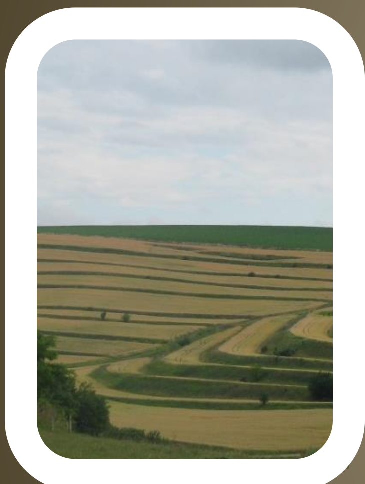
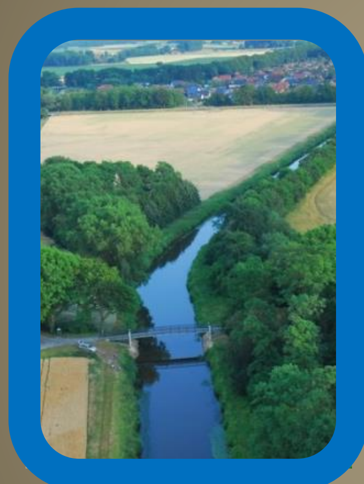
Managing our land: the multi-functional approach


Prof. Rachel Creamer, Soil Biology Group, Wageningen University


1 NO POVERTY
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
14 LIFE BELOW WATER
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
15 LIFE ON LAND
13 CLIMATE ACTION
CHALLENGE
SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD

UNDERSTANDING SOIL FUNCTIONS

The concept of five aggregated soil functions :

- Primary productivity: food, fibre, fuel
- Water regulation & purification
- Habitat for functional & intrinsic biodiversity
- Carbon regulation & sequestration
- Nutrient Cycling




Schulte et al., 2014


ENVIRONMENTAL SCIENCE & POLICY 38 (2014) 45–58

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/envsci

ELSEVIER

Functional land management: A framework for managing soil-based ecosystem services for the sustainable intensification of agriculture☆

CrossMark


Environmental Science & Policy 56 (2016) 39–48

Contents lists available at ScienceDirect

Environmental Science & Policy

journal homepage: www.elsevier.com/locate/envsci

ELSEVIER

Review

A Functional Land Management conceptual framework under soil drainage and land use scenarios

CrossMark

Cait Coyle[a,b,*], Rachel E. Creamer[c], Rogier P.O. Schulte[c], Lilian O'Sullivan[c], Phil Jordan[a]

[a] School of Environmental Sciences, Ulster University, Cromore Road, Coleraine BT52 1SA, Northern Ireland, United Kingdom
[b] Department of Environmental Science, Institute of Technology Sligo, Ash Lane, Sligo, Co. Sligo, Ireland
[c] Teagasc, Crops, Environmental and Land Use Programme, Johnstown Castle, Wexford, Co. Wexford, Ireland


frontiers

Making the most of our land: managing soil functions from local to continental scale

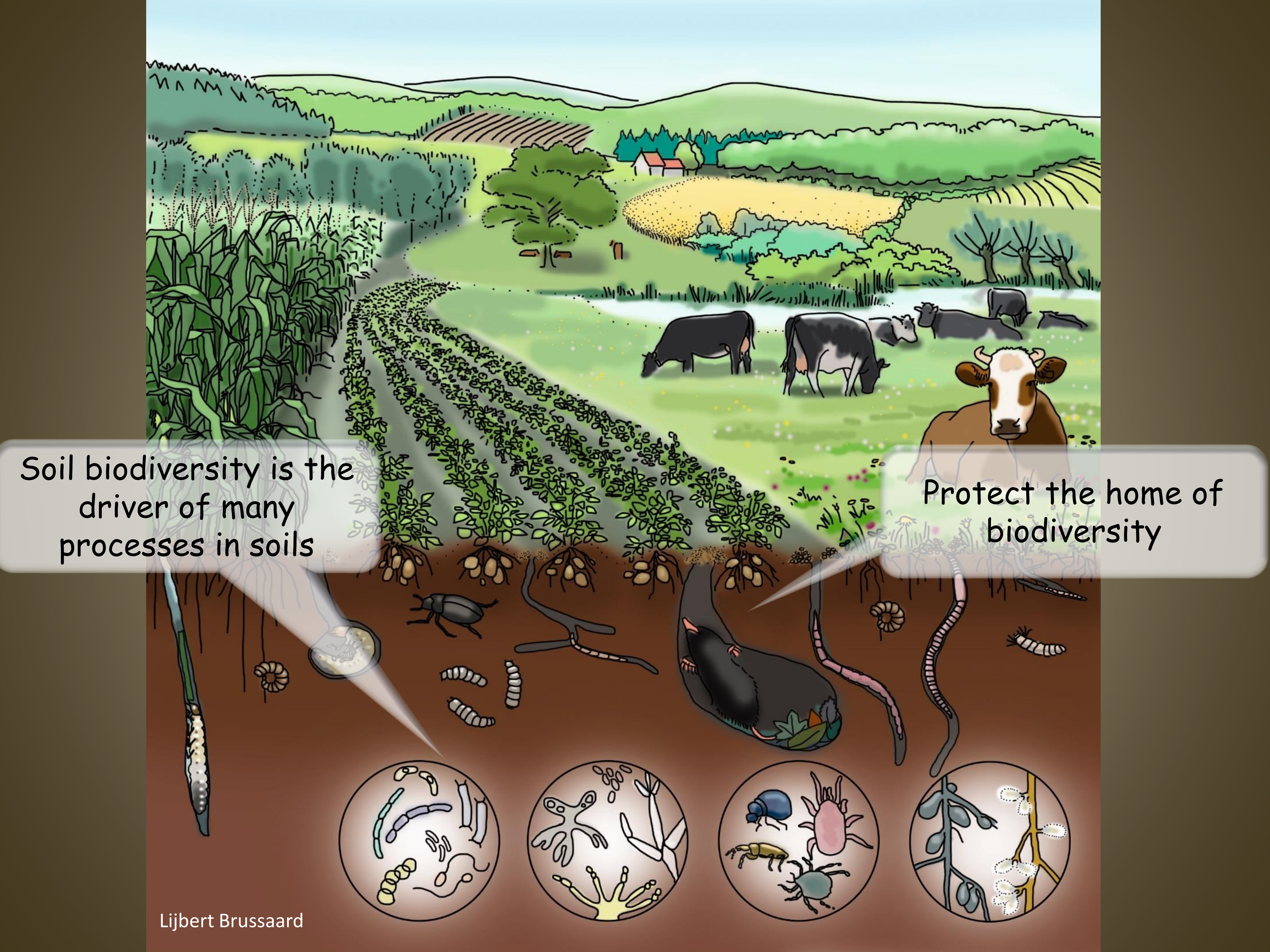
Rogier P. Schulte[1, 2*], Francesca Bampa[1], Marion Bardy[3], Cait Coyle[1, 4, 5], Reamonn Fealy[6], Ciro Gardi[7], Bhim Ghaley[8], Phil Jordan[5], Hjalmar Laudon[9], Cathal O'Dononghue[6], Daire Ó'hUallacháin[1], Lilian O'Sullivan[1], Michiel Rutgers[10], Johan Six[11], Gergely L. Toth[12], Dirk Vrebos[13], Rachel Creamer[1]


How do we increase our productivity?


We need better water regulation by our land…


We need to protect our carbon resources


We need to find a home for our waste…


Soil biodiversity is the driver of many processes in soils
Protect the home of biodiversity
Lijbert Brussaard

FUNCTIONAL LAND MANAGEMENT - THE CONCEPT

The c

so

- Pr
- W
- Ha
  bi
- Ca
- Nu

"All soils perform all functions…

…but different parts of the land(scape) are better at delivering different functions…"

Schulte et al., 2014

ENVIRONMENTAL SCIENCE & POLICY 38 (2014) 45–58

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/envsci

Functional land management: A framework for managing soil-based ecosystem services for the sustainable intensification of agriculture☆

Environmental Science & Policy 56 (2016) 39–48

Contents lists available at ScienceDirect

Environmental Science & Policy

journal homepage: www.elsevier.com/locate/envsci

Review

A Functional Land Management conceptual framework under soil drainage and land use scenarios

Cait Coyle[a,b,*], Rachel E. Creamer[c], Rogier P.O. Schulte[c], Lilian O'Sullivan[c], Phil Jordan[a]

[a] School of Environmental Sciences, Ulster University, Cromore Road, Coleraine BT52 1SA, Northern Ireland, United Kingdom
[b] Department of Environmental Science, Institute of Technology Sligo, Ash Lane, Sligo, Co. Sligo, Ireland
[c] Teagasc, Crops, Environmental and Land Use Programme, Johnstown Castle, Wexford, Co. Wexford, Ireland

frontiers

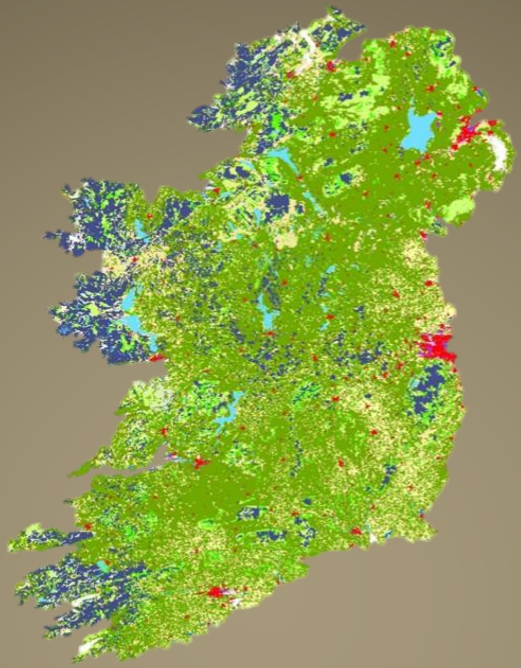
Making the most of our land: managing soil functions from local to continental scale

Rogier P. Schulte[1, 2*], Francesca Bampa[1], Marion Bardy[3], Cait Coyle[1, 4, 5], Reamonn Fealy[6], Ciro Gardi[7], Bhim Ghaley[8], Phil Jordan[5], Hjalmar Laudon[9], Cathal O'Dononghue[6], Daire Ó'hUallacháin[1], Lilian O'Sullivan[1], Michiel Rutgers[10], Johan Six[11], Gergely L. Toth[12], Dirk Vrebos[13], Rachel Creamer[1]

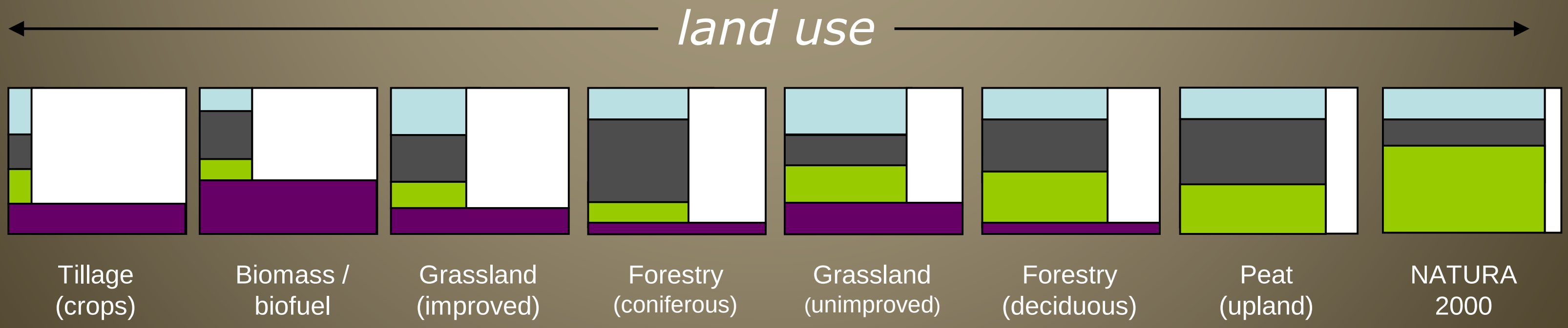
The capacity of soils to perform each of the five soil functions depends on land use and landscape

FUNCTIONAL LAND MANAGEMENT - THE CONCEPT

(Dwyer et al., 2013)



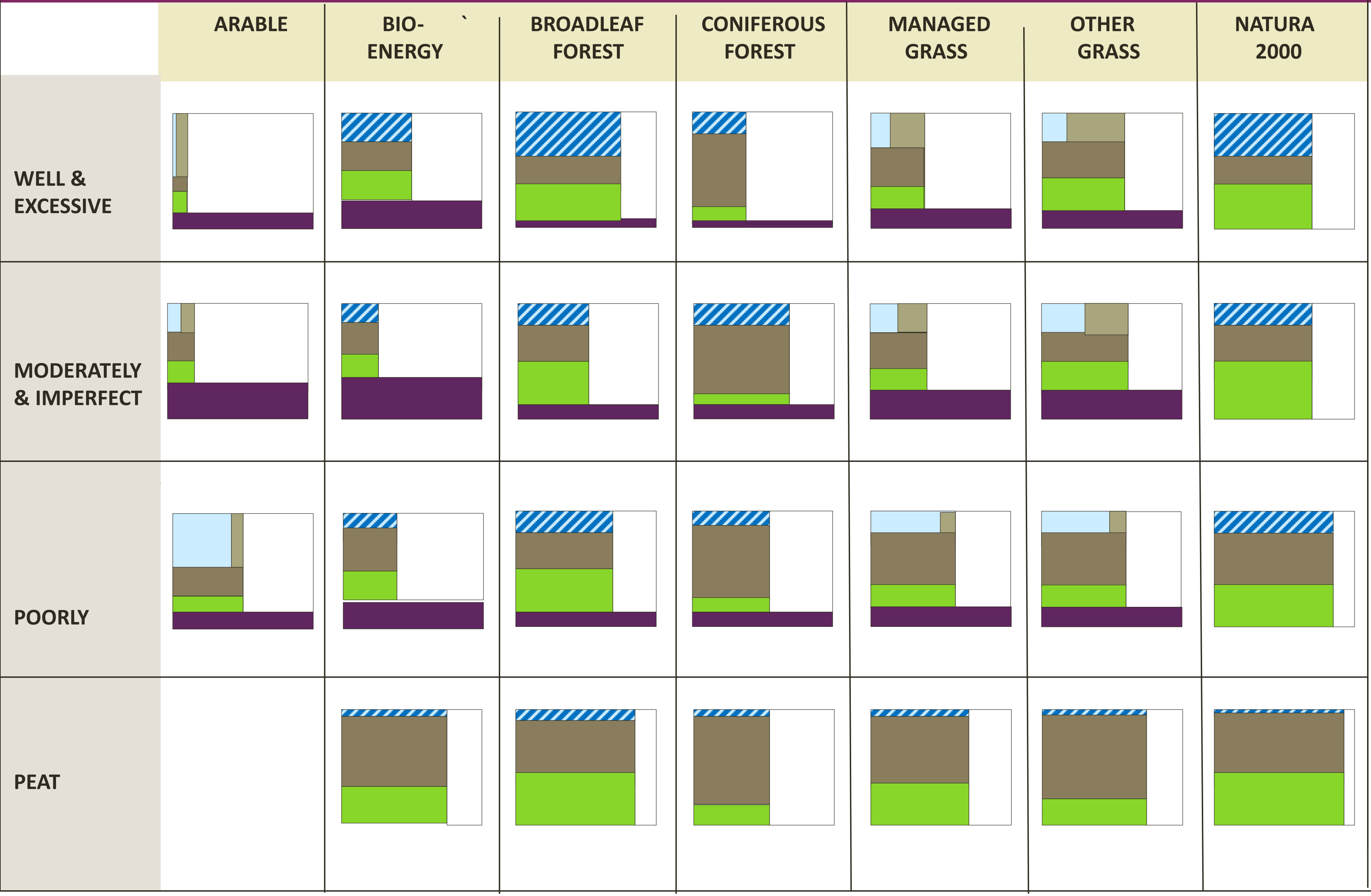
Relative importance depends on land use



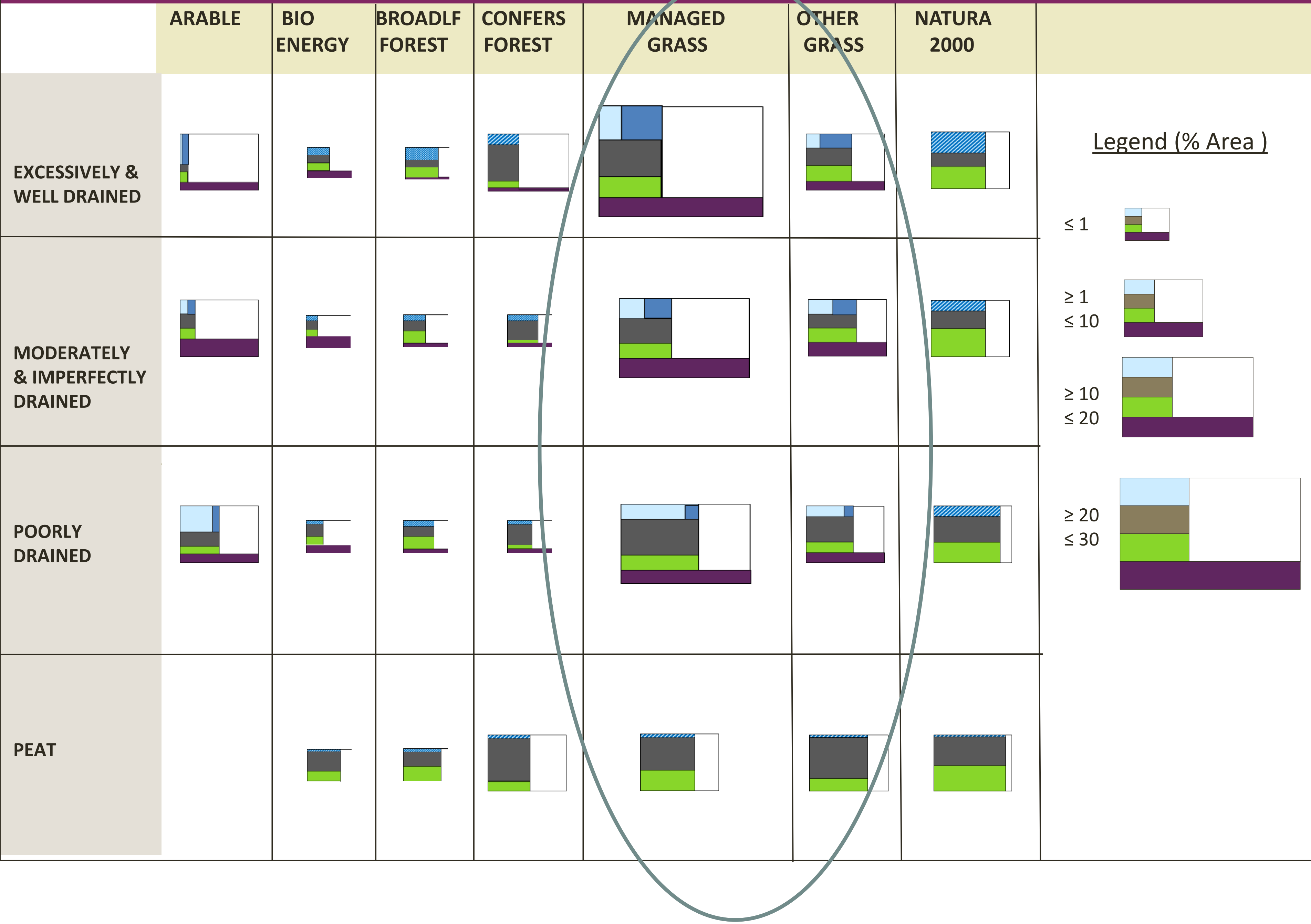
FUNCTIONAL LAND MANAGEMENT - THE CONCEPT

Relative importance depends on land use **x soil**:

SOIL FUNCTIONS MATRIX

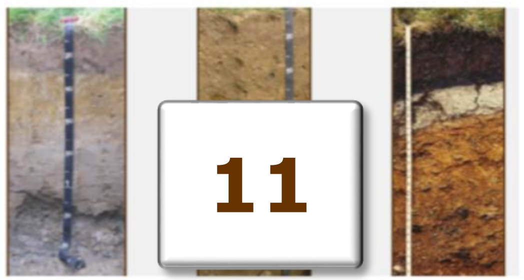


SOIL FUNCTIONS MATRIX – AREA LAND USE BY DRAINAGE



National scale application

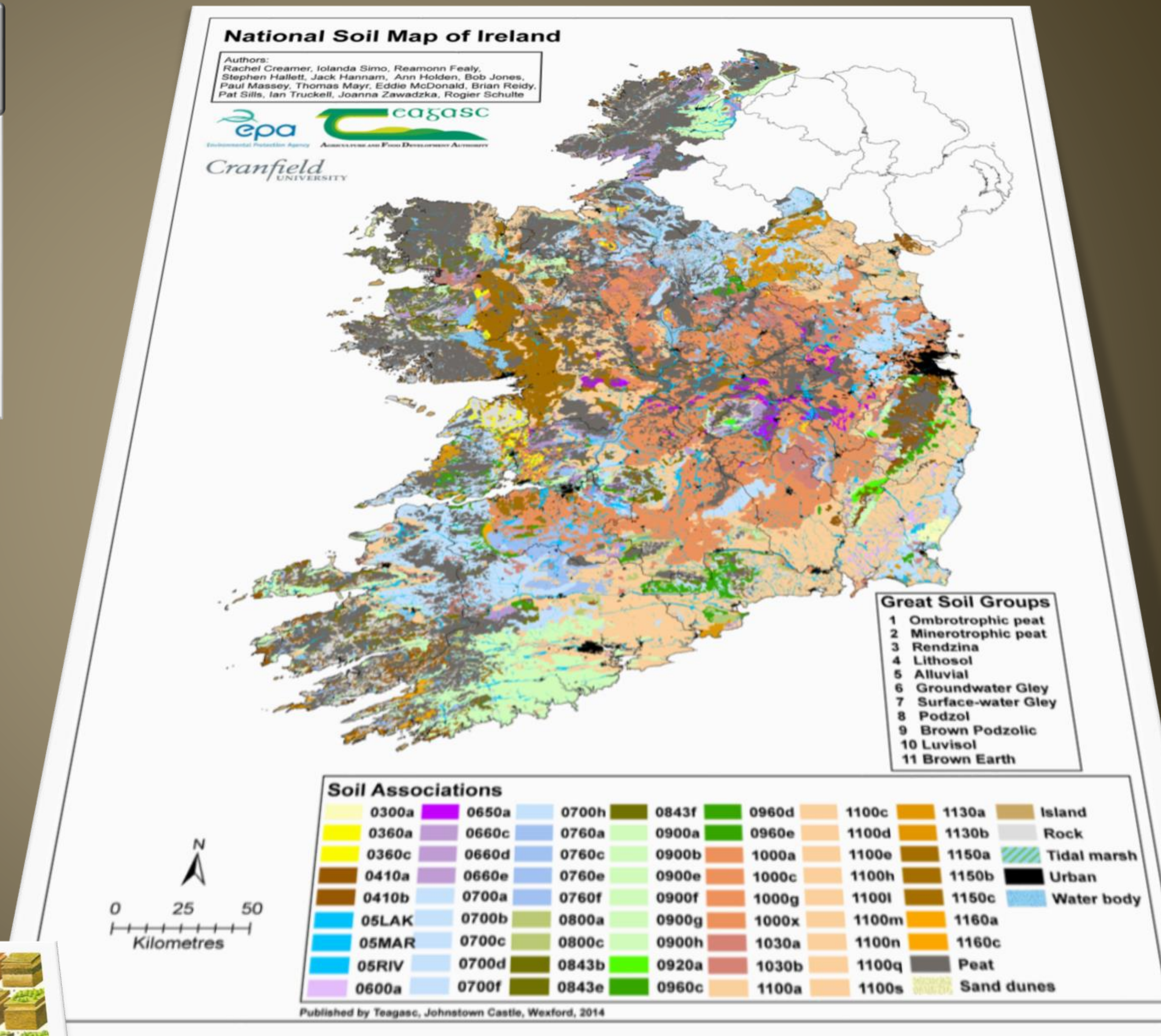
Irish Soil Information System



11

66

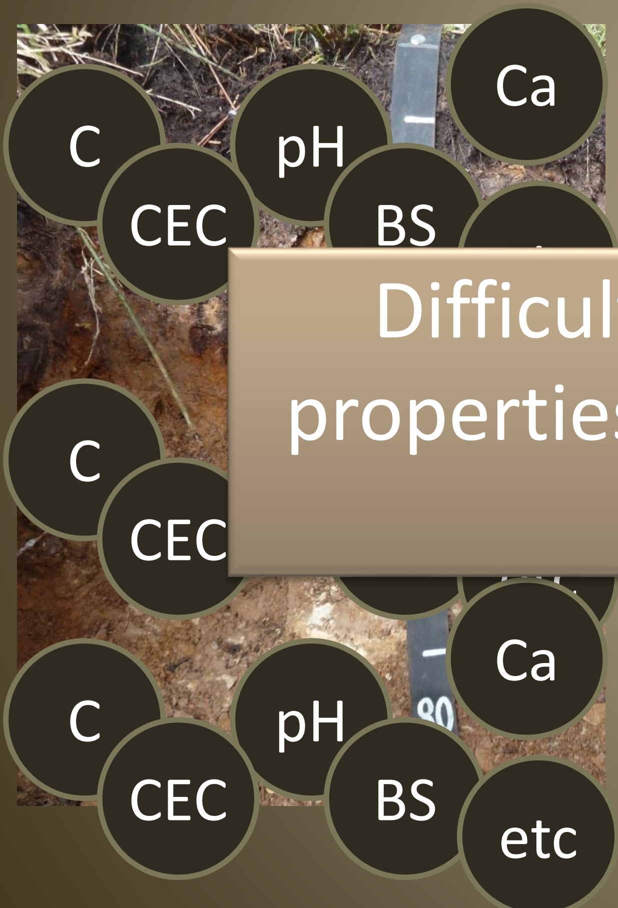
213



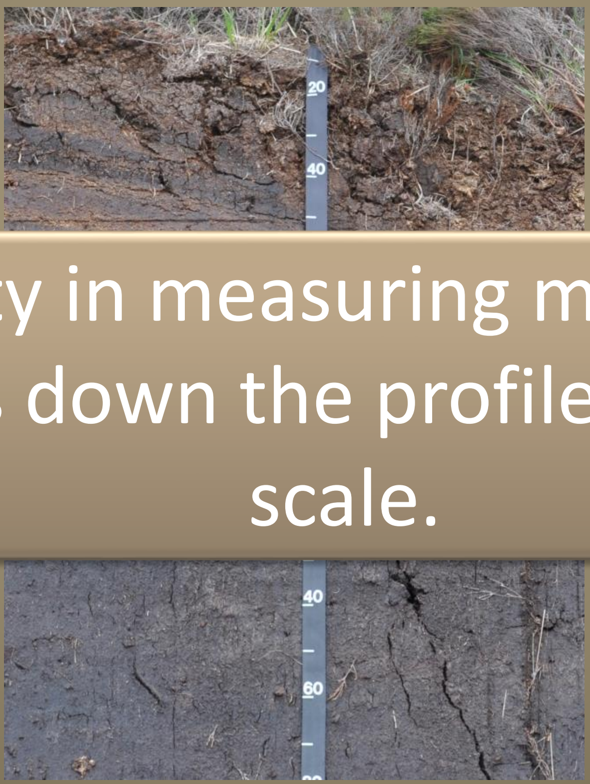
DIAGNOSTIC APPROACH

Option 1: soil properties

Soil A



Soil B



Soil C

Difficulty in measuring multiple soil properties down the profile at the larger scale.

DIAGNOSTIC APPROACH

Option 2: categorical approach

Soil A

Soil B

Soil C

213 series or 66 soil sub-groups recognised in Ireland

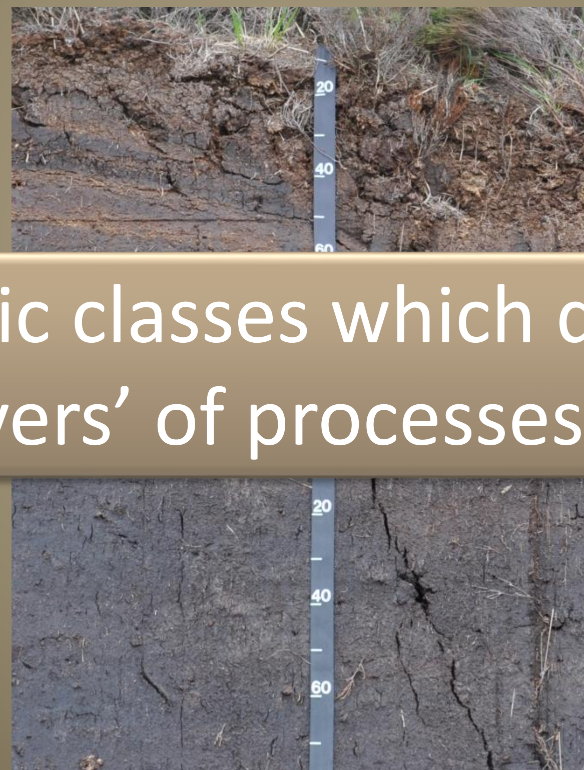
Still a lot of categories for describing soil relationships to functions

Diagnostic approach

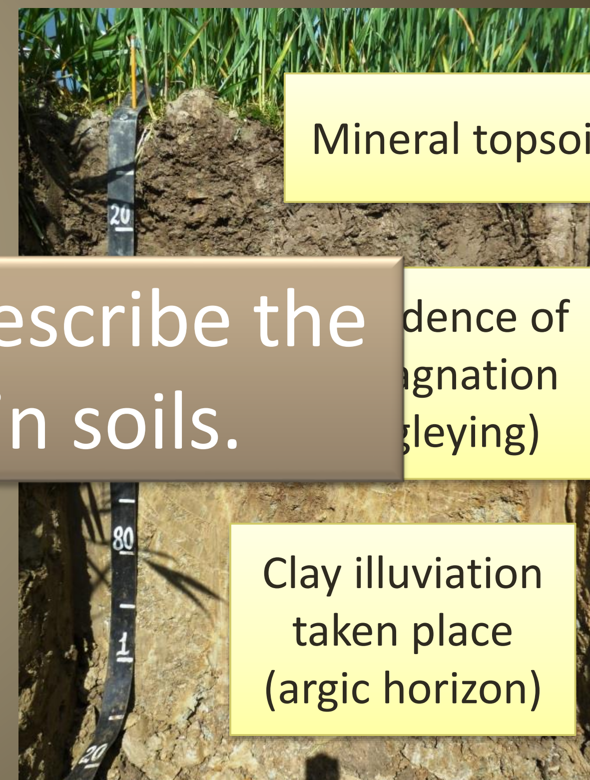
Option 3: diagnostic approach

Soil A

Soil B



Soil C



Five diagnostic classes which describe the main ‘drivers’ of processes in soils.

SIMPL

Scoring	Org			Spodicity class
0	*Miner*		*al*	no Bs horizons present
0.5	*Hum*		*c*	profile contains Bs horizon enriched in iron oxides, aluminium with humus
1	*Histic*	>:	*Podzolic*	profile contains eluviated E horizon and Bs horizon enriched in iron oxides, aluminium with humus

European Journal of Soil Science

European Journal of Soil Science, May 2018, **69**, 414–428 doi: 10.1111/ejss.12551

Linking diagnostic features to soil microbial biomass and respiration in agricultural grassland soil: a large-scale study in Ireland

A. RICHTER[a,b], D. Ó. HUALLACHÁIN[b], E. DOYLE[a], N. CLIPSON[a], J. P. VAN LEEUWEN[c], G. B. HEUVELINK[d] & R. E. CREAMER[b,e]

[a]*School of Biology and Environmental Science, Earth Institute, University College Dublin, Belfield, Dublin 4, D04 V1W8, Ireland,* [b]*Teagasc Johnstown, Environment Research Centre, Co. Wexford Y35 Y521, Ireland,* [c]*Biometris, Wageningen University and Research, Droevendaalsesteeg 4, 6708 PB Wageningen, The Netherlands,* [d]*ISRIC, Droevendaalsesteeg 3, 6708 PB Wageningen, The Netherlands, and* [e]*Soil Biology and Biological Soil Quality, Wageningen University and Research, Droevendaalsesteeg 4, 6708 PB Wageningen, The Neth*

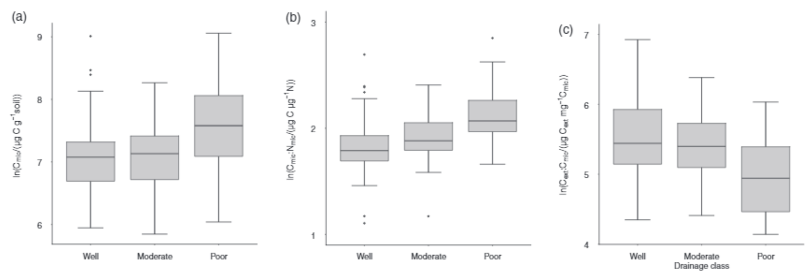
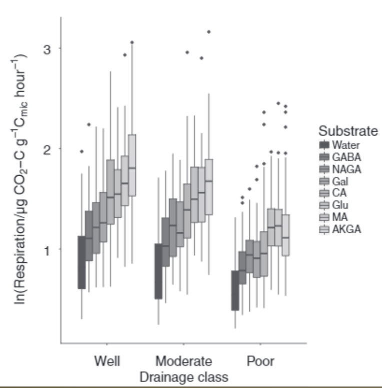


Figure 5 Box and whisker plots of ln-transformed (a) microbial biomass carbon (C_{mic} in mg C g^{-1} soil), (b) microbial biomass carbon and nitrogen ratio (C_{mic}:N_{mic} in mg C mg^{-1} N) and (c) biomass specific available carbon (C_{ext}:C_{mic} ratio in µg C_{ext} mg^{-1} C_{mic}). Data are shown for each diagnostic drainage class: well drained ($n = 74$), moderately drained ($n = 36$) and poorly drained ($n = 46$). Boxes display lower and upper quartiles and median. Whiskers show 1.5 × interquartile range.



microbial properties. Physicochemical properties, especially OM, WHC, N and pH (Table 4), are shown as significant predictors. Organic matter content, in particular, explained the most variation within C_{mic}:N_{mic} (30%) and C_{ext}:C_{mic} (28%), WHC was the best predictor for C_{mic} (52%) and N_{mic} (38%), and N was the best predictor for C_{ext} (33%) and C_{mic}:C_{org} (32%). Argillicity affected C_{mic}:C_{org} and CAI, whereas drainage class explained a significant proportion of the variation for C_{mic}, C_{mic}:N_{mic}, C_{ext} and C_{ext}:C_{mic}. Organic matter content and drainage class were tested further for interaction, but regression models revealed no interaction between the two variables in relation to C_{mic}:N_{mic} and C_{ext}:C_{mic}. Microbial C, however, shows a steeper response with increasing OM in poorly drained soil when compared with moderately and well-drained soils (Figure 7).

Environmental factors related to multiple substrate-induced respiration

Table 3
Assignment of the six dominant

Dominant identifiers	ty	Calcareous
Subgroup		
01.1.0 Natural Ombrotrophic		
01.7.0 Drained Ombrotrophic		
01.8.0 Cut Ombrotrophic Pea		
01.9.0 Anthropic Ombrotrophi		
02.1.0 Natural Minerotrophic		0.5
02.7.0 Drained Minerotrophic		0.5
02.8.0 Cut Minerotrophic Pea		0.5
03.0.0 Typical Rendzinas		1
03.1.0 Histic Rendzinas		1

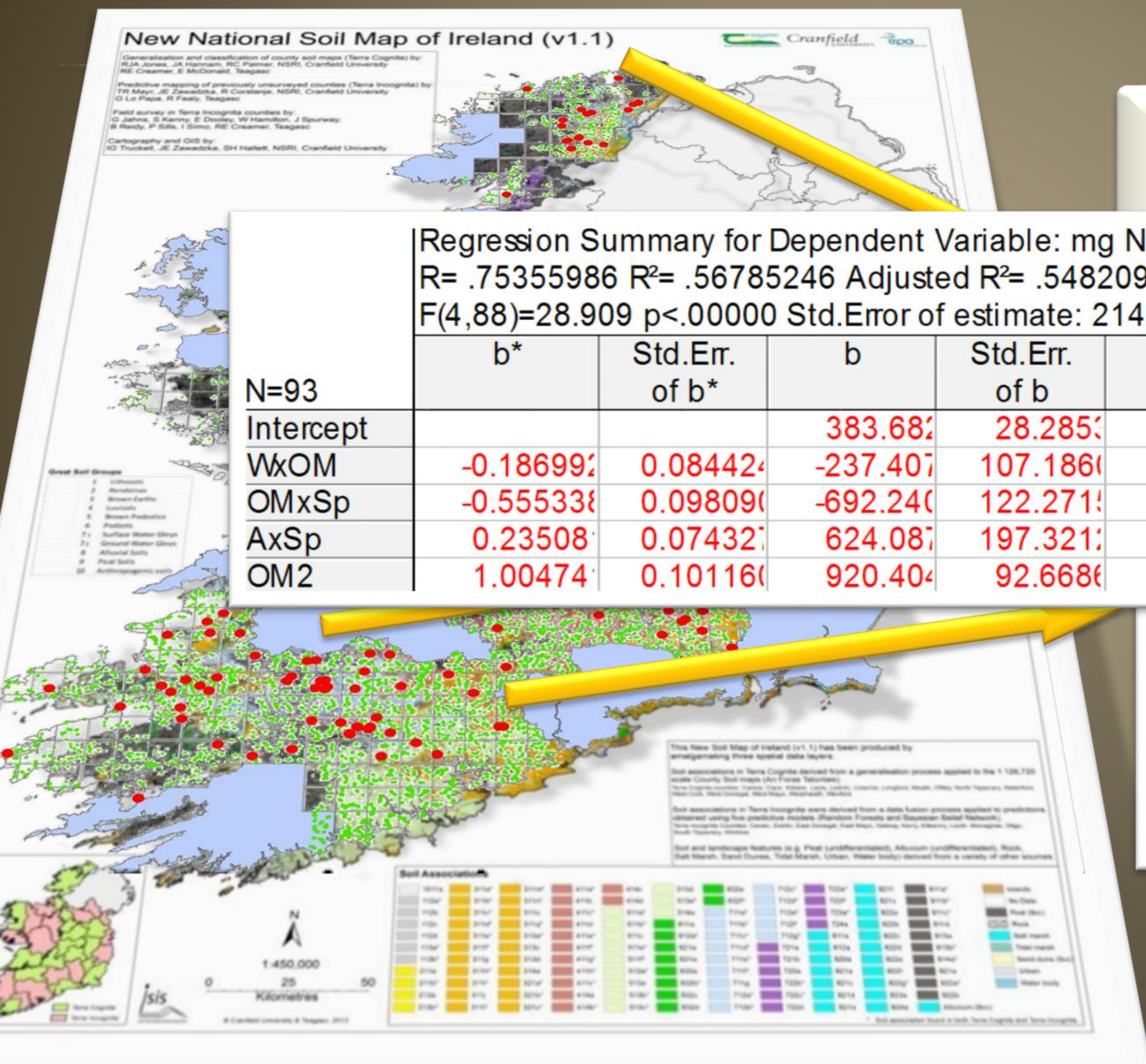
NUTRIENT CYCLING

Example: soil specific nutrient advice

<u>N-fertilizer =</u>

N-requirement

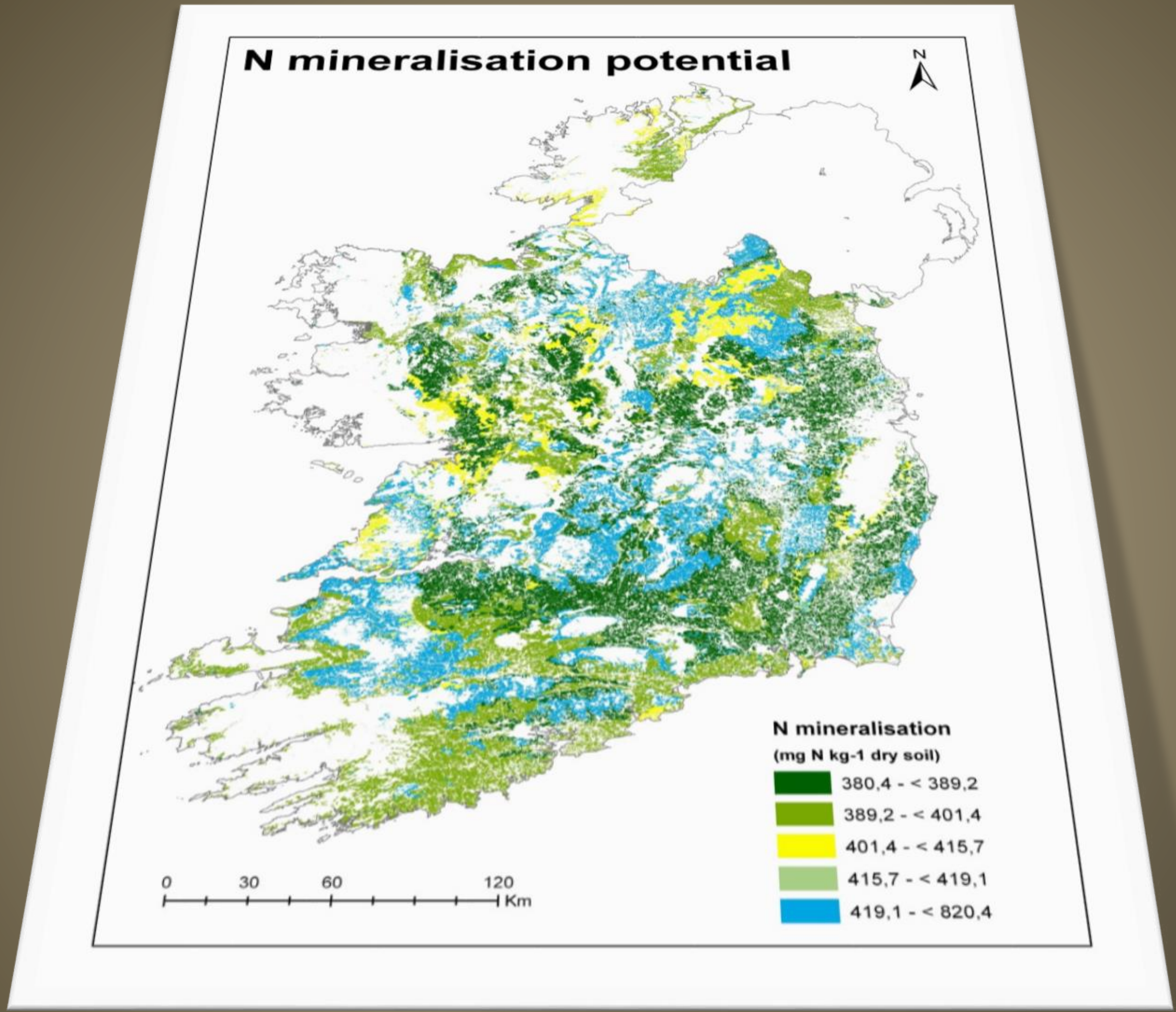
eralisation



Regression Summary for Dependent Variable: mg N kg-1 dry soil (Means)
R= .75355986 R^2= .56785246 Adjusted R^2= .54820939
F(4,88)=28.909 p<.00000 Std.Error of estimate: 214.71

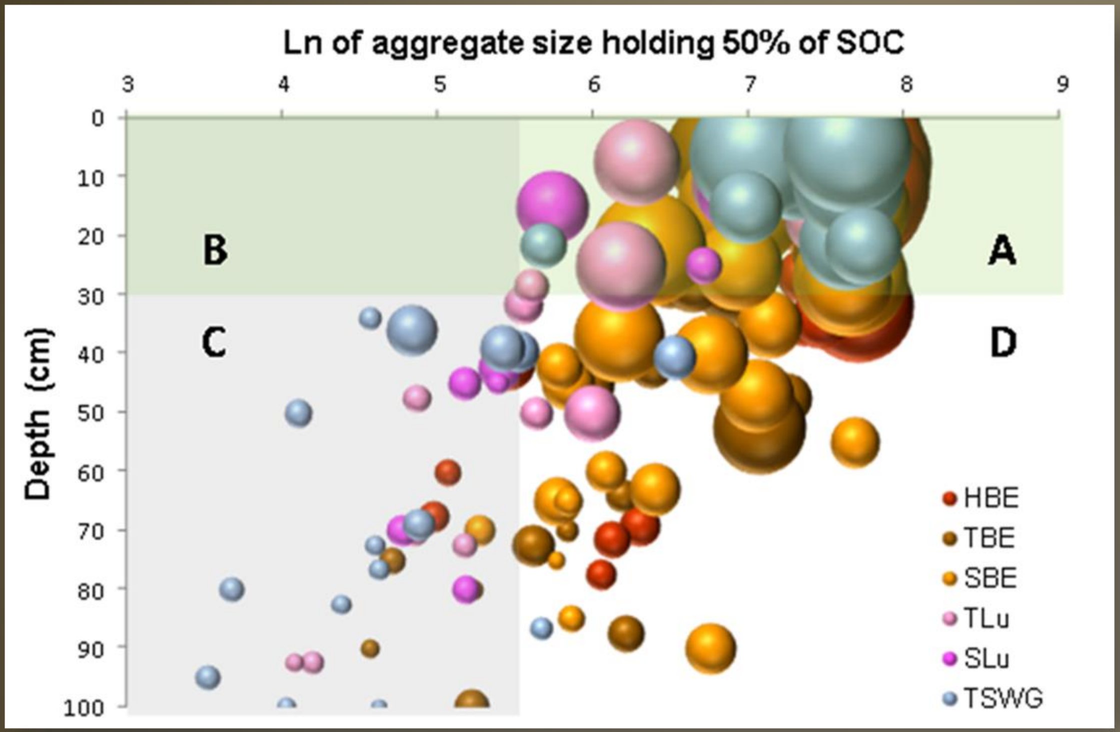
N=93	b*	Std.Err. of b*	b	Std.Err. of b	t(88)	p-value
Intercept			383.68	28.285	13.5646	0.00000
WxOM	-0.18699	0.08442	-237.407	107.186	-2.2149	0.02934
OMxSp	-0.55533	0.09809	-692.24	122.271	-5.6615	0.00000
AxSp	0.23508	0.07432	624.08	197.321	3.1628	0.00214
OM2	1.00474	0.10116	920.40	92.668	9.9322	0.00000

NUTRIENT CYCLING

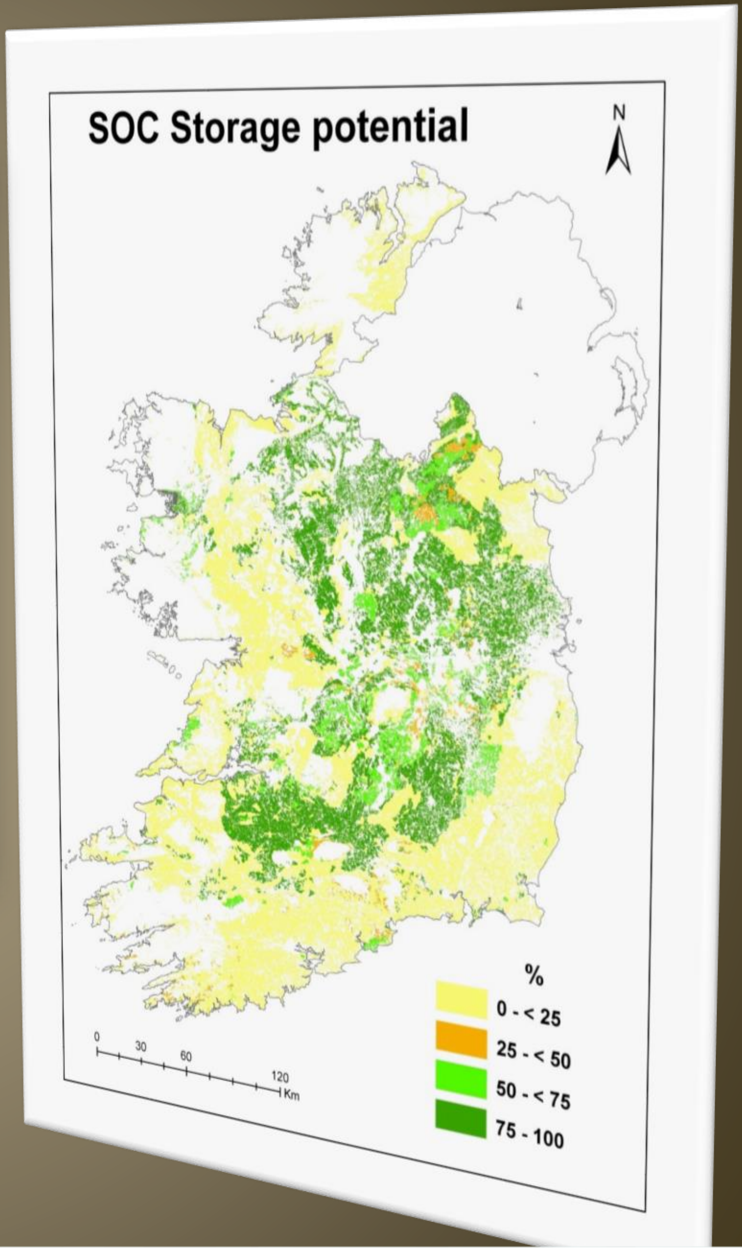


N-mineralisation = $\alpha + \beta_1 * SOC^2 - \beta_2 * SOC*Wetness - \beta_3 * SOC*Spodicity + \beta_4 * Spodicity*Argic$

CARBON SEQUESTRATION



Torres-Sallan, G. Schulte, R.P.O., Lanigan, G.J., Byrne, K.A., Reidy, B., Simo, I., Six, J., Creamer, R.E. (2017). Clay illuviation provides a long-term sink for C sequestration in subsoils. Nature Scientific Reports 7:45635.



Stability = intercept – β1 x depth x – β2 x depth x argillicity

Objective: to quantify the supply of soil functions across the EU as determined by soil properties, land use and soil management practices.

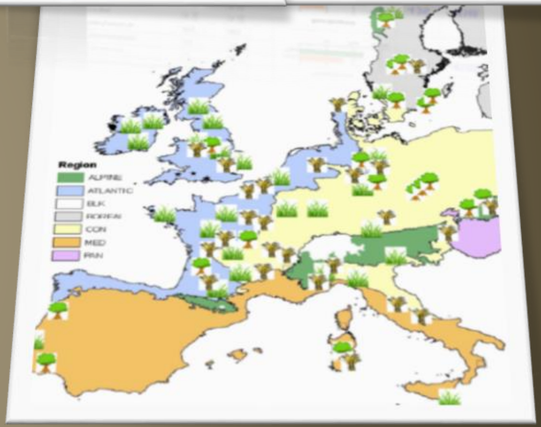
LANDMARK

THREE SPATIAL SCALES

1. **Farm scale:** Develop an agricultural Decision Support Tool (DST) for soil management

2. **Country scale:** Design a monitoring scheme for Soil Functions that is applicable at regional scale, for a range of soil types, land uses and pedo-climatic zones;

3. **EU scale**: Develop a policy framework for 'Functional Land Management' at European scale that aims to optimise the sustainable use of Europe's soil resource



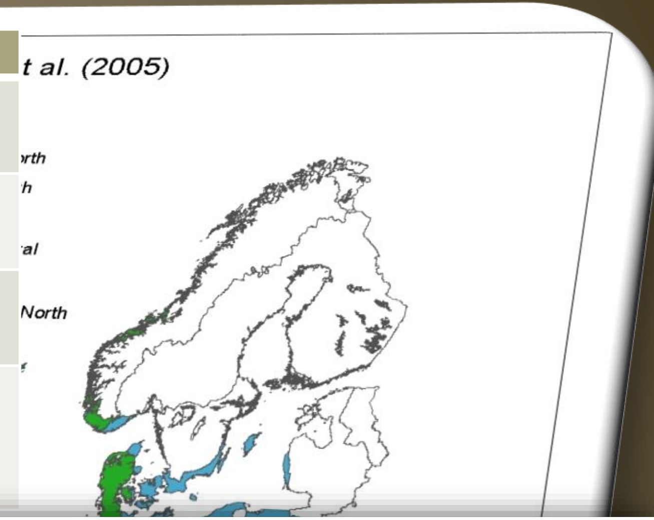
LANDMARK

email landmark@teagasc.ie twitter @Landmark2020

MONITORING SOIL FUNCTIONS

- Soil Biodiversity and Habitat
  - Nutrients

Chemical	Physical	Biology	In field	Function
OC/TN	Bulk density	Fun: Bac biomass ratio	Thickness of organic layer	Yield
pH	Texture	Bacterial biomass (DNA)	soil depth <50 >50)	
Available P/K	Infiltration capacity	Fungal biomass (DNA)	groundwater table within 50cm	
CEC	Soil moisture deficit (#days > field capacity)	Earthworm abundance	soil drainage class	



- Microbial
  - Bacterial biomass
  - Fungal biomass
  - Fungal:Bacterial biomass ratio
- Faunal
  - Earthworm diversity
  - Nematode diversity
  - Microarthropod diversity
  - Enchytraeid diversity
- Management related
  - Pesticide application
  - Land use
  - Sterilization management
- Structure
  - Vertic/Fragic horizon
  - Soil attributes
    - Texture
    - Bulk density
  - Management attributes
    - Tillage
    - Trampling

LANDMARK MANAGEMENT QUESTIONNAIRE:

Appendix 2. Questionnaire for cereal farm visits (answers to given by ticking boxes)

1. Farm

			0	1-25	26-50	51-75	76-99	100
1.1	Land cover	Share (%) of cereals in UAA						

		Conventional	Integrated	Organic	Conservation
1.2	Farm management type				

		Yes	No
1.3	Artificial drainage measures (e.g. tile drains, ditches)		

		Yes	No
1.4	Irrigation measures (e.g. flooding, sprinklers, drippers)		

Skip 1.5 if answer to 1.4 is 'No'

		0-40	41-80	>81
1.5	Irrigation rate (mm/season) = (l/m²/season			

Skip 1.6 if answer to 1.4 is 'No'

		1	2-3	4-5	>6
1.6	Irrigation frequency				

Understanding the role of soils in Functional Land Management