

The intake of copper and lead by sheep grazing on a contaminated shooting range

-A field study

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Is this a problem?



Do sheep ingest toxic amounts of metals from grazing on Norwegian shooting ranges?

- Attraction
- Soil ingestion
- Accumulation/uptake in grass
- Cu/Mo-rate
- Dose
- Liver concentration

Sample and data collection

Monitoring

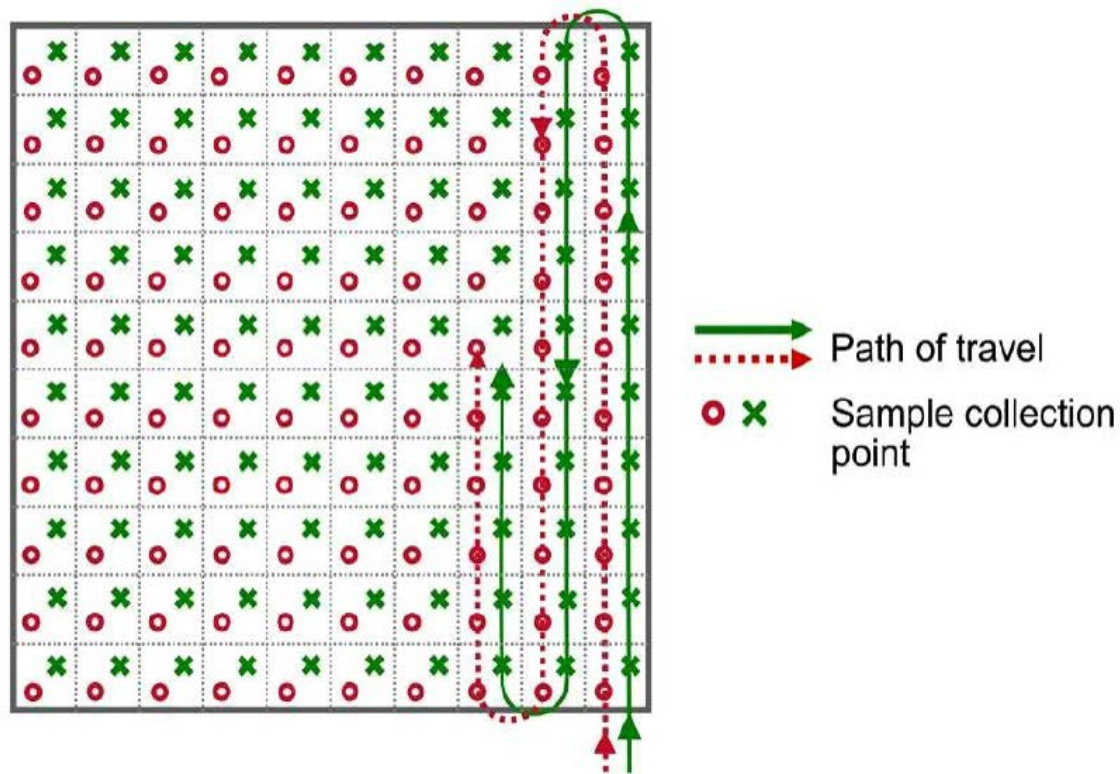
- GPS
- Wildlife cameras

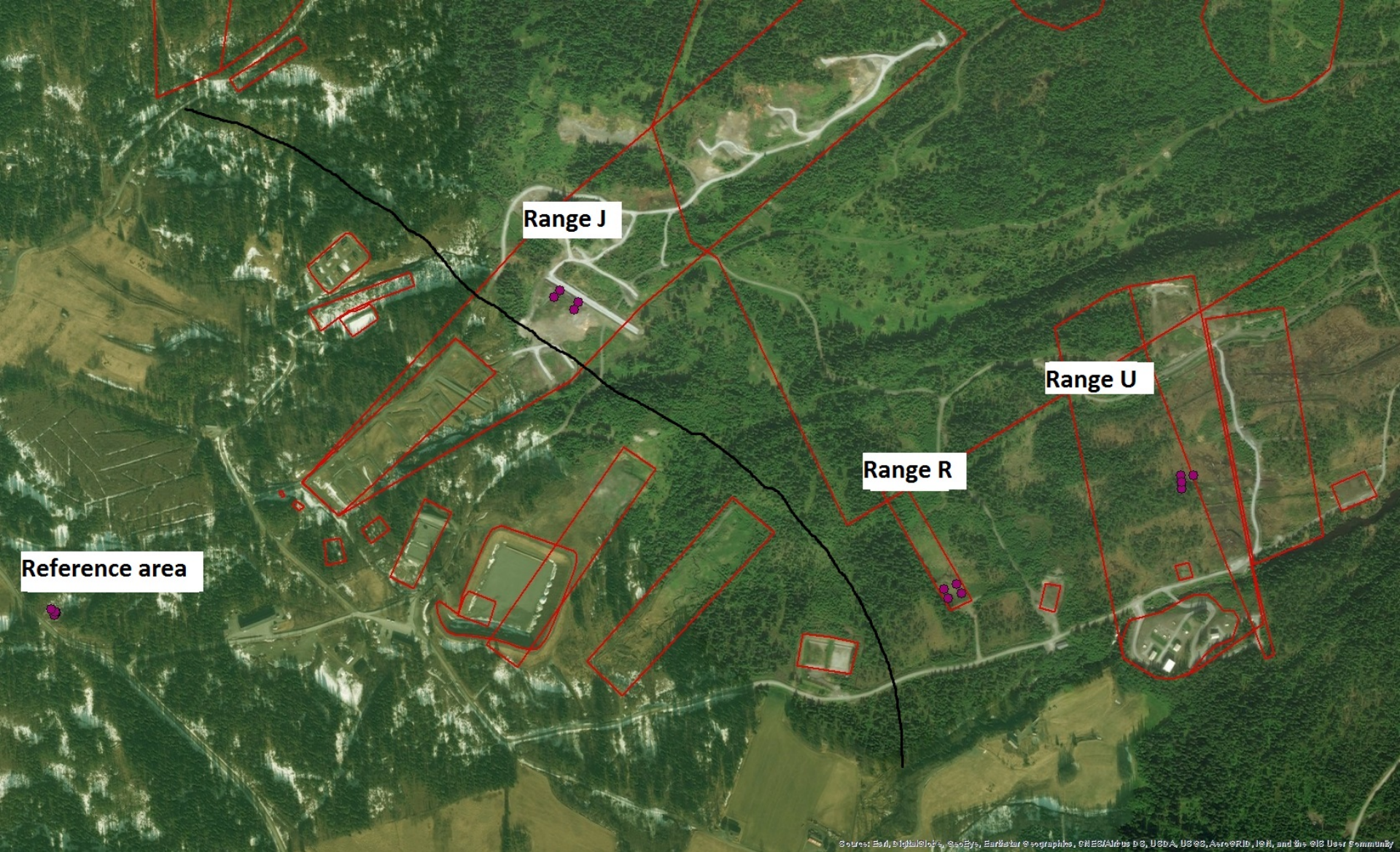
Samples in field (MIS)

- Soil
- Grass
- Feces (from sheep)

Samples when slaughtered

- Liver





Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Sample preparation and analysis

- Half of the grass in each sample was washed
- Drying
- Sieving (only soil)
- Crushing/homogenizing
- Digestion
- ICP-MS analysis

Results

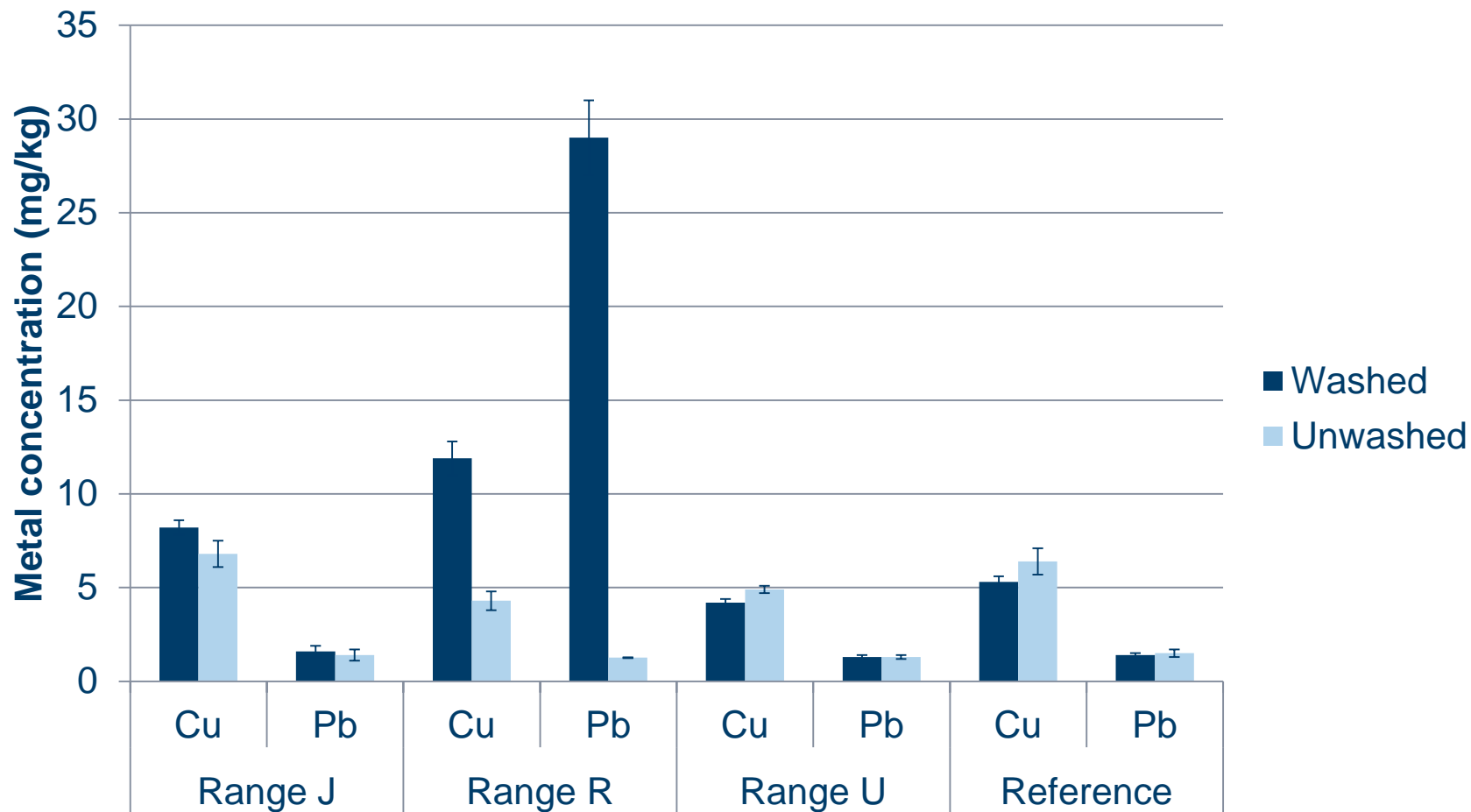


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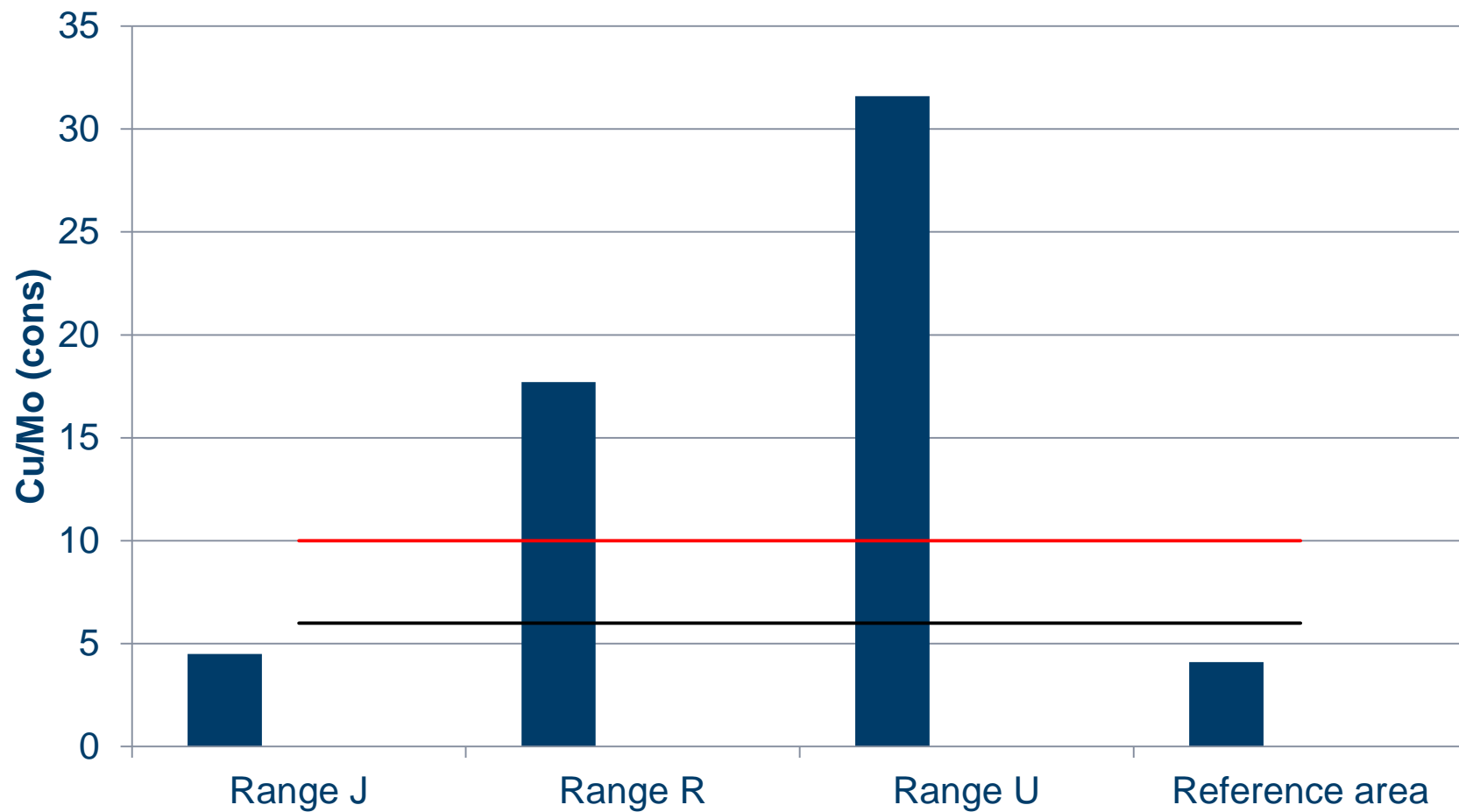
Metal concentration in soil

mg/kg	Ti	Cu	Pb
Range J	3382 ± 541	42 ± 5	41 ± 6
Range R	3696 ± 291	580 ± 44	7189 ± 1827
Range U	97 ± 9	279 ± 18	347 ± 26
Reference area	1899 ± 82	18 ± 1	55 ± 1

Metal concentration in grass



Cu/Mo-rate



Soil ingestion rate

mg/kg	Ti
Range J	46 ± 2
Range R	11.9 ± 0.2

Calculation:

$$\% \text{ Soil - ingestion} = \frac{(1 - D_v) T_{i_F} \times 100}{T_{i_S} - D_v \times T_{i_F}}$$

D_v - Digestability of vegetation (70 %)

T_{i_F} - Ti concentration in feces

T_{i_S} - Ti concentration in soil

	Range J	Range R
Soil ingestion rate (%)	0.4	0.1

Calculated dose

$$D = \frac{S \cdot F \cdot (Si_T \cdot DD + Si_V \cdot RD) + P_k \cdot F \cdot (1 - (Si_T \cdot DD + Si_V \cdot RD))}{BW} \cdot G_t$$

mg/kg BW	Lead			Copper		
	Acute		Chronic	Acute		Chronic
	Per day	Per 14 days	Per day	Per day	Per 14 days	Per day
Range J	0.13	1.8	0.029	0.23	3.2	0.052
Range R	19	269	0.11	1.7	24	0.0095
Range U	0.92	13	0.013	0.79	11	0.011
Total	-	-	0.15	-	-	0.073
Poisonous dose	600-800		6	20-100		0.26-0.35

Average concentration of copper and lead in liver of sheep

mg/kg	Cu	Pb
Shooting range	273 ± 111	0.3 ± 0.16
Vikan and Cultivated pasture	381 ± 166	0.19 ± 0.08
Normal concentration	<300	<3
Risk/sign of poisoning	>1000	>10

Conclusion

- Attraction
- Soil ingestion
- Accumulation/uptake in grass
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