Soil management

David Michie
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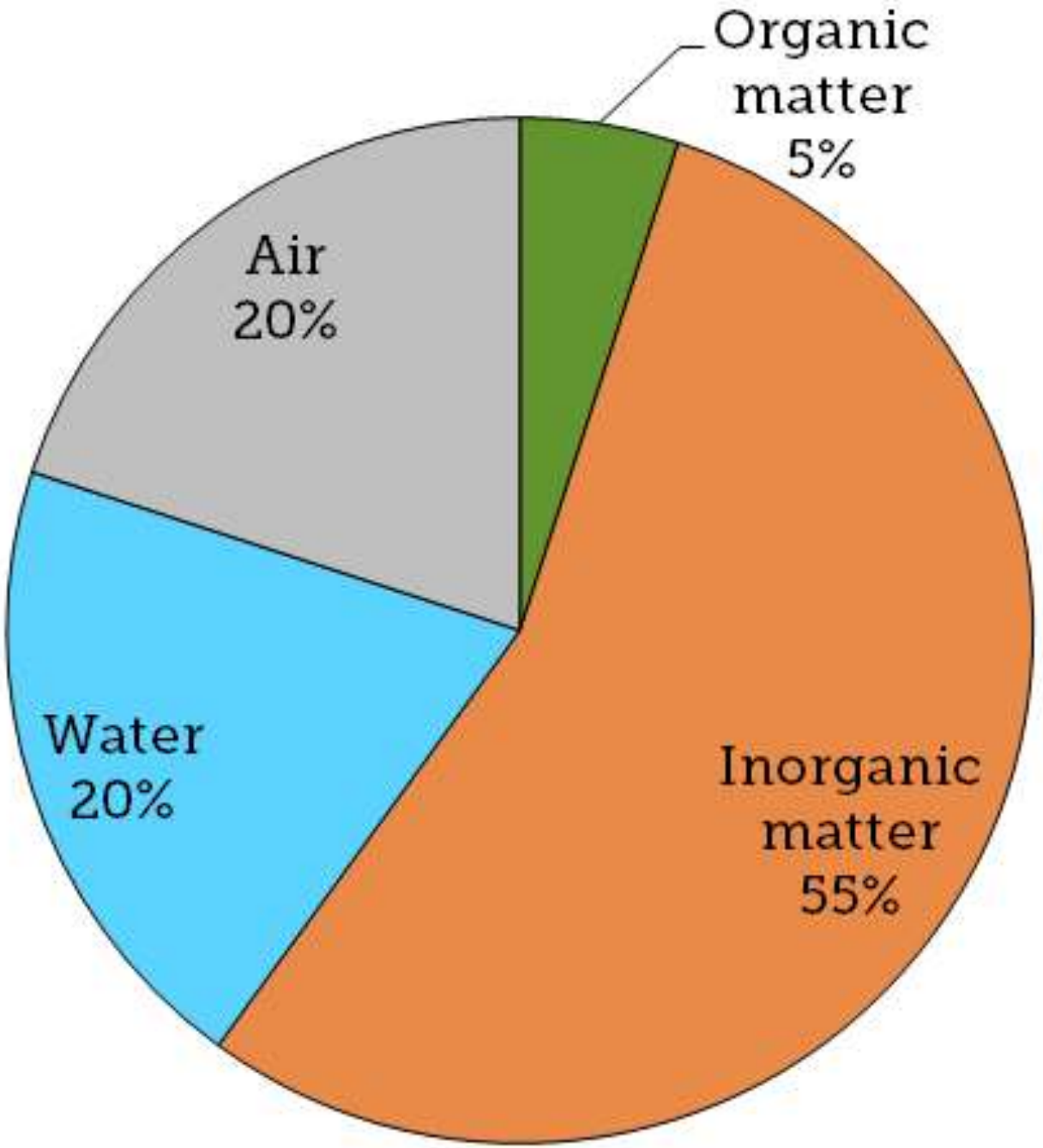
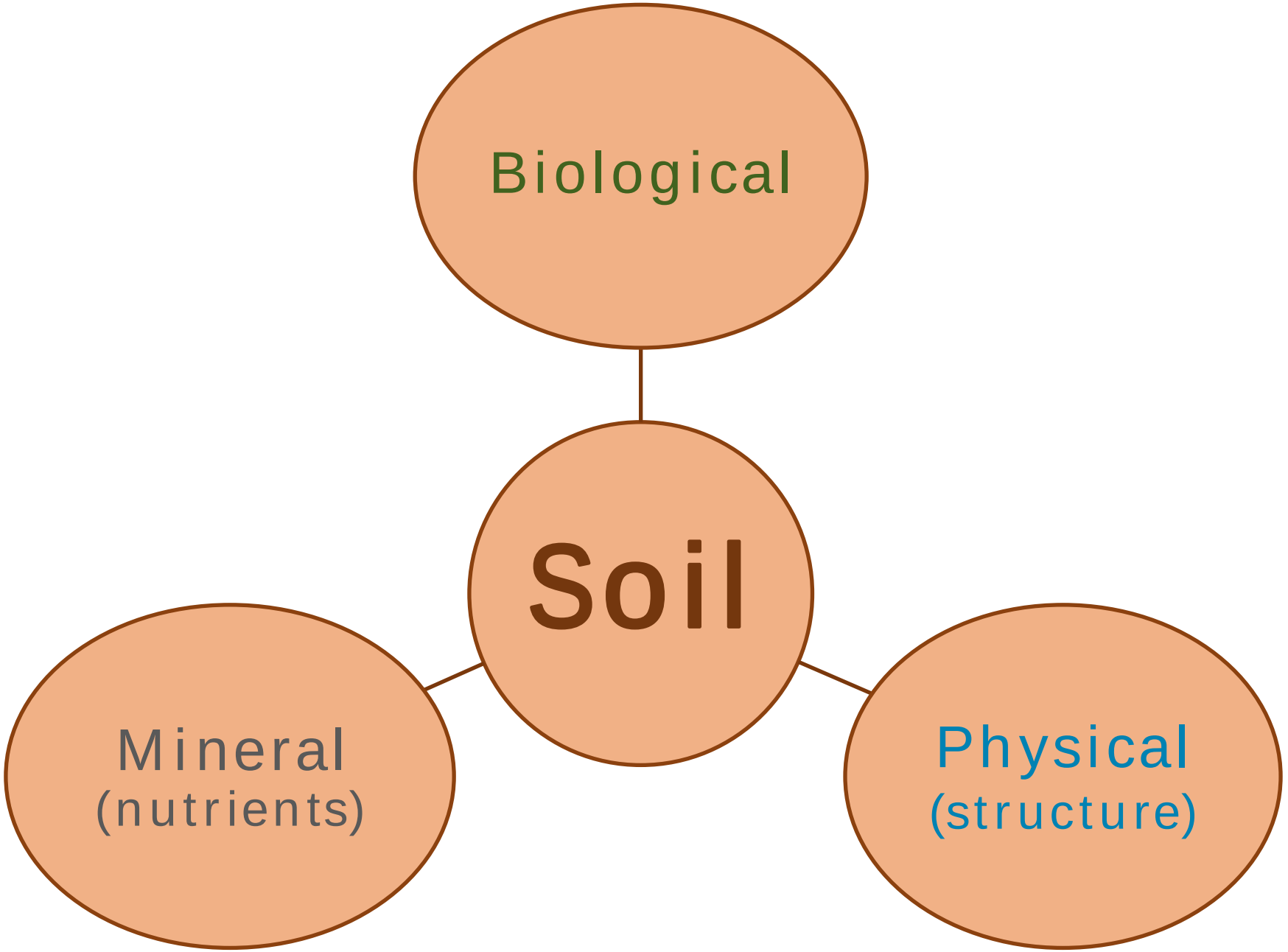
The European Agricultural Fund for Rural Development: Europe investing in rural areas
The Scottish Government
QMS
Forestry Commission Scotland
The Prince's Charities
Innovative Farmers
Part of the Duchy Future Farming Programme

What is soil?



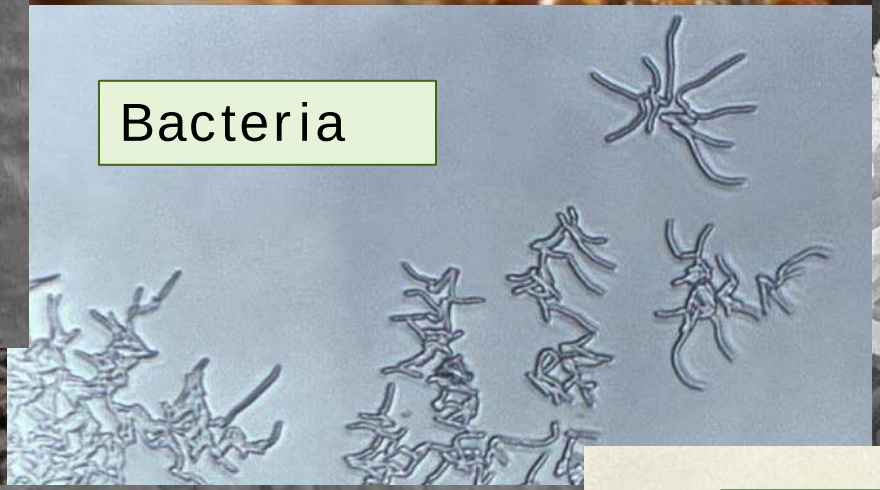

Biological
Soil
Mineral
(nutrients)
Physical
(structure)

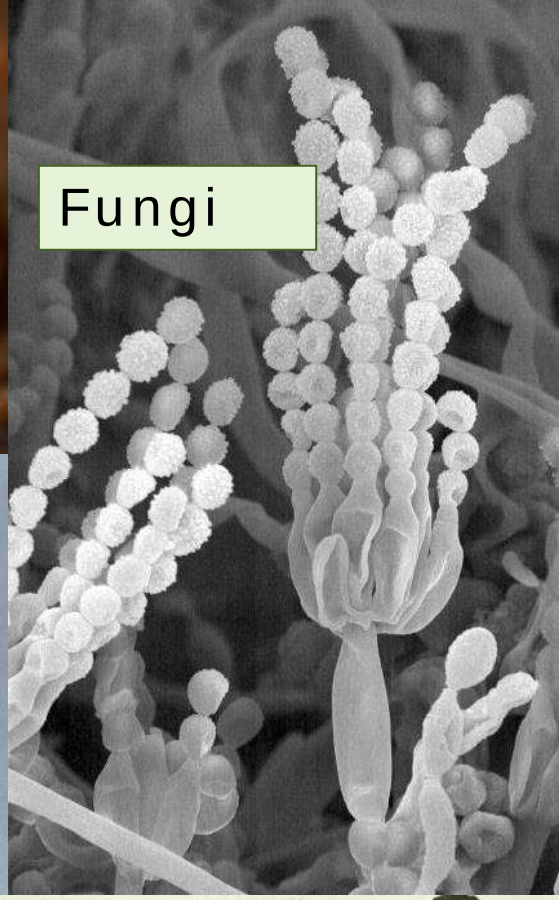
Biology

- Soil is a living environment
- A handful of soil contains billions of organisms
- They need **air** to breathe
- Essential for soils to function
- Complex web of soil ecology that turns dead plant and animal material into plant available nutrients, and mix up the mineral with the organic

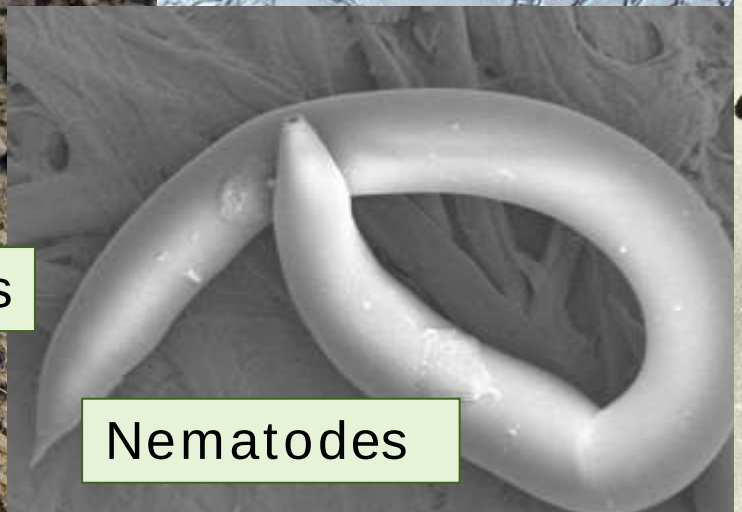

Mites

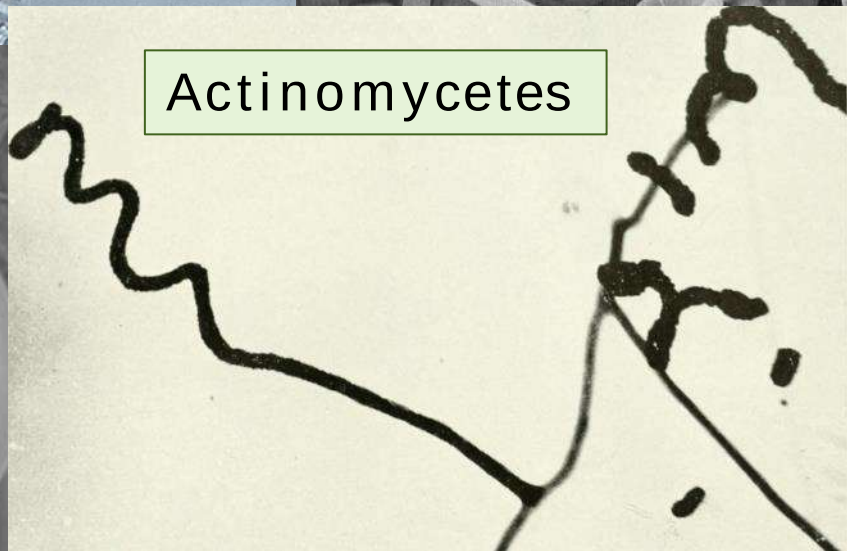

Collembola


Bacteria


Fungi


Earthworms


Nematodes


Actinomycetes

Earthworms

- Healthy soil indicator
- Soil drainage
- Casts are a good source of available nutrients
- Can survive in submerged soils for 120 days
- pH >5.5

Tardigrades

Tardigrades

- Can survive extremes:
- Temperature
  - Just above absolute zero to >100°C
- Pressure
  - 6x greater than in the deepest ocean trenches
- Ionizing radiation
  - 100s x higher than a lethal human dose
- Vacuum of outer space...
  - ...and can go without food or water for >10 years!

Organic matter

- Soil organic matter is a mix of stuff that is:
  - Alive
  - Dead
  - Very dead

Soil organic pools

Fraction	Amount (t/ha)	Amount (%)	Turnover time (years)
Microbial biomass	0.3	**(<1%)**	2.4
Readily decomposed plant material (crop residues, livestock manure)	0.1	**(<1%)**	0.2
Resistant plant material	0.6	**(2%)**	3.3
Physically protected organic matter	13.6	**(47%)**	71
Chemically stabilized organic matter (**humus**)	14.6	**(50%)**	2,900

Jenkinson (1981)

Organic matter

- A good indicator of quality soils
- Very important!
  - Fuels biological activity
  - Drainage
  - Structural stability
  - Water holding capacity
  - Drought resistance

Soil organic matter

- Can be lost by
  - Erosion
  - 'Burning' off with tillage
- Can be preserved with
  - Ley periods
  - Bulky organic manure application
  - Deep rooting crops
  - Good nutrient budgeting
  - Reducing tillage

Soil organic matter

- Soil texture can indicate organic matter levels
- Sandy soils can be down to ~2%
- Organic/peat soils are >20%
- Influences heavy metal toxicity and trace element availability
  - So affects target pH

Soil pH

- The **power** of **Hydrogen** (H^+)
- A measure of acidity or alkalinity
- Very important, because it affects:
  - Nutrient availability
  - Biology
  - Even has an effect on soil structure (Ca:Mg ratio)
- The 'wrong' pH is a frequent cause of nutrient deficiencies

Soil pH

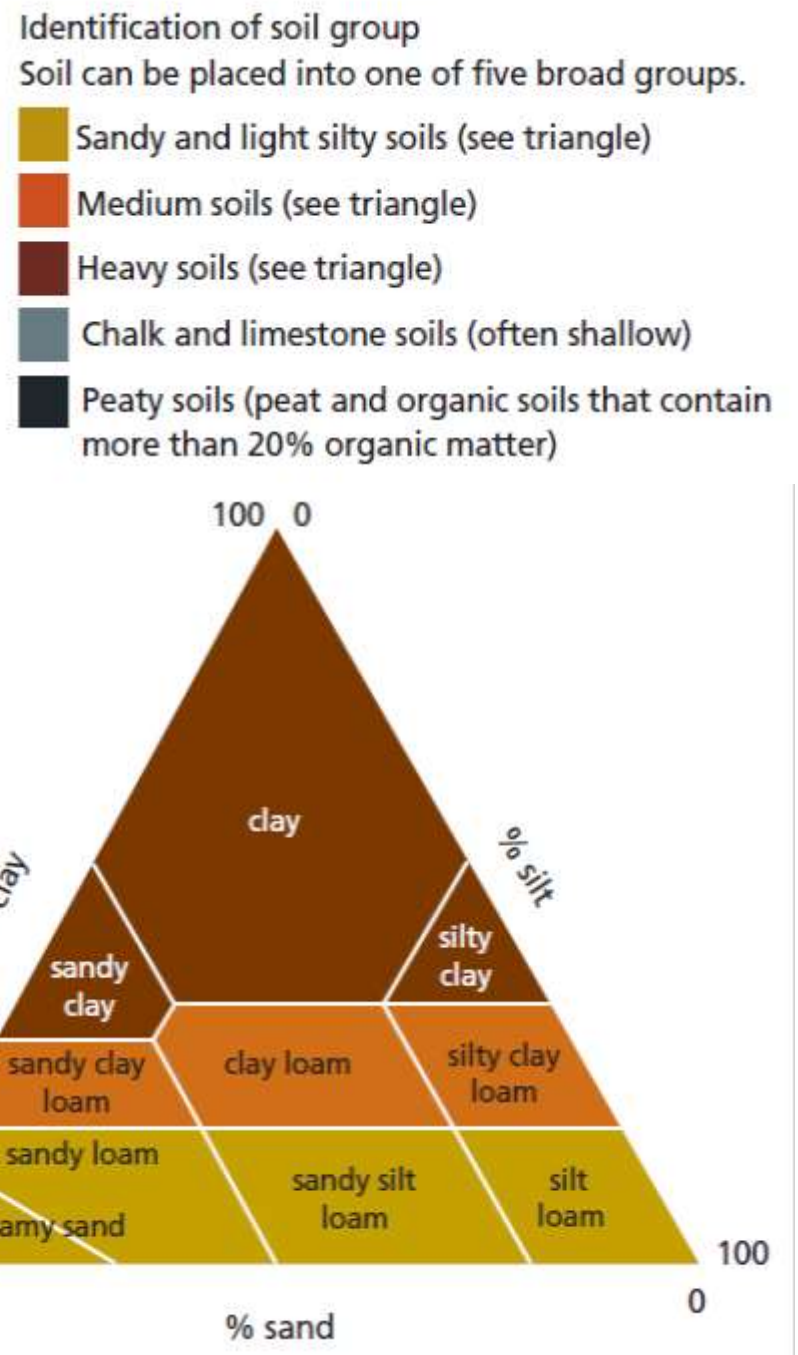
- Influences plant growth
- Nutrient availability
  - Particularly phosphate
- Trace elements / potentially toxic ions
  - Essential manganese (Mn) is deficient at a higher pH
  - Toxic aluminium (Al) is available at a lower pH

Target pH for soils

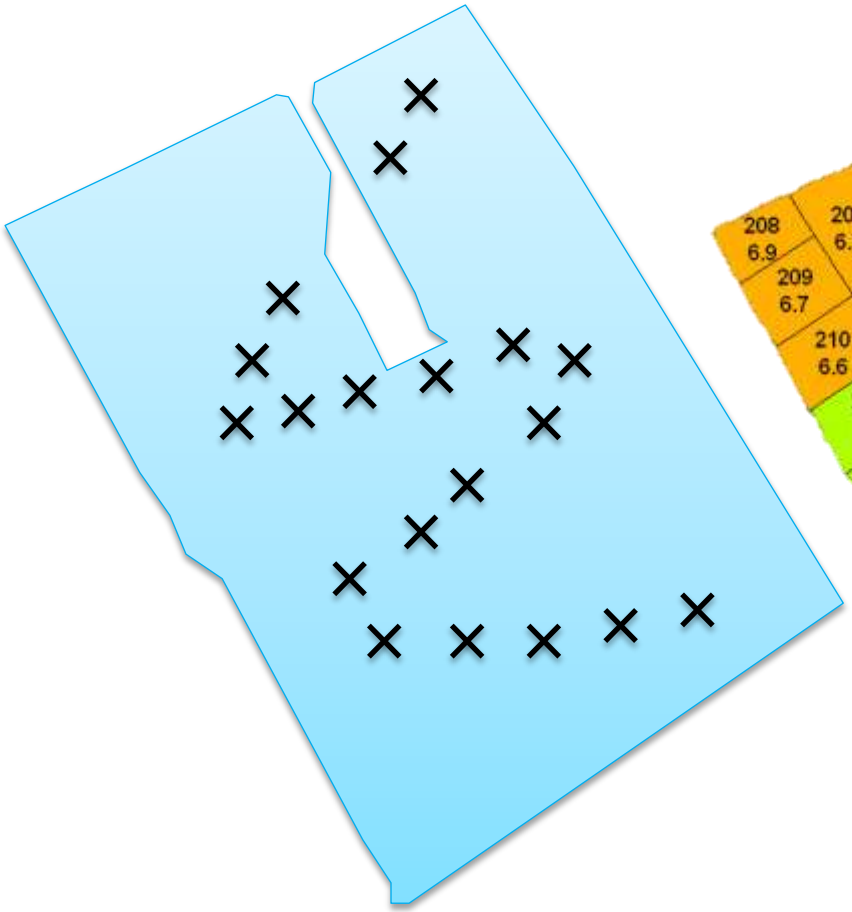
- Depends on ***soil type*** and ***cropping***
- Mineral soils
  - Target **pH 6.2** (rotational ground)
  - Target **pH 5.9** (permanent grass)
- Peaty soils
  - Target **pH 5.1** (permanent grass)
- *Based on old fashioned W sampling*

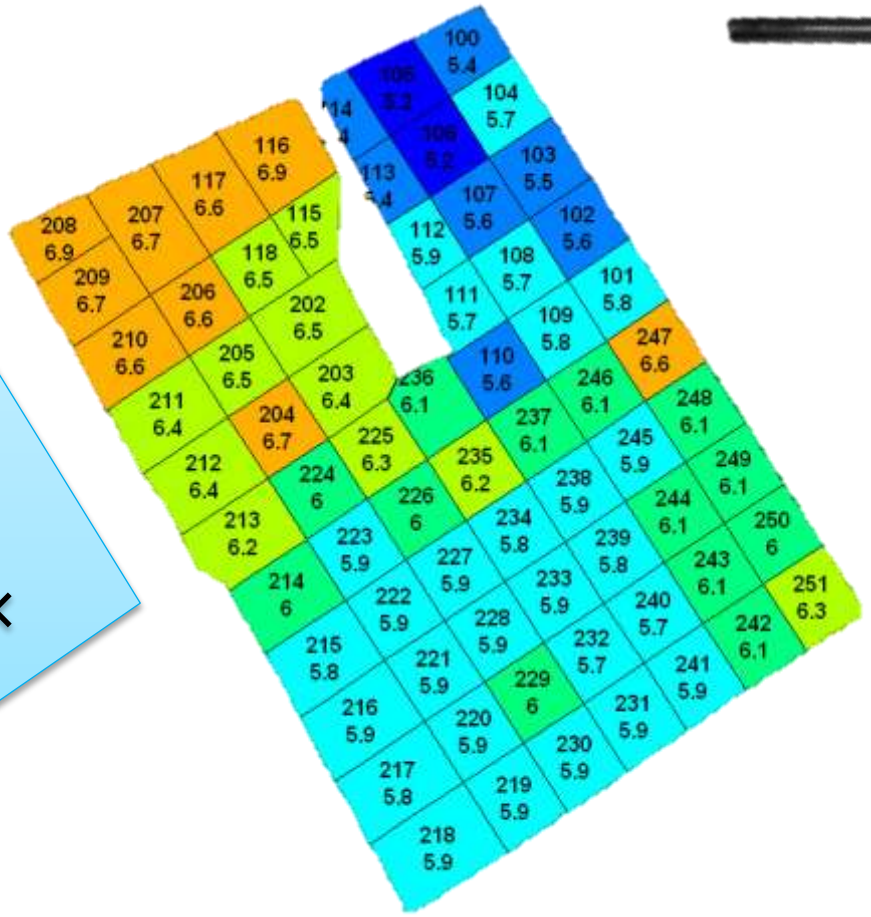
Soil texture

- pH will drop at different rates in different soils
  - Management
  - Soil texture
    - Sandy soils – little and often
    - Clay soils – less frequently



W sampling




100 5.4
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103 5.5
107 5.6
102 5.6
112 5.9
108 5.7
101 5.8
111 5.7
109 5.8
247 6.6
110 5.6
246 6.1
248 6.1
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237 6.1
245 5.9
249 6.1
235 6.2
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250 6
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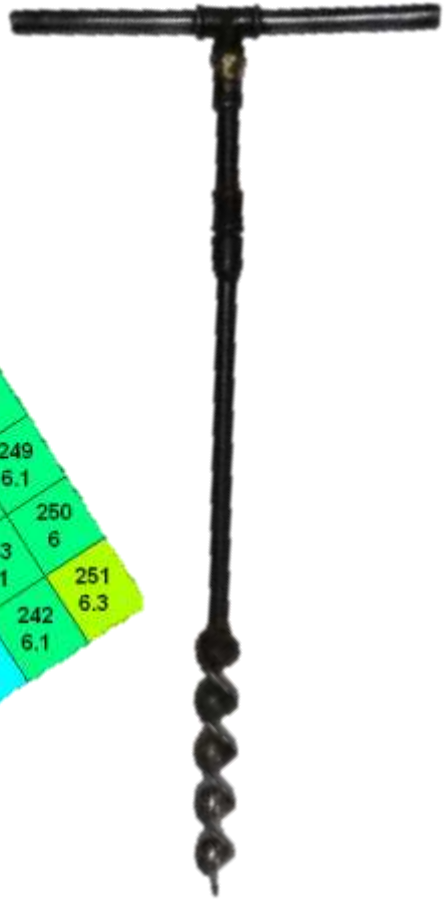
115 6.5



Optimum pH

- Maintaining **optimum pH** in the topsoil is important for
  - Optimum yields
  - Consistent crop quality
  - Good root development
- Maximise nutrient uptake
- Minimise nutrient losses
  - To air and water

Technical Note TN656

SRU

January 2014 • All

Soils information, texture and liming recommendations.

SUMMARY

- Web based access to information on your soils on your farm is described.
- Soil texture classes of mineral soils are described and identified by hand texturi
- Liming recommendations for different soils and managements are tabulated.

1. Introduction

Scotland's soils have been comprehensively surveyed, classified, and studied over the past 75 years. Understanding and using this information at the farm level has up till now been difficult due to its complexity and the accessibility of information.

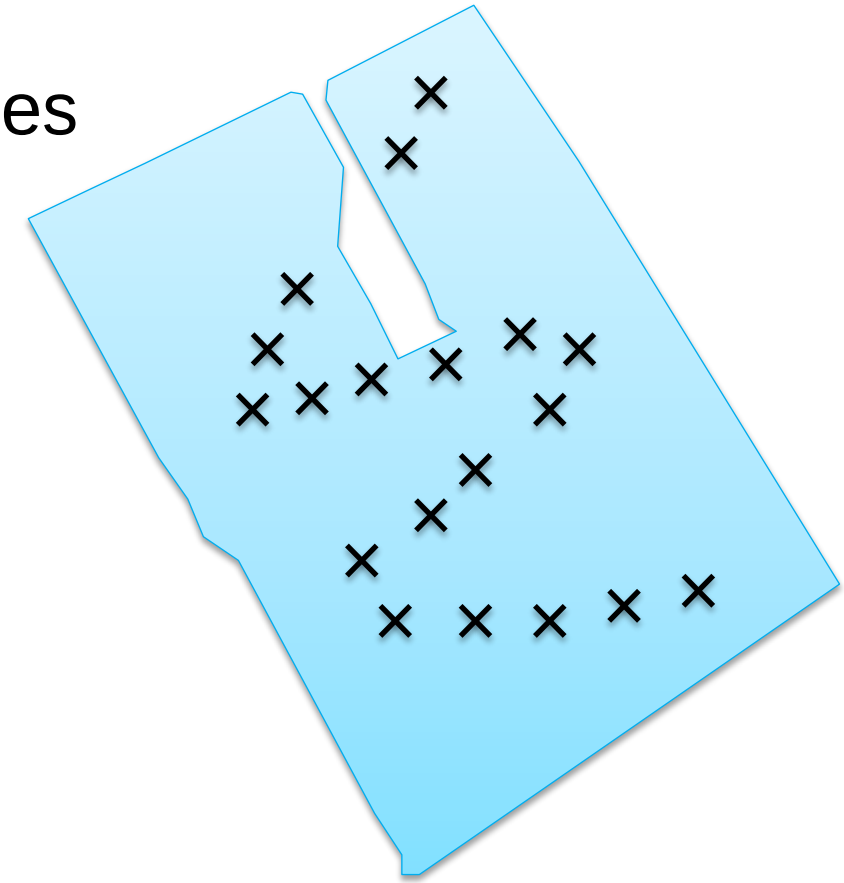
In this technical note the influence of soil texture on ta soil pH values and liming requirements of crops and gras described. Regular soil testing is required every 4 - 5 yea order to monitor success in maintaining targeted levels of l

Soil analysis

- Every 4 or 5 years; keep an eye on:
  - pH
  - Phosphate (P)
  - Potash (K)
  - Magnesium (Mg)
- Lime little and often
- Aim for Moderate P and K status
- Replace what you take off
  - Silage takes off more than grazing

Soil sampling

- **Get your soils sampled and analysed!**
- Soil sampling
  - Take lots of subsamples
  - W formation
  - 15 cm deep
  - Bulk them together



UKAS TESTING
7624

Advisory Soil Report

SAC COMMERCIAL LTD

Client: [redacted]

Your reference:	Quarry
Last crop:	Spring barley
Next crop:	Winter barley
Soil type:	Mineral

Lab sample no:	13011416
Batch no:	_1354
Date received:	17/10/2013
Date reported:	23/10/2013

Determination	Result	Units	Status
pH	5.9		
Lime requirement arable	3	t/ha	
	1.2	tons/acre	
Lime requirement grass	0	t/ha	
	0.0	tons/acre	
Extractable phosphorus	3.2	mg/l	Low
Extractable potassium	135	mg/l	M(-)
Extractable magnesium	96.0	mg/l	Mod

Technical Note TN652

SRUC

April 2013 • Elec

Fertiliser recommendations for grassland

SUMMARY

- The main limitations to grass production are temperature, moisture, soil pH, soil drainage and structure, and nitrogen (N).
- Recommendations take account of nutrient management planning in the PLANET Scotland software tool and NVZ Action Programme rules.
- Good soil management is required to optimise nutrient use and maximise grassland productivity.
- Regular soil analysis is essential to manage soil pH and optimise phosphate (P_2O_5) and potash (K_2O) inputs for maximum yields and profitability.

Soil analysis

- Can test for other things:
  - Sulphur (S)
  - Cobalt (Co)
  - Copper (Cu)
  - Organic matter (LOI)
- Calcium (Ca) shouldn't be a problem if the soil has been limed
  - Lime is $CaCO_3$

Nutrient management

- Replace what you take off
  - Silage takes off more than grazing, and can remove lots of potash that needs replaced
  - Grazed permanent grass takes very little off each year – some phosphate and potash
- Target bulky organic manures to silage fields

Nutrient values

Manure type	Application rate	Available N* (kg /ha)	Total P_2O_5 (kg /ha)	Total K_2O (kg /ha)
15:15:20	600 kg/ha	90	90	120
Cattle FYM	20 t /ha	*24*	64	160
Cattle slurry	30 m^3 /ha	*36*	36	96

*N availability will depend on application timing and method of incorporation

Values:

- 15:15:20 £165 /ha
- Cattle FYM £xxx /ha
- Cattle slurry £XXX/ha

Organic manures – N

1. *Readily available nitrogen*
   - Immediate uptake, amounts vary with application timing and incorporation
2. *Crop available N*
   - For the following crop
3. *Potentially available N*
   - Broken down slowly, available over several years
   - Bulky organic manures, i.e. muck

Technical Note TN650

SRUC

April 2013 • Elec

Optimising the application of bulky organic fertilisers

SUMMARY

- Livestock manures should be viewed as valuable resources rather than as waste products. They can bring significant benefits to soils and crops when used appropriately, and their use can result in considerable savings on purchased fertilisers.
- Bulky organic fertilisers, other than livestock manures, (for example: biosolids, distillery effluent, compost and digestate) can be useful and cost-effective crop nutrient sources that can also confer benefits to soil fertility. They can be particularly useful where livestock manures are unavailable or in short supply.
- The principles of nutrient supply and losses, and the need for livestock manure

Nutrients – P & K

- **Get your soils sampled and analysed!**
- Target organic manures (i.e. muck) to fields with low K and/or P status
- Take organic manures into account, *especially* if you always apply to the same fields

Nutrients – N

- Muck will also provide some N, and small but significant quantities of trace elements
- Take **clover** into account
  - Near Aberdeen (SRUC's Craibstone campus) the *average* rate of N fixation was 112 kg N /ha /year (~90 units /acre)
  - This could be higher on the west coast (milder and wetter climate)

DIY soil assessments

- How easy is it to dig?
  - Soil structure
- Earthworms
  - Number
  - Diversity
- Smell
- Colour
- Wetness
- Root growth

Healthy Grassland Soils –
Four quick steps to assess soil structure

Step one: **Surface assessment**

Look at sward quality to identify potentially damaged areas which require further assessment.

Good
- Sward intact
- No poaching
- Few wheelings

Moderate
- Surface poached
- Wheelings in places
- More weed species

Poor
- Surface compacted
- Soil exposed
- Poaching
- Poor sward quality

Step two: **Soil extraction**

- Dig out one spade-sized block of soil (depth approx. 30cm). Cut down on three sides and then lever the block out leaving one side undisturbed
- Lay soil block on a plastic sheet or tray

Tip: When starting out it is useful to dig in an area where you know there may be a problem (eg a gateway) and get familiar with signs of soil structure damage.

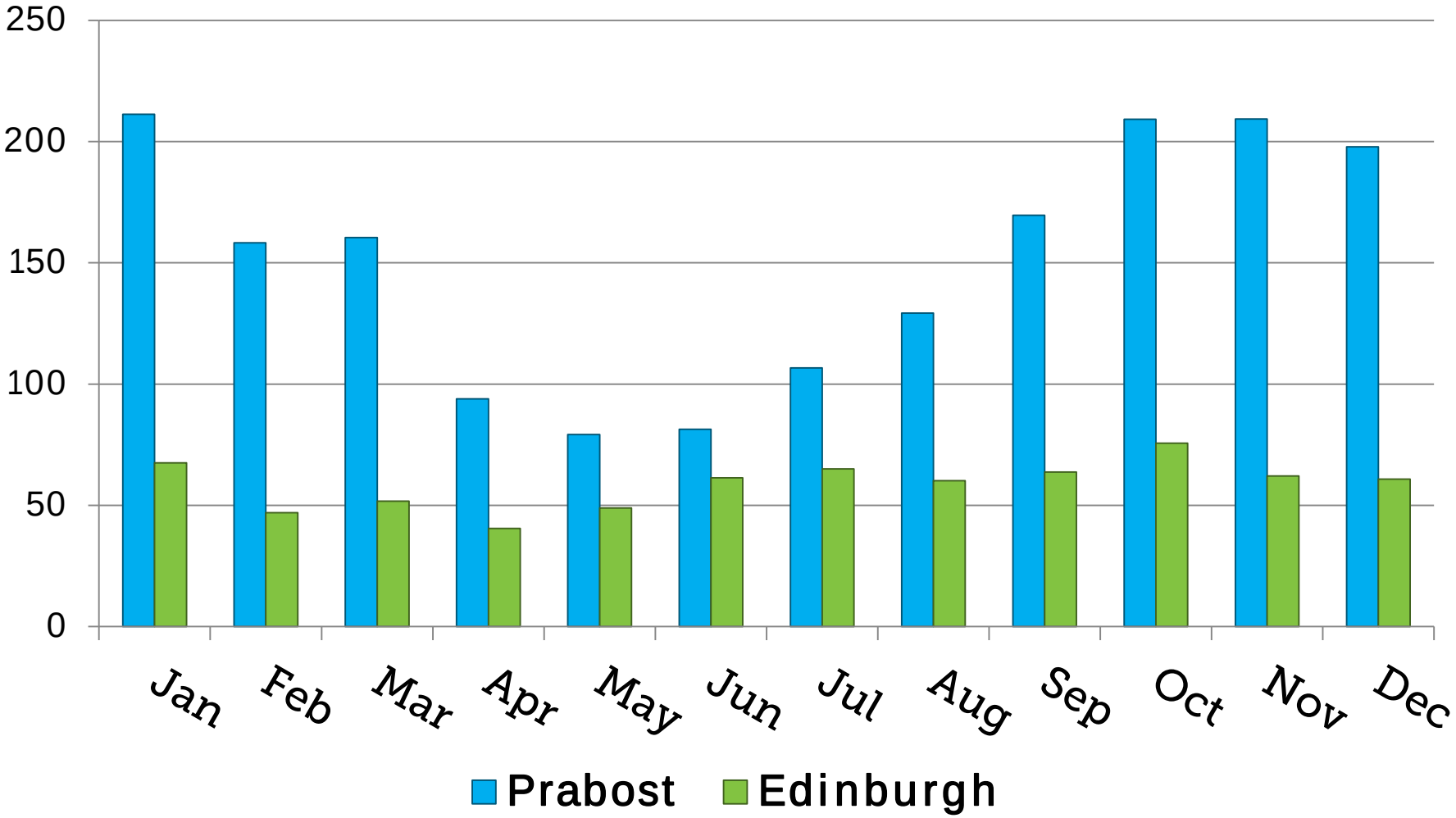
Soil structure

- **Compaction** of the upper soil layers:
  - Limits root development
  - Restricts nutrient uptake
  - Reduces growth potential
  - **Reduces yield**
- Compaction is associated with denitrification (loss of NO_x) – a particularly bad GHG

Poor structure: causes

- Livestock
  - Overgrazing
  - Poaching
- Heavy machinery
  - Over-cultivation
  - Working in wet conditions

Prabost average monthly rainfall (mm), 1981 – 2010



Aerators & subsoilers

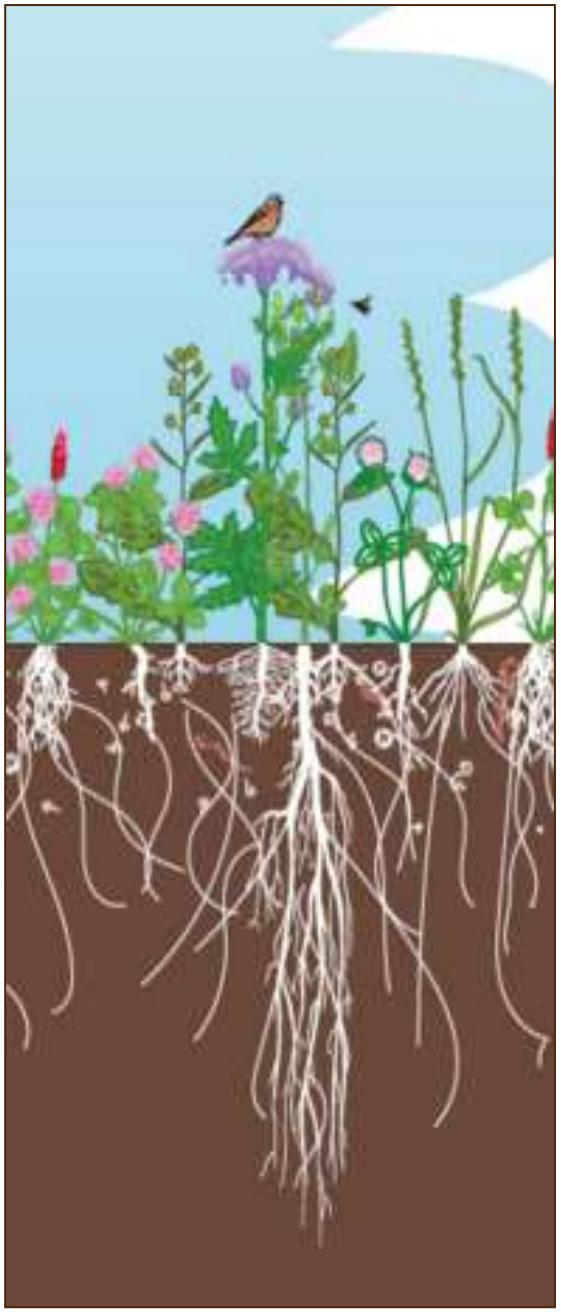
- Soils need **air** to breathe
- Soil life
  - Nitrogen fixation
  - Nutrient cycling
- Drainage
- Rooting

Topsoil trial: results

Sward lifter	Aerator	No treatment
		

Roots

- Deep roots can open up the soil
  - Red clover
  - Chicory
  - Cocksfoot
  - Mustard
- Also
  - Provide organic matter
  - Bring up trace elements



Messages

- Keep an eye on your soil
- Carry out soil sampling and analysis
- Keep the soil in the right pH range
- Replace the nutrients you take off
- Check your soil structure

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