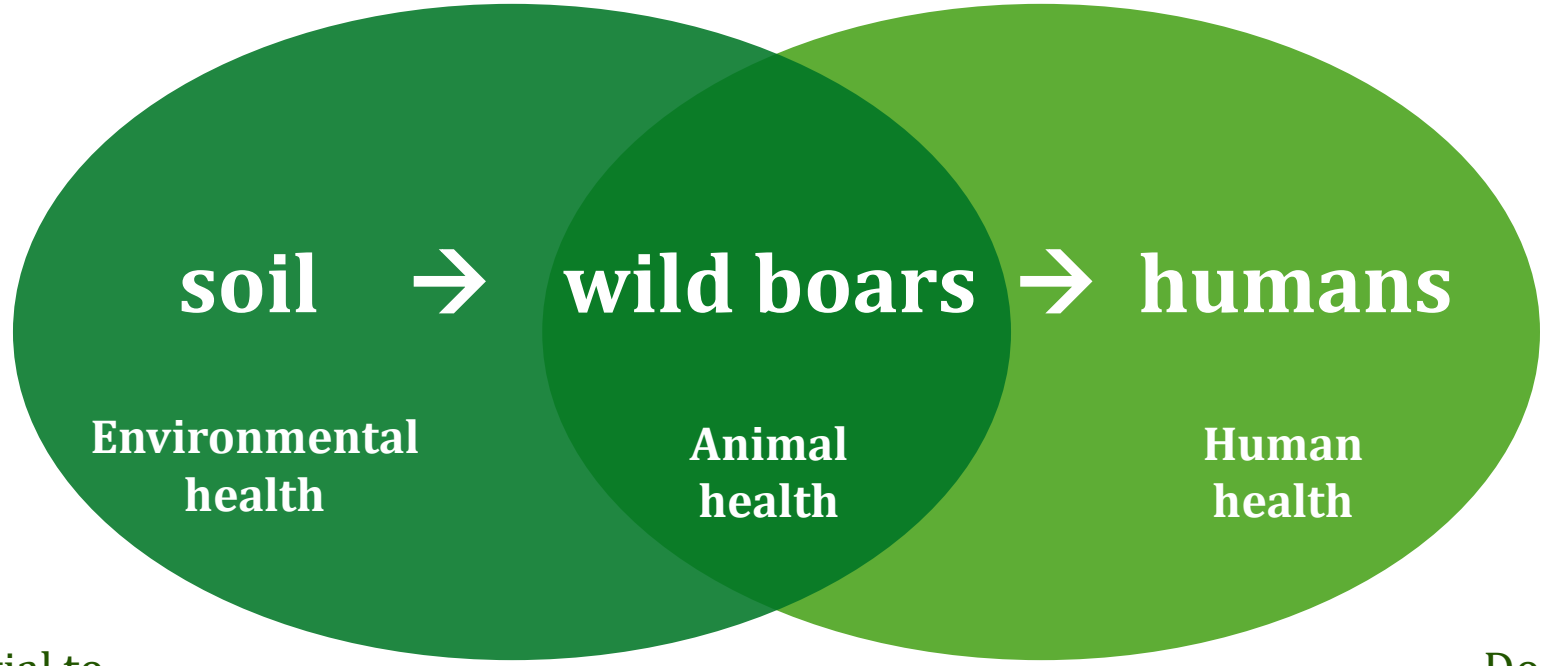
Take home messages

- **High PFAS accumulation in wild boars**
  - **in hot-spot area higher than background**
- **Wild boar livers suggested as suitable bioindicators for PFAS in the terrestrial environment**
- **Details regarding exposure pathway are still unclear (soil, plant/ animal food, drinking water)**
- **Eco(toxicolo)gical consequences of PFAS accumulation in wild boars are not known**

Take home messages

One health perspective!

High PFAS accumulation in wild boars



Potential to indicate PFAS hot-spots

Do not eat advisory for livers

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Umwelt Bundesamt

Thank you for your attention.

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References

1. Garza et al. (2018). J. Mammal. 99(1), 97–107.
2. Fielitz (2021). Ressortforschungsberichte zum Strahlenschutz, 21(182). http://nbn-resolving.de/urn:nbn:de:0221-2021080227845.
3. ENETWILD-consortium funded by EFSA (2024). https://doi.org/10.5281/zenodo.10809293.
4. DJV (2025). https://www.jagdverband.de/jagd-und-wildunfallstatistik.
5. Guckert et al. (2023) Sci. Total Environ. 875, 162361.
6. Tarazona et al. (2016). Toxicol. Lett. 241, 200–206.
7. Numata et al. (2014). J. Agric. Food Chem., 62(28), 6861–6870.
8. EFSA (2008). EFSA Journal 2008, 6(7), 1–131.
9. Stahl et al. (2012). Arch. Environ. Contam. Toxicol. 62(4), 696–703.
10. Schröder et al. (2024). Sci. Total Environ., 922, 171187.
11. Felder et al. (2023). Environ. Sci. Pollut. R. 30(6), 15575–15584.
12. LAVES (2009). https://www.laves.niedersachsen.de/startseite/lebensmittel/ruckstande_verunreingungen/-73872.html.
13. Kowalczyk et al. (2018). Arch. Environ. Contam. Toxicol. 75(4), 594–606.
14. Laufer et al. (2019). https://www.ua-bw.de/pub/beitrag.asp?subid=3&Thema_ID=5&ID=3061&lang=DE&Pdf=No.
15. Arenholz et al. (2011). LANUV-Fachbericht, 34. https://www.lanuv.nrw.de/landesamt/veroeffentlichungen/publikationen/fachberichte.
16. Brambilla et al. (2016). Organohalogen Compd., 78, 338–340.
17. Rupp et al. (2023) Sci. Total Environ. 871, 162028.
18. BfR (2024). BfR-Stellungnahmen, 36. https://doi.org/10.17590/20240802-101947-0.
19. BMUV (2024). https://www.bmuv.de/en/topics/health/overview-health/overview-food-safety/consumer-tips.
20. Frische et al. (2023): PFAS Contamination Patterns in Wild Boar Liver Samples and Soil Samples from a PFAS Hot Spot Area – Distinct, yet Indicative. FLUOROS 2023 – International Symposium on Per- and Polyfluoroalkyl Substances PFAS, Idstein, Germany, August 31 – September 1, 2023.