Estimating the risk of cobalt deficiency in pasture soils, at a regional scale

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Introduction

Cobalt is an essential element for ruminant health, required for the synthesis of vitamin B_{12}. Inadequate dietary supply causes various metabolic disorders, leading to poor thrift and 'pine' in sheep.

Deficiency can be remediated with either direct supplementation (animal dosing) or pasture fortification, depending on pasture conditions as recommended by Teagasc (Coulter & Lalor, 2008).

Taken from table 8-2 of Coulter & Lalor (2008)

Soil cobalt index	Upper soil cobalt concentration (mg/kg)	Upper soil manganese concentration (mg/kg)		
		600	1000	>1000
1	3	High risk Treat soil[1]		
2	5	Low risk Treat soil[2]	High risk Treat animal[3]	
3	10	No risk	No risk	Low risk Treat animal[3]
4	>10	No risk	No risk	No risk

[1]Apply cobalt sulphate (21% cobalt) at 3 kg/ha to ¼ of grassland every four years[4]
[2]Apply cobalt sulphate (21% cobalt) at 2 kg/ha to ¼ of grassland every four years[4]
[3]Treat animals directly by oral cobalt drench, cobalt bullet or vitamin B12 injection
[4]Annually if high pH soil

In order to assess the risk of cobalt deficiency and identify the most appropriate remedial method, Teagasc have produced a look-up table which uses both soil cobalt and manganese concentrations.

Importantly, these thresholds are based on a soil chemical analysis that uses *aqua-regia* to extract the cobalt and manganese from the soil. This is the same method as used for Tellus Border soils, and thus we assume the Tellus Border data to be directly comparable with the Teagasc guidance thresholds.

Tellus Border soil cobalt and manganese concentrations

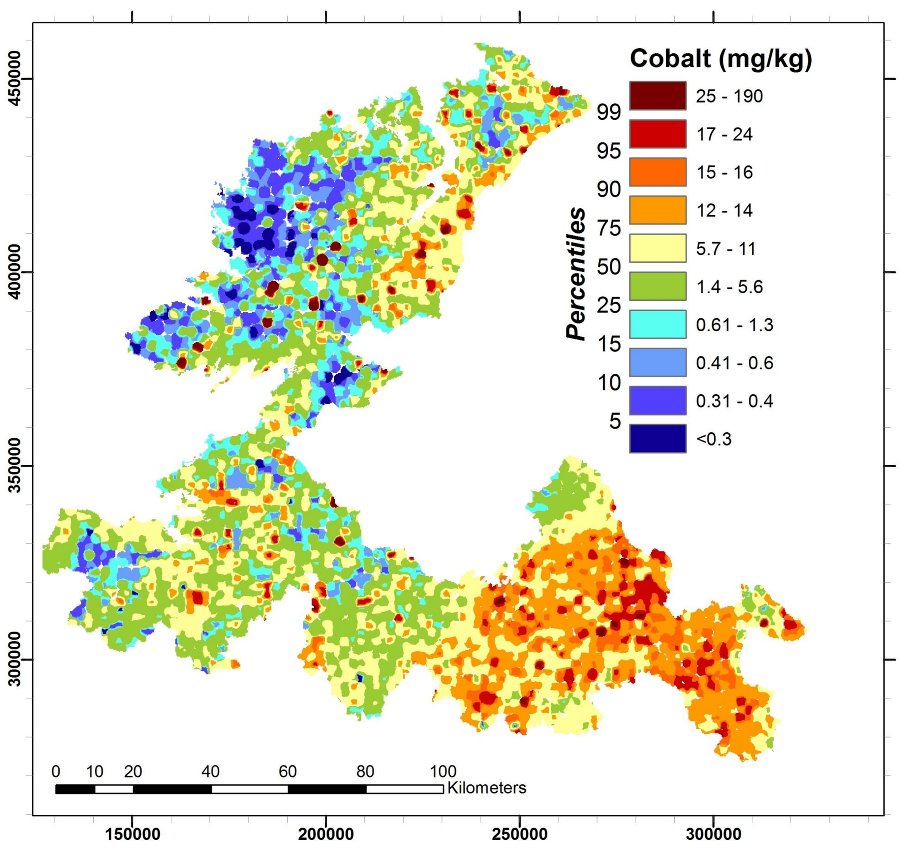


Figure 1: Soil cobalt concentrations

The Tellus Border cobalt and manganese soil data are shown here as maps, *Figure 1* and *Figure 2*.

Comparing the concentration scale of these data with the thresholds shown in the table above, it can be seen that both elements extend over the full ranges of interest in this study and suggest that regional cobalt deficiency risks can usefully be assessed.

There is a strong influence of underlying geology on the soil concentrations. This effect of soil 'parent material' is exemplified by the high concentrations of cobalt in the majority of soils in Counties Louth, Monaghan and southern Cavan. This reflects the occurrence of rocks of Ordovician and Silurian age, as well as glacial sediments derived from those rocks, where cobalt is naturally of higher concentration than in soils formed over other rock types.

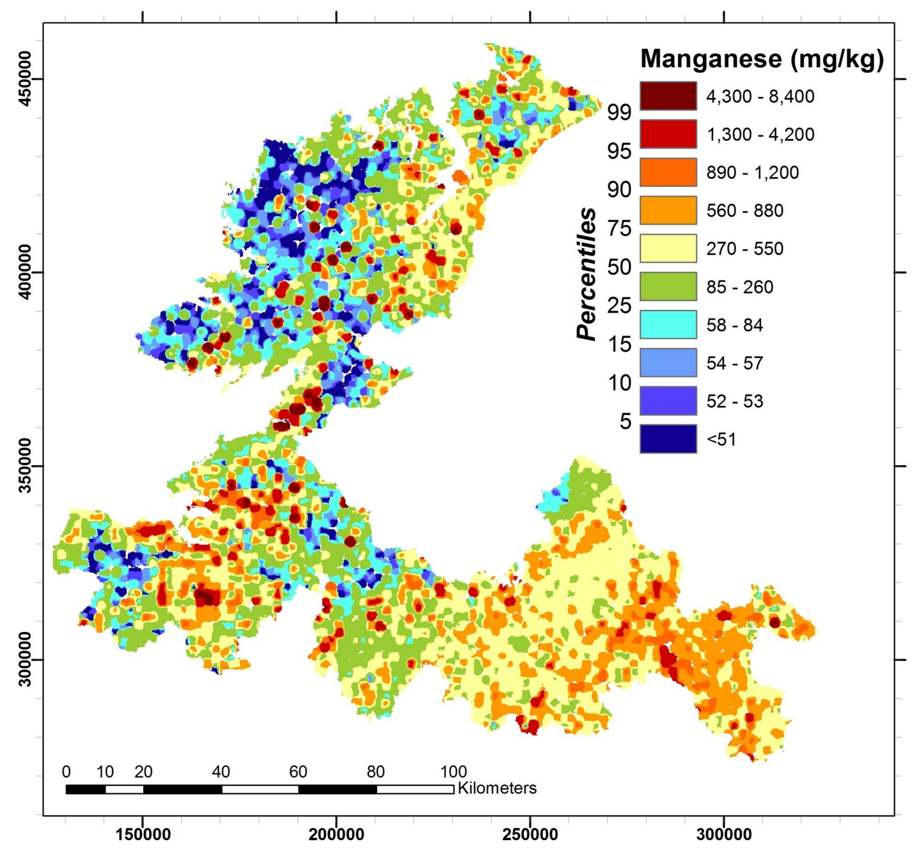


Figure 2: Soil manganese concentrations

Soil indices mapping methodology

A geostatistical approach has been used to calculate where concentrations of cobalt and manganese would be likely to give rise to cobalt deficiency in sheep, as defined by the thresholds in the table above.

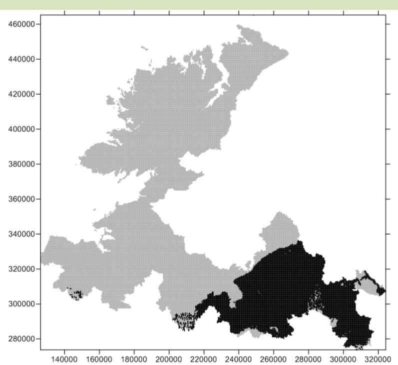


Figure 3: Sub-regions

Firstly, the data was divided into two sub-regions. This was based upon whether soil parent material was Ordovician or Silurian (Lower Palaeozoic era), or was glacial till formed from the erosion and re-deposition of Lower Palaeozoic rocks in the last glaciation. These were combined in sub-region A (black area on map) because they both imparted a typically high cobalt concentration.

The remaining sample site data was then included in the other sub-region (B), shown as a grey area on the map (*Figure 3*).

Data for these two sub-regions was transformed to meet necessary conditions of normal (Gaussian) data distribution. Because their statistical properties differed, two transformations were required: Box-Cox and Normal-scores were used for sub-regions A and B respectively.

Co-kriging of the cobalt and manganese data was then used to predict concentrations at un-sampled locations. Once a model that best described the data had been established, prediction of cobalt and manganese on a 500 × 500 m grid over the Tellus Border study area could be made (*Figure 4*).

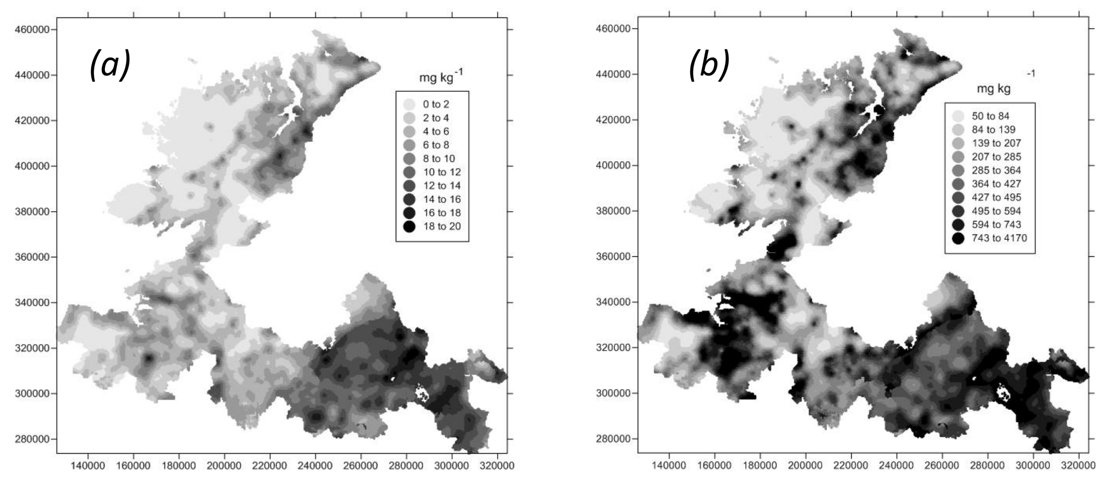


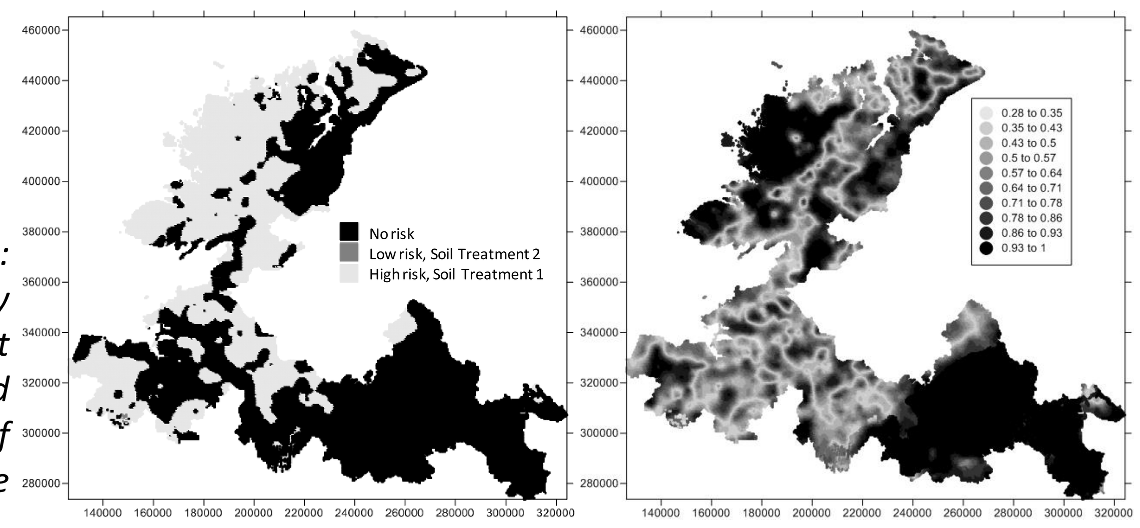
Figure 4: Conditional expectation of concentration (a) cobalt, (b) manganese concentration

Prediction of management classes

Figure 5a shows the most probable management classes in which the predictions are found to occur.

This shows that, on a regional basis, these are largely expected to give rise to a soil treatment recommendation where risk of deficiency is predicted. However, *Figure 5b* shows that there is considerable uncertainty in the prediction in some areas (probability as low as 0.28). This is due to the variability in the soil chemistry (*cf*. Figures 1 and 2).

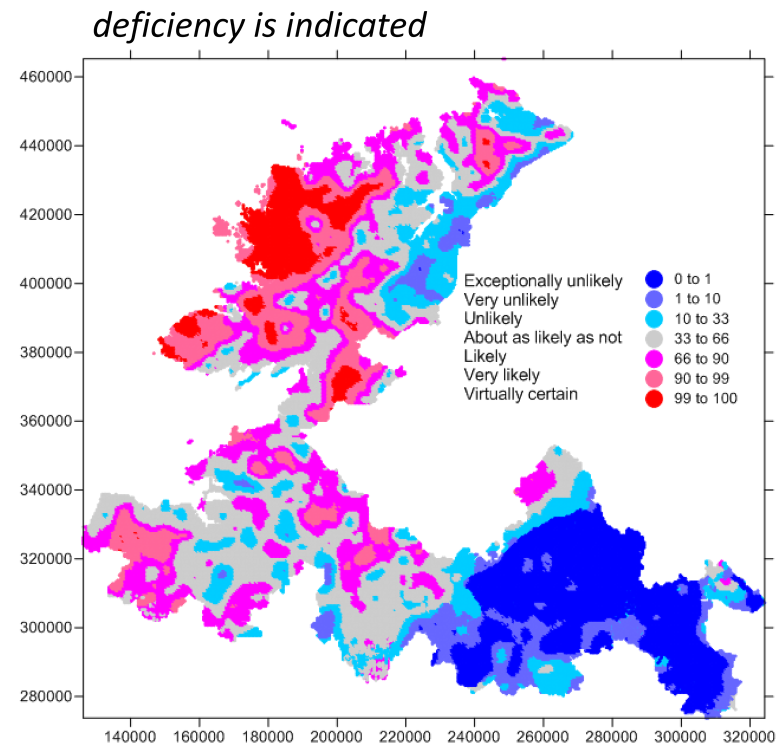
Figure 5: Most likely management class and probability of that outcome



Probability of intervention and type of intervention being required

The probability that topsoil cobalt and manganese concentrations will give rise to cobalt deficiency is mapped in *Figure 6*. Blue colours indicate that risk of deficiency is unlikely, whilst the converse is true where red colours are found. Grey colours are used for the prediction being 'about as likely as not'.

Figure 6: Probability that a cobalt deficiency is indicated



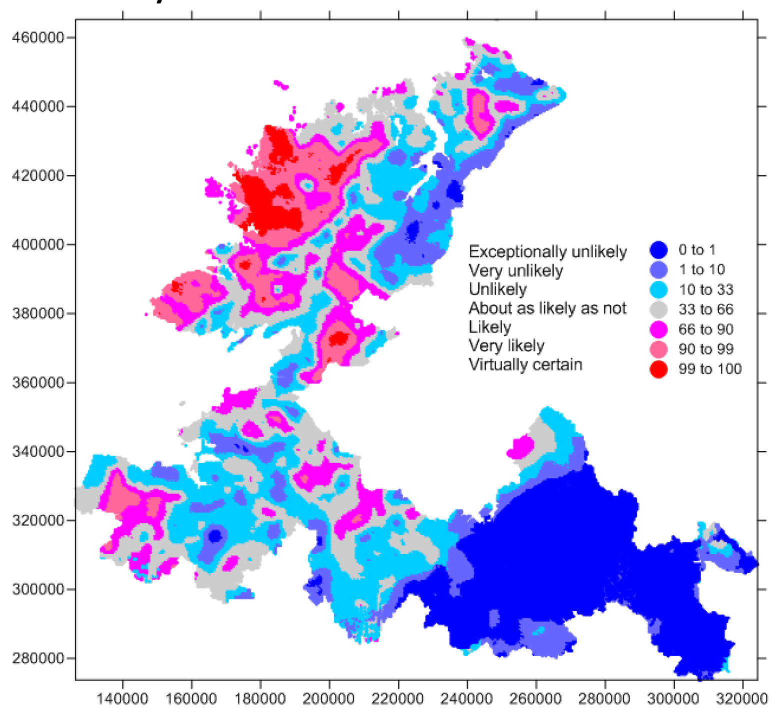


Figure 7: Probability that soil treatment 1 is indicated.

An example is shown in *Figure 7* of the prediction that intervention by soil treatment 1 (see table) will be required, using the same verbal scale as for Figure 6. The numerical probabilities are also shown on this scale.

Summary

We have shown that data from a regional geochemical survey can be combined with agronomic guidance to produce a probability map of likely deficiency based on the soil cobalt and manganese concentrations.

This information could benefit regional understanding of likely conditions, and locally may be useful for decision making. For instance, if it is 'exceptionally unlikely' that cobalt is deficient, the costs of local soil sampling for this are unlikely to be justified, let alone those of any intervention.

Uncertainty calculations used here do explicitly include the spatial variability of cobalt and manganese concentrations and predict at a 500 m grid scale. However, we do not include uncertainty on how grazing livestock respond to local conditions. We also differentiate between appropriate interventions based on the Teagasc guidance, rather than because animal treatment will not necessarily be an efficacious intervention for cobalt deficiency.

Reference: Coulter, B.S., Lalor, S., 2008. Major and Micro Nutrient Advice for Productive Agricultural Crops (3rd Ed). Teagasc, Johnstown Castle, Co. Wexford, Ireland.

The Tellus Border Results and Research Conference
24th October 2013. Hillgrove Hotel, Co. Monaghan, Ireland

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