Risk assessment of soil compaction in Walloon Region (Belgium)

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Objective

To identify zones sensitive to compaction in the Walloon Region (RW) (Belgium) and to map them.

Context

Soil compaction depends on interaction between soil characteristics (permanent and variable) and agricultural or sylvicultural practices. In RW, beetharvest could generate high compaction because it happens during a wet season and machines (loader or self propelled complete machines) have axle load that may exceed 10 tons.

Fig.1. Self propelled complete machine

Method

Two stages of mapping

I. Map of soil compaction sensitivity

- Precompression stresses (Pc) are calculated at two pF values (1.8 and 2.5) and two depths by Pedotransfer Functions (PTFs) of Lebert & Horn (1991).
- These PTFs require soil characteristics (texture, organic carbon content, bulk density, …)
- These parameters are available in Aardewerk database (granulometry, organic matter content) and in literature: saturated hydraulic conductivity (Mualem-Van Genuchten, 1992), bulk density (Manrique & Jones, 1991), cohesion and angle of internal friction (Van den Akker, 2004), ….

Table 1. Classification of the precompression stress

Pc (kPa)	Soil sensitivity	Colour on map
High (up to 400)	very low	
	low	
↓	medium	
	high	
Low (until to 10)	very high	

Map of soil compaction sensitivity

Legend
Precompression stress (kPa)
Value
High : 411.5 (Very low soil compaction sensitivity)
Low : 11.3111 (Very high soil compaction sensitivity)
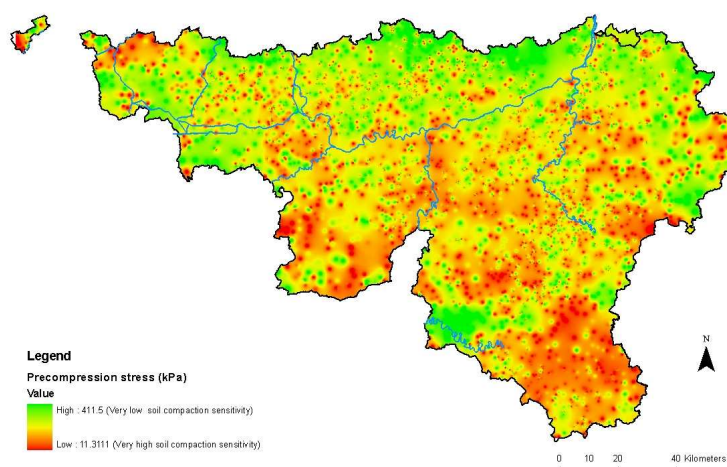
0 10 20 40 Kilometers

Fig.2.

II. Potentially compacted soils

Calculation of vertical stress (σ_z) distribution induced by the passage of a machine is performed by the software Soilflex (Keller, 2005).

Hypotheses

- A 'superellipse' shape (Keller,2005) is used to represent vertical constraints distribution of tire-soil contact
- In-depth distribution of σ_z and contact area depend on a stress concentration factor (ξ) which characterizes their spatial distribution.
- The self propelled Holmer TerraDos is considered as an example (Table 1).

Table 2.

Net weight (kg)	Hopper capacity (t)	Axles number	Front wheels		Back wheels	
			Inflation pressure	Naming	Inflation pressure	Naming
23580	18	2	2.2	800/65 R32	2.2	72/44.00 R32

Comparison of Pc and σ_z
If Pc > σ_z → Elastic behaviour of soil
If Pc < σ_z → Plastic behaviour of soil

Vertical stress σ_z (kPa)

0-20 20-40
40-60 60-80
80-100 100-120
120-140 140-160
160-180 180-200
200-220 220-240
240-260 260-280
280-300 300-320
320-340 340-360

à 30 cm Sigma z > Pc

Pc (180.5kPa) < σ_z (220-240 kPa)
→ Soil will be durably compacted in a 30 cm depth

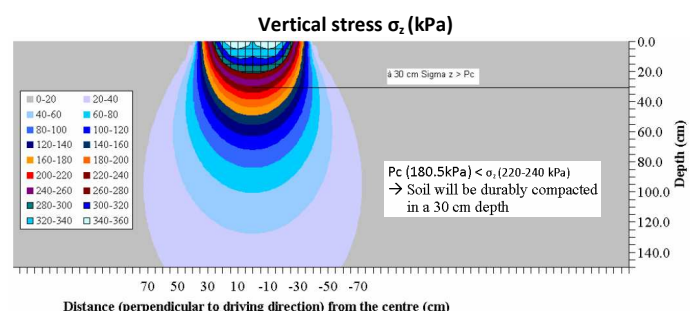Distance (perpendicular to driving direction) from the centre (cm)

Fig.3. Vertical stress distribution. Passage of a beetharvester Holmer TerraDos on a loamy soil (Hannut, Belgium).

III. Experimental measurement of Pc on sites

To analyse the machine influence, oedometric tests are performed before and after machine passages on agricultural and forest sites in RW.

Fig.4. Soil sampling for oedometric test.

Fig.5. Automatic oedometer.