Categorizing European soils according to their ability to retain or transmit diffuse source pollutants

Objectives for creating FOOTPRINT Soil Types

> To identify **a limited number** of soil types suitable for modelling environmental fate of pollutants across Europe.

> To represent the **complete range** of relevant **pollutant transfer pathways** from the soil surface to water resources.

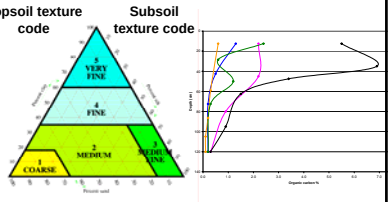
> To represent the **complete range** of soil **sorption potential** relevant to 'reactive' pollutants.

Defining FOOTPRINT Soil codes

FOOTPRINT Soil class:

L 4 4 n

- **Hydrological code**
- **Topsoil texture code**
- **Subsoil texture code**
- **Sorption attributes code**



The Hydrological Component

> A combination of the Hydrology Of Soil Types system - **HOST** (Boorman *et al* 1994; Schneider *et al* 2007) and the **CORPEN** system (Groupe "diagnostic" du CORPEN, 1996)

> HOST provides a quantitative link between soil types and stream response to rainfall.

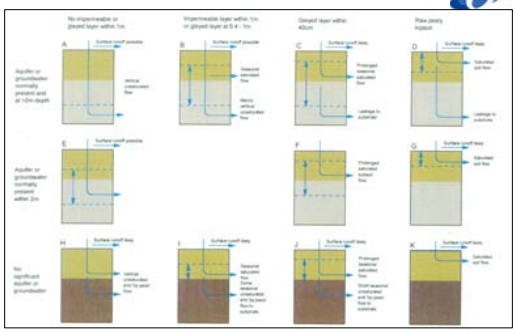
> CORPEN provides seasonal differentiation of pollutant transfer pathways.

BOORMAN, D.B., HOLLIS, J.M. & LILLY, A. (1995). *Hydrology of Soil Types: A hydrologically - based classification of the soils or the United Kingdom*. Institute of Hydrology Report No. 126, Wallingford, UK. 137 pp.

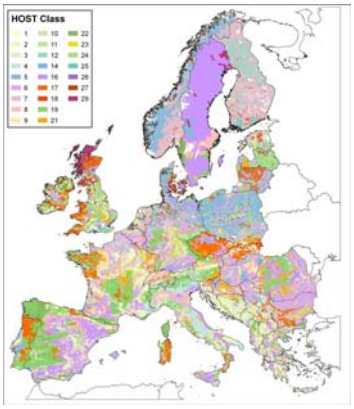
SCHNEIDER, M.K., BRUNNER, F., HOLLIS, J.M. & STAMM, C. (2007). Towards a hydrological classification of European soils: Preliminary test of its predictive power for the base flow index using river discharge data. *Hydrol. Earth Syst. Sci.*, **11**, 1–13.

Groupe "diagnostic" du CORPEN (1996). *Qualité des eaux et produits phytosanitaires: Propositions pour une demarche de diagnostic*. Republique Francaise, Ministere de L-Environnement et Ministere de l'Agriculture, de la Peche et de l'Alimentation. 113 pp.

HOST Conceptual Models



Databases of soil physical properties - with feedback from catchment scale hydrological variables: long term flow data in >800 catchments.



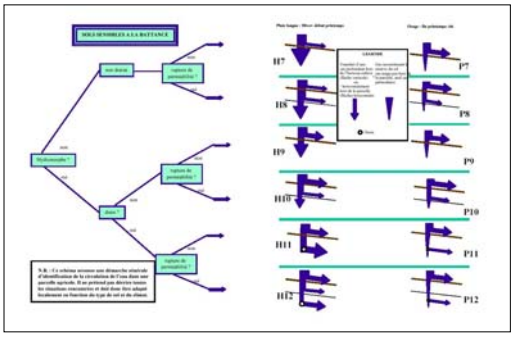
HOST in Europe

Schneider *et al* 2007. Hydrology & Earth Systems Science, **11,** 1-13

Linked to the SGDBE via Soil Typological Unit (STU).

The CORPEN Flow Charts

Hydrological pathways in soils susceptible to capping



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Combining HOST & CORPEN

> Use HOST (Europe) to identify FOOTPRINT hydrological classes and provide a relative quantification of the amount of rapid response.

> Use CORPEN concepts to identify transfer routes and seasonal differences.
(Flow Pathway Categories – FPCs).

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FOOTPRINT soil hydrological class

FOOTPRINT hydrological code	HOST class	Description	SPR
L	1, 2, 3, 5, 13	Permeable, free draining soils on permeable sandy, gravelly, chalk or limestone substrates with deep groundwater (below 2m depth).	2 – 12%
M	4	Permeable, free draining soils on hard but fissured substrates (including karst) with deep groundwater (below 2m depth).	20%
N	6	Permeable, free draining soils on permeable soft loamy or clayey substrates with deep groundwater (below 2m depth).	34%
O	7	Permeable soils on sandy or gravelly substrates with intermediate groundwater (between 1 & 2 m depth)	20%
P	8	Permeable soils on soft loamy or clayey substrates with intermediate groundwater (between 1 & 2 m depth)	30%
Q	9, 10, 11	All soils with shallow groundwater (within 1m depth) and artificial drainage	25 – 35% (drained peat 2%)
R	17	Permeable, free draining soils with large storage, over hard impermeable substrates below 1 m depth	30%
S	19	Permeable, free draining soils with moderate storage, over hard impermeable substrates at between 0.5 & 1 m depth	45%
T	22	Shallow, permeable, free draining soils with small storage, over hard impermeable substrates within 0.5 m depth	60%
U	20	Soils with slight seasonal waterlogging ('perched' water) over soft impermeable clay substrates	47%
V	23, 25	Soils with prolonged seasonal waterlogging ('perched' water) over soft impermeable clay substrates	50 – 60%
W	16	Free draining soils over slowly permeable substrates	22%
X	18	Slowly permeable soils with slight seasonal waterlogging ('perched' water) over slowly permeable substrates	47%
Y	14, 21, 24	Slowly permeable soil with prolonged seasonal waterlogging ('perched' water) over slowly permeable substrates	40 – 47%
Z	12, 15, 26, 27, 28, 29	All undrained peat or soils with peaty tops	50 – 60%

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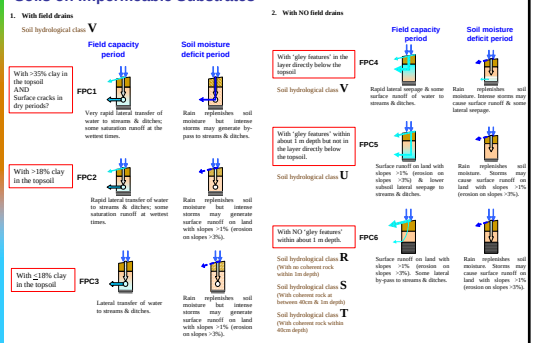
Transfer Routes for Hydrological Classes R, S, T, U & V

Soils on Impermeable Substrates



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Defining & Characterizing FOOTPRINT Soil Types in Europe – Default derivation

> **SGDBE in the scale 1:1.000 000 000 is used as default dataset.**

> **It is assumed that the SGDBE represents the whole range of soils within Europe.**

> **SPADE 1 and SPADE 2 databases (aproximately 2000 profiles) has been used to derive land use-specific profile parameters for each FOOTPRINT soil class.**

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Defining & Characterizing FOOTPRINT Soil Types in Europe

> Assign classes to each STU in SGDBE using stu.dbf attributes.

> Define FST hydrological class:
Based on HOST in Europe, Schneider *et al*, 2007.

> Define topsoil and subsoil texture class:
1 – 5 (from TEXT & TD in stu.dbf)

> Define sorption attributes:
Organic matter profiles; (identified by soil class from stu.dbf)
Depth to rock (identified by soil class, IL & ROO from stu.dbf)
Clay increase in subsoil (identified by soil class, TEXT & TD from stu.dbf)

> Combine to define FOOTPRINT soil classes.

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FOOTPRINT Soil Types (FST) in the SGDBE

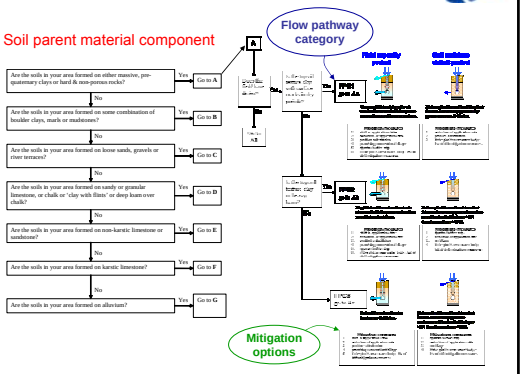
- All STU's in the SGDBE represented by 388 FOOTPRINT soil types.
- 264 FST's represent soils under arable or permanent crops.
- 287 FST's represent soils under managed grassland.
- 33 FST's represent soils **only** under non-agricultural uses.

Identifying FSTs in the field

- A comprehensive **flow chart** (The "FOOTPRINT Decision Tree") has been developed to correlate local soil types with a FOOTPRINT soil type and its associated soil hydrological and 'organic profile' information.
- The FST flow chart consists of a series of questions relating to:
  - soil parent material;
  - the presence of artificial drains;
  - the presence of soil colours indicating intermittent waterlogging, organic-rich or organic-poor layers;
  - topsoil and subsoil textures;
  - the presence of coherent rock within 1 m depth.
- A stand-alone software version of the FOOTPRINT decision tree is already available. It is also already incorporated in FOOT-FS and will be available through the FOOTPRINT web site soon.

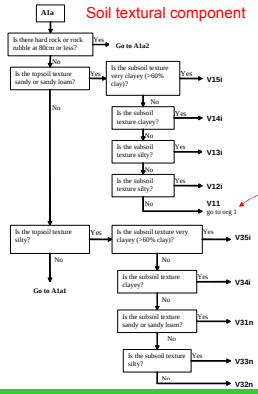
The FST Flow chart - 1

Soil parent material component



The FST Flow chart - 2

Soil textural component



Terra Rossa (Cambisol)

Kras, Dobravlje, Slovenia

- A_1 0-12 cm
- B_{rz} 12-68 cm
- B_t 68-104 cm
- C 104 + cm

Are the soils in your area formed on:

- Recent alluvium or thick peat
- Either massive, pre-quaternary clays or hard & non-porous rocks
- Some combination of boulder clays, glacial till, marls or mudstones
- Loose sands, gravel or river terraces
- Sandy or granular limestone, or chalk or 'clay with flints' or deep permeable loam or clay, or loose volcanic materials
- Non-karstic limestone or sandstone
- Karstic limestone or volcanic rocks

Does the field you are assessing have drains?

- Yes
- No

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Gley morphology. Select the option that best fits your local situation:

- Are there gley features in the layer directly below the topsoil / Does the soil remain wet for at least about 5 days after rain in early spring?
- Are there gley features within about 1 m depth (but not directly below the topsoil / Does the soil remain wet for at least about 2 days after rain in early spring?
- Neither of the above

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Is there solid rock or rock rubble?

- At 40cm or less
- At 80cm or less
- Neither of the above

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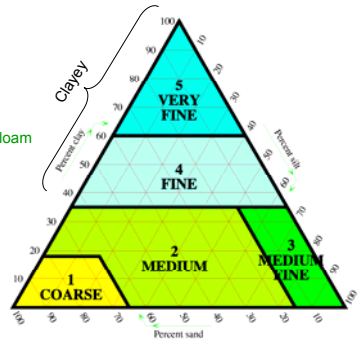
Is the topsoil texture:

- Organic peaty
- Clayey
- Silty
- Loamy
- Sandy or sandy loam



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Is the subsoil texture:

- Organic peaty
- Clayey
- Silty
- Loamy
- Sandy or sandy loam

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Organic 2. Select the option that best fits your local situation:

- The soil has a dark coloured topsoil rich in organic matter and is formed over volcanic materials
- The soil is formed over volcanic materials but with no dark coloured topsoil
- The soil has a dark coloured topsoil rich in organic matter and a texture that gets heavier or more clayey within 0.8 m depth
- The soil has a dark coloured topsoil rich in organic matter but is not formed over volcanic materials and does not have a texture that gets heavier or more clayey within 0.8 m depth
- The soil has a pale coloured topsoil with very little organic matter and gets heavier or more clayey within 0.8 m depth
- The soil has a pale coloured topsoil with very little organic matter but does not get heavier or more clayey within 0.8 m depth
- The soil has a texture that gets heavier or more clayey within 0.8 m depth but does not have a dark coloured or pale coloured topsoil
- None of the above

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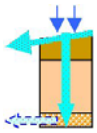
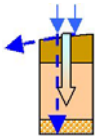
N44h, FPC24

Field capacity period	Soil moisture deficit period
	
Leaching to groundwater with some surface runoff on land with slopes >1% (erosion on slopes >3%). Prolonged rain may cause by-pass to groundwater & some leakage to stream & ditches. Stream response to rainfall is 'dampened'.	Rain replenishes soil moisture but intense storms may generate surface runoff on land with slopes >1% (erosion on slopes >3%) and some leaching to groundwater.

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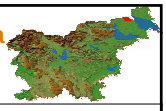
Apace Valley (53 km^2) , Slovenija

Soil map digitized in the scale 1:5.000



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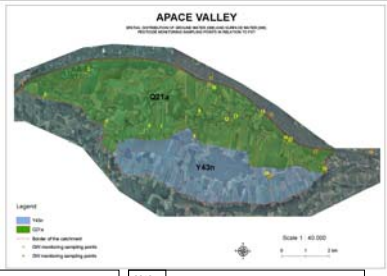
Transformation: STUs → FSTs



Q21a	Winter	Summer
		

Lateral seepage of water to streams. Storms may cause some leaching. Risk of flooding.

Y43n	Winter	Summer
		

Lateral seepage & some saturation runoff of water to streams & ditches. Intense storms may cause surface runoff & some lateral seepage.

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Linking FOOTPRINT Soil Types to Mitigation measures -1

FOOTPRINT Soil Types

Q21a

↓

FPC40

Field capacity period

Lateral seepage of water to streams & ditches. Risk of flooding.

Mitigation measures

1. shift in application date
2. reduction of application rate
3. product substitution
4. practising conventional tillage
5. if the plot is near water body : list of drift mitigation

Soil moisture deficit period

Rain replenishes soil moisture. Intense storms may cause some leaching, lateral seepage or local flooding.

Mitigation measures

1. reduction of application rate
2. product substitution
3. practising conventional tillage
4. if the plot is near water body : list of drift mitigation measures

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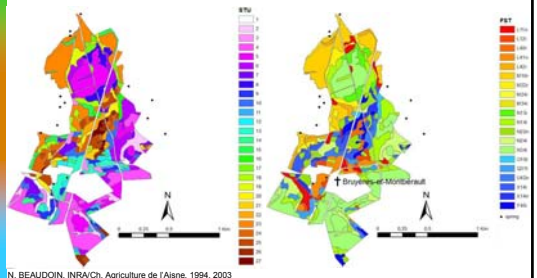
Soil map: Bruyères-et-Montbérault (France)

STUs → FSTs



N. BEAUDOIN, INRA/Ch. Agriculture de l'Aisne, 1994, 2003

INRA EGC

AgroParisTech

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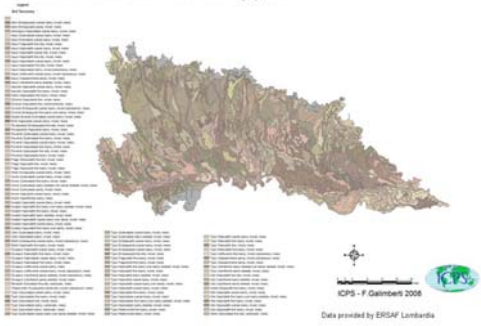
Transformation of the existing (national/regional/catchment) Soil Maps to Footprint Soil Maps

SOIL TAXONOMY - Lombardy plain



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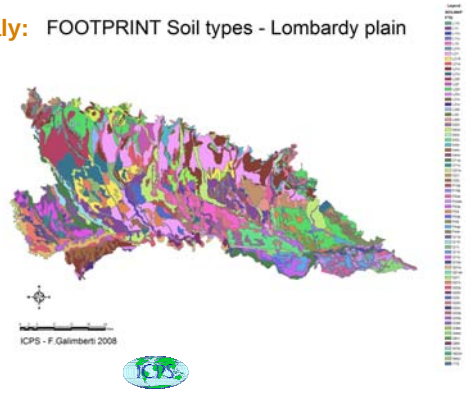
Italy: FOOTPRINT Soil types - Lombardy plain



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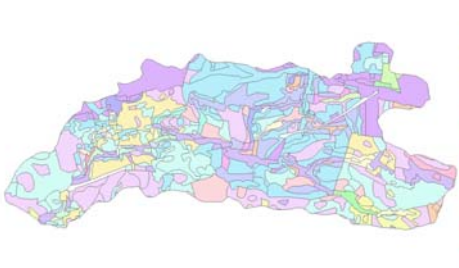
Footprint Soil Map: Ciesielska Woda (Poland)



WUELS

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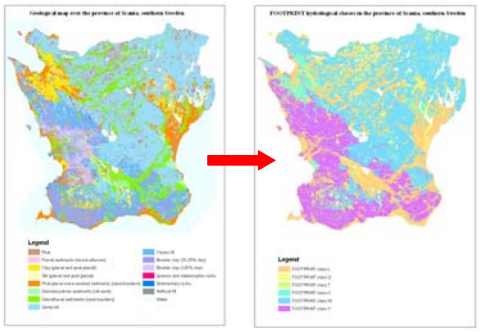
FOOTPRINT hydrological classes of Skåne, Southern Sweden



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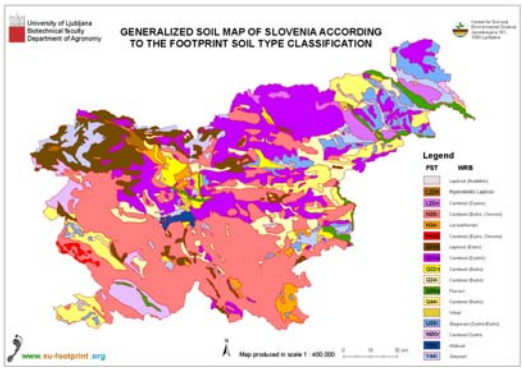
National Soil Map of Slovenia - FSTs



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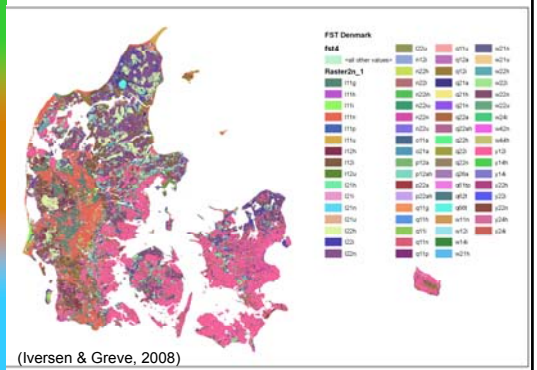
National Soil Map of Denmark - FSTs



(Iversen & Greve, 2008)

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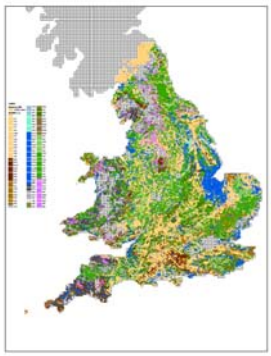
1:250,000 scale National Soil Map of England & Wales - FSTs



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Status of FOOTPRINT soil maps

Footprint soil maps have been already done for:

National maps:
- England and Wales,
- Denmark,
- Slovenia,
- Sweden (Skåne).

Catchment maps:
- Poland (Ciesielska Woda),
- Italy(Lombardy plain),
- France (Bruyères-et-Montbérault),
- Slovenia (Apače Valley),
- England and Wales (Teme, Leam, Cherwell, Deben, Wensum).

Conclusions

- A limited set of **FOOTPRINT Soil Types** have been developed that combine hydrological and sorption characteristics.
- They represent the range of soil types across Europe as characterised by the **SGDBE**.
- The FSTs can be used to model pollutant fate and behaviour **at all scales** (from local to the European level).
- They can be used to identify **pollutant transfer pathways** and associated **mitigation measures**.
- Flow charts incorporating simple questions enable **non-specialist users** to identify the FSTs **using local data.**
- The FOOTPRINT decision tree will be made **widely available**.

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