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Overview of AAFC Soil Health Research and a Soil “Fingerprinting” Framework for Soil Health Assessments

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Canada

Soils Expertise within AAFC

Staff with Soils Expertise

in the following subject areas:

- 26 Researchers
- 42 Science professionals
- 40+ Technicians
- Numerous students

- Environmental Modelling (2)
- Nutrient Cycling (37)
- Soil Ecology (12)
- Soil Erosion (3)
- Landuse Planning (6)
- Geomatics & Earth Observations (21)
- BMP development and analysis (27)

 **Research, Development and Transfer Centres**

**Centre for Agricultural Climate,
Geomatics and Earth Observation**

Ottawa
St-Jean-sur-Richelieu
Sherbrooke
London
Guelph
Harrow

AAFC Soil Health-Related Priorities

- **Conserve soil resources** and **reduce** soil chemical, biological and physical **degradation** to improve productivity
- Develop **soil management practices** to maintain or improve soil health
- Understand chemical, physical and biological processes that lead to **N and P losses** from agricultural lands (into **surface, groundwater and atmosphere**) and develop diagnostic tools to identify soils at risk
- Identify **BMPs to mitigate** major regional **water, soil, and air contamination** issues
- Understand role of **diversified agricultural landscapes** in optimizing services/benefits that support sustainable intensification of production
- Use an **integrated ecosystem function approach** to maintain sustainable high output agricultural systems
- **Forecast and analyze** the impact of **extreme weather events** to develop more adaptive and resilient crop and livestock production systems
- **Transfer knowledge** to the sector in the form of **decision-support tools**

.....large number and variety of projects

Soil Health



Soil Health



**Bulk
Density**

Structure

Permeability



**Bulk
Density**

Structure

Permeability

Physical Characteristics

Chemical Characteristics

Soil Health



Bulk
Density

Nutrients

Structure

Organic Matter

pH

Electrical
Conductivity

Permeability



Bulk
Density

Nutrients

Structure

Organic Matter

pH

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Conductivity

Permeability

Physical Characteristics

Chemical Characteristics

Biological Characteristics

Soil Health



Bulk
Density

Soil biota
populations

Nutrients

Structure

Organic Matter

pH

Electrical
Conductivity

Microbial
processes

Ecotoxicity

Permeability



Bulk
Density

Soil biota
populations

Nutrients

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pH

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Microbial
processes

Ecotoxicity

Permeability

Physical Characteristics

Chemical Characteristics

Biological Characteristics

Soil Health

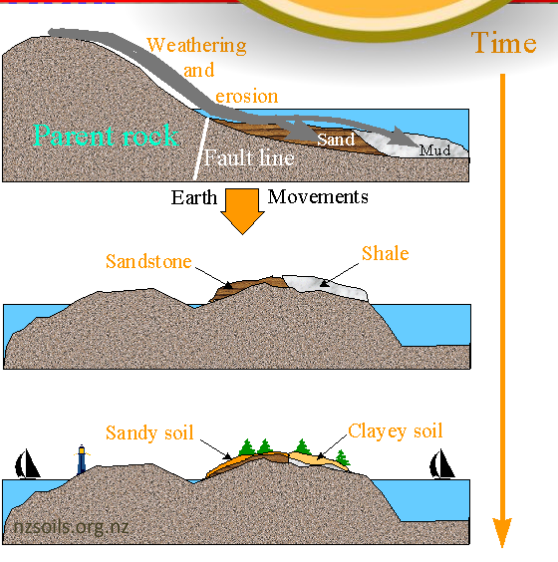
Soil Formation Processes



contextual
information...



Bulk



Ecotoxicity

betterground.org

Soil biota
populations

Organic Matter

Microbial
processes

Permeability

Bulk
Density

Nutrients

Structure

pH

Electrical
Conductivity

Ecotoxicity

vro.depi.vic.gov.au

Organic Matter

Soil biota
populations

Microbial
processes

Permeability

Physical Characteristics

Chemical Characteristics

Biological Characteristics

Soil Health

Soil Formation Processes

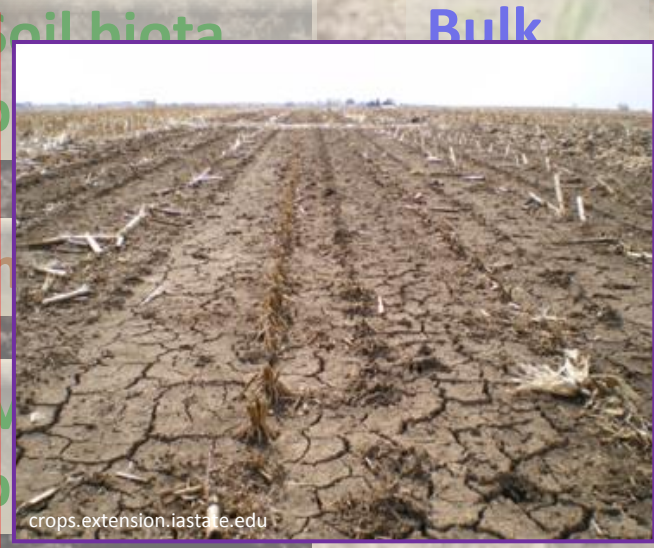
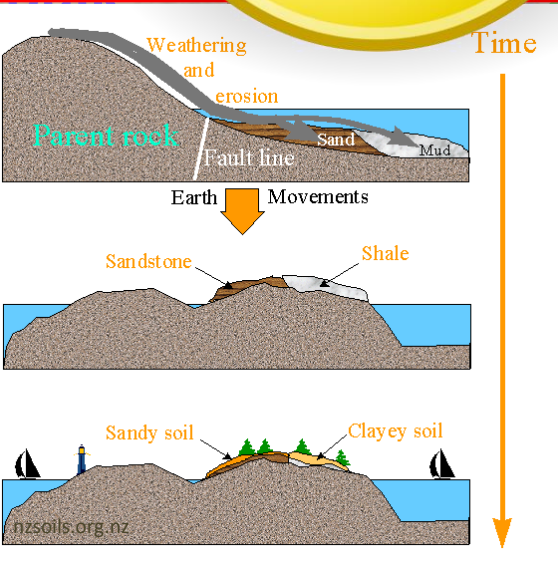
Land Surface Conditions



contextual
information...



Bulk



Bulk

Soil biota
populations

Nutrients

Organic Matter

Microbial
processes

Electrical
conductivity

Ecotoxicity

Permeability

Permeability

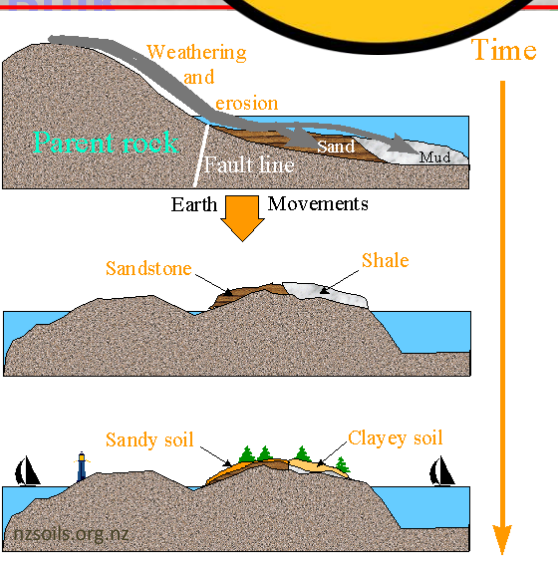
Physical Characteristics
Chemical Characteristics
Biological Characteristics

Soil Health

Soil Formation Processes
Land Surface Conditions
Land Use/Management



contextual
information...



Ecotoxicity Permeability Ecotoxicity Permeability

[nzsoils.org.nz
betterground.org](http://nzsoils.org.nz/betterground.org) vro.depi.vic.gov.au

AAFC Soil 'Fingerprint' Framework

- Based on soil taxonomic principles, it uses syntax and symbology rulesets to describe the characteristics of a soil sample in a single line of code that is *unique to that soil sample at the time it was collected*
- It succinctly integrates quantitative and qualitative data

An **Ap** horizon with **morainal deposition** with **coarse subangular blocky structure** with a **bulk density** estimate of **1.2 -1.4** and a measured value of **1.3 Mg m⁻³**; it is a **heavy clay soil** with an estimated **medium level of organic carbon** and a measured value of **2.1%**. It is **weakly acidic** with a **pH range** of **6.1-6.5** and a measured value of **6.2** and is considered **non-saline** with a measured **conductivity value** of **1.2 dS/m**. It has been **recently cultivated** and subjected to **wheel traffic** from its **agricultural land use** cultivating **cereal crops** on a **simple 3% slope** at the **toe-slope position**.



mAp[c.sbk;BD2/1.3]HC(m;2.1){wa;6.2/N;1.2};R;WT/aC/sTS3

Basic A Horizon 'Fingerprint' Framework

Environment Prefixes		Soil Process	Soil Structure; Bulk Density	Organic Carbon	pH/Electrical Conductivity	Soil/Land Context Information
Level 1-p	A	Level 1-s	[Level 2]	(Level 3)	{Level 4}	Level 5: A,B,C,D



Required

+

Any of Levels 1-p and 2 to 5 can be added

Full-detail Generic Soil Fingerprint:

Level 1-p A Level 1-s # [Level 2] Level 5A (Level 3) {Level 4};Level 5B/Level 5C/Level 5D



Full-detail Unique Soil Sample Fingerprint

mAp2[70m.sbk2+30vf.gr1;BD2/1.3]SiCL(m;2.1){wa;6.2/N;1.1};R;WT/aC/sMS3

Site Location:

Notes

Ref. No. 1: Luttmerding (1981). Ref. No. 2: Ellis et al. (1965). Ref. No. 3 and No. 4 from Woodslee Long-Term Study; Woodslee Ontario, assessed by C. Fox.

[illegible]

Soil Fingerprint Code: Minimum Detail: Dynamic Soil Properties

Name C. Fox

Site Location:	Gobles Soil (GO)					
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[Level 2] Soil Structure Characterization (up to maximum of 4 types) and Bulk Density

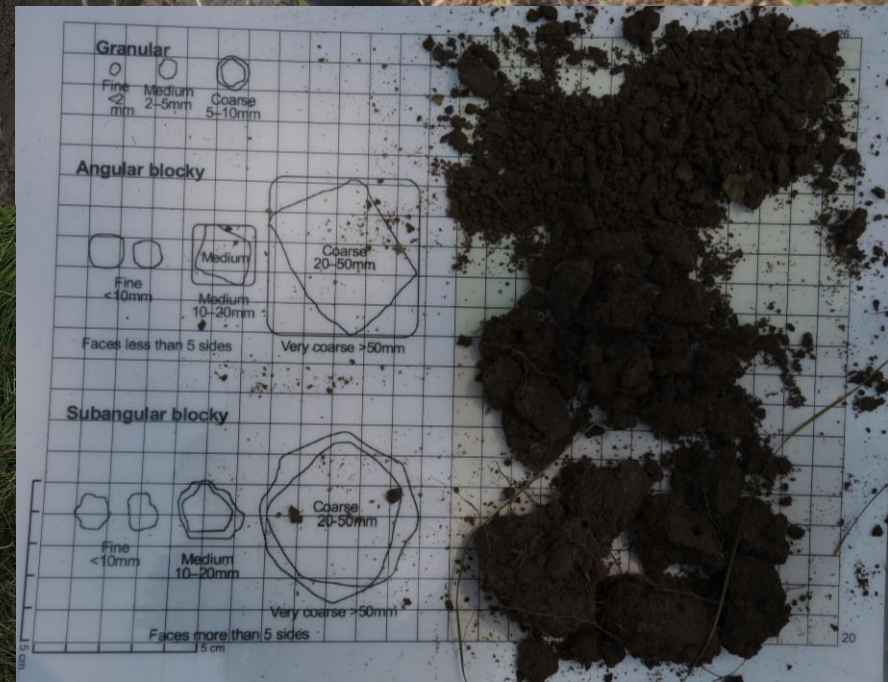
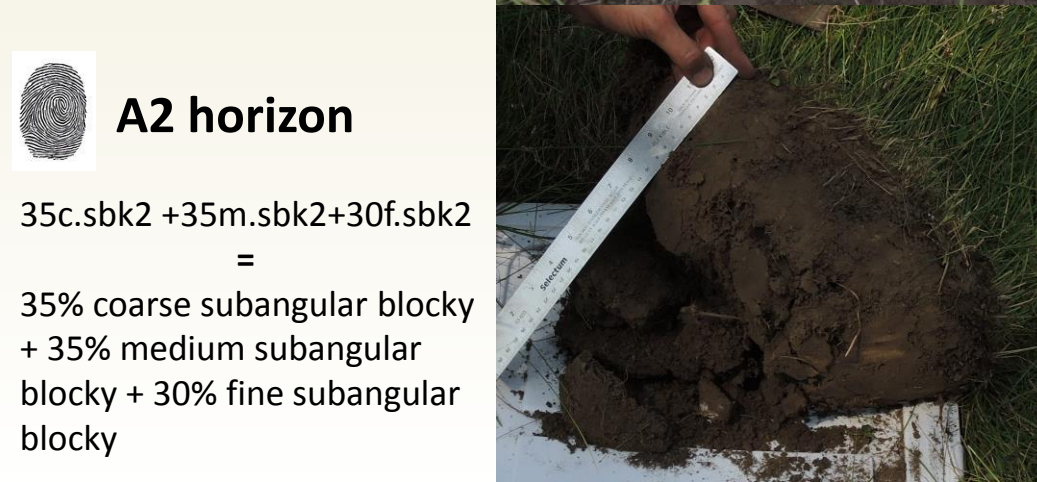
[illegible]

Soil Structure Description

- Systematic
- Detailed
- Quantitative and qualitative
- Multiple A horizons

Includes:

- Structure type, size, consistency
- Proportion of different types



A2 horizon

35c.sbk2 + 35m.sbk2 + 30f.sbk2
=

35% coarse subangular blocky
+ 35% medium subangular
blocky + 30% fine subangular
blocky

Additional endpoints can be added to meet user needs: e.g., yield, rotation, tillage, residue, microbial processes, # earthworms, *etc.*

Level 6: Cropland

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Reference Number Identifier	Field Site	Plot	Repl. No.	Depth (cm)		Level 6: Cropland				
				Upper	Lower	Tillage	Crop	Cropping	Current	Yield
						System	System	Method	Crop	Est.

Yield Estimate

xh Extremely High
h High
av Average
lw Low
xl Extremely Low

Cropping Method

Ym Monocropping
2Y 2-year rotation
3Y 3-year rotation
4Y 4-year rotation

Crop System

c conventional
or organic
ipm integrated management
in industrial (biofuels)

Tillage System

CN Conventional (moldboard plow)
CV Conservation (Minimum tillage, disk)
NT No-till
ZT Zone till
RT Ridge tillage
CH Chisel plow
RD Reduced tillage (shallower plow depth)
SF Summer Fallow

Current Crop

W Wheat	R Rye	Ps Pasture	Cl Clover
S Soybeans	sB Sugar beets	V Grapes	
Cf Field Corn	Hp Peppers	Bk Buckwheat	
T Tomatoes	Oa Apples	Sp Specialty crop	
P Potatoes	Op Peaches	Bn Beans - Pulses	
Af Alfalfa	Oc Cherries	Fx Flax	
B Barley	Ops Pears	M Mustard	
Cn Canola	Hr Raspberries	Sn Sunflower	
O Oats	Hs Strawberries	Tb Tobacco	
Cs Sweet Corn	Rp Rapeseed	N Nursery	

Long-Term Crop Rotation Trial (since 1959): Different Rotations, Same Soil Type

Conventional Tillage; silty clay loam; Humic Gleysol (Woodslee, Ontario, Canada)



Ahp[fm.gr+pc/fm.sbk;BD1](6.0)

Apfn[bk-sbk+py+gr;BD2](2.8)

Apg[cd-sbk;BD3](2.3)

Long-Term Cover Crop Trial (since 2007): Tomatoes + Cover Crops, Same Soil Type
Conventional Tillage; sandy loam; Typic Hapludafts (Ridgetown, Ontario, Canada)

Treatment	Horizon Depth A1(cm)
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No cover crop	15	gfAp1[30csbk1+60fsbk1+10fgr1]SL(3.05){5.87};B/aH/SL
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Oat	17	gfAp1[45csbk1+15fsbk1+15cgr1+25fgr1]SL(2.77){6.36};CR/aH/SL
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Oilseed Radish (OSR)	21	gfAp1[35csbk1+15fsbk1+25cgr1+25fgr1]SL(2.61){6.54};CR/aH/SL
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Cereal Rye (CR)	15	gfAp1[30csbk1+20fsbk1+30cgr1+20fgr1]SL(2.96){6.07};CR/aH/SL
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OSR + CR	18	gfAp1[35csbk1+20fsbk1+15cgr1+30fgr1]SL(3.11){6.54};CR/aH/SL
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Long-Term Cover Crop Trial (since 2007): Tomatoes + Cover Crops, Same Soil Type
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On-going work



- Developing guidance for soil structure description
- Developing interpretation for individual fingerprints
- Continued field application in soil health assessments
- Integration into other soil assessment frameworks/monitoring?



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Questions?

Contact: natalie.feisthauer@agr.gc.ca

Soil Fingerprint Framework Description:

Fox, C.A., Tarnocai, C., Broll, G., Joschko, M., Kroetsch, D. and Kenney, E. 2014. Enhanced A Horizon Framework and Field Form for detailed field scale monitoring of dynamic soil properties. *Canadian Journal of Soil Science* 94: 189-208

Recently Published New Field Application:

Störrle et al., 2016. Soil structure of arable and non-arable land in the Western Siberian Grain Belt in Russia—Application of the soil fingerprint code for topsoil characterization. *J. Plant Nutr. Soil Sci.* 2016, 179, 510–519

Canada 