Climate change & mountain soils

Silvia Stanchi

Outline

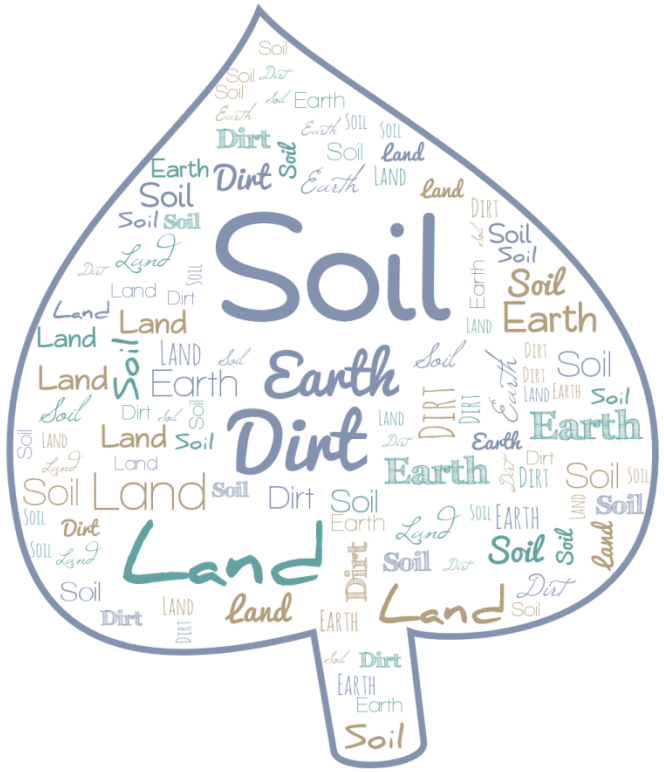
Part 1

- Mountain soils: genesis & properties

Part 2

- Mountain soil: functions & ecosystem services; threats

What is soil?



An "official" definition….

Soil - The unconsolidated mineral or organic matter on the surface of the Earth that has been subjected to and shows effects of genetic and environmental factors of: **climate**, and macro- and micro**organisms**, conditioned by **relief**, acting on **parent material** over a period of **time**.

Soil differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054280

Mountain soils: genesis & properties

Let's talk about soil

Main messages

Soils are fundamental for ***food security***

Many ***threats*** put soils in danger (sealing, pollution, erosion…..)

Soils can be ***quickly lost***

Soils ***form slowly***

…..particularly in mountains

Why are mountain soils important?

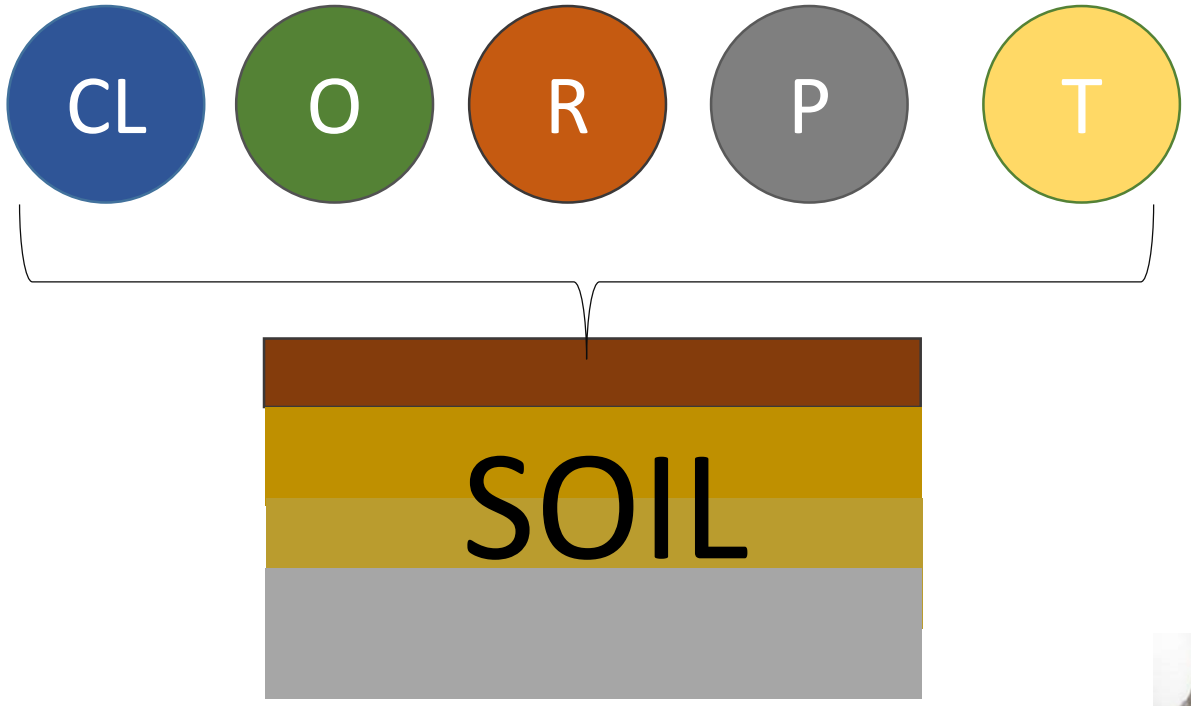
Global mountain area

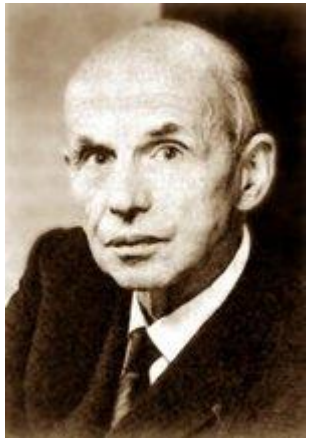
39.3 million km^2 -> 27% of the Earth's land surface

~900 mln people in the world

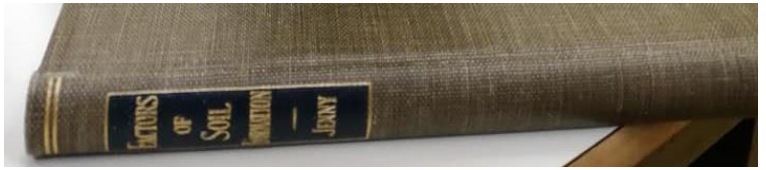
½ of mountain dwellers -> vulnerable to food insecurity

Jenny's model: «clorpt for short»



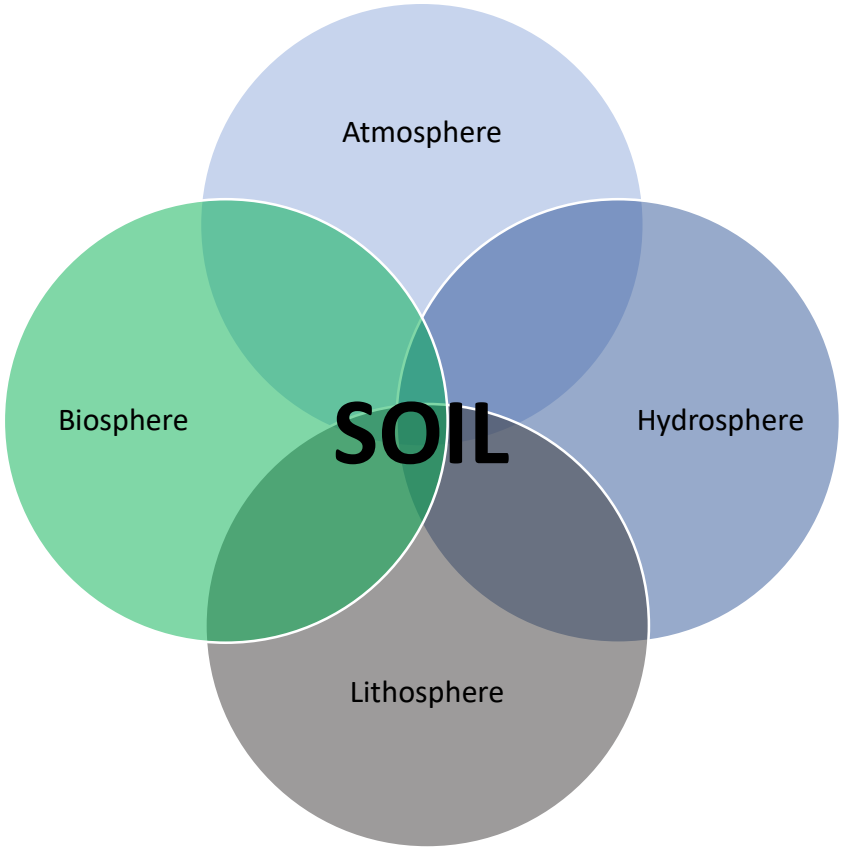


Hans Jenny (1900-1992)
Born in Switzerland, professor at Berkeley (CA-USA)



Want to know more? Watch!
https://ourenvironment.berkeley.edu/2011/08/the-hans-jenny-memorial-lecture-in-soil-science-the-genius-of-soil-by-garrison-sposito
Look for infographics? http://www.fao.org/soils-2015/resources/infographics/en/

Soils may be complex….

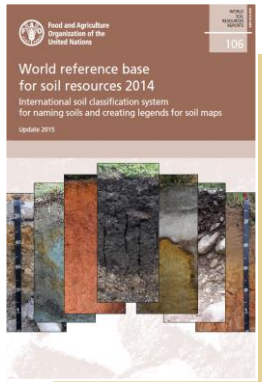


But interesting

Ph. Credits: Links4Soils

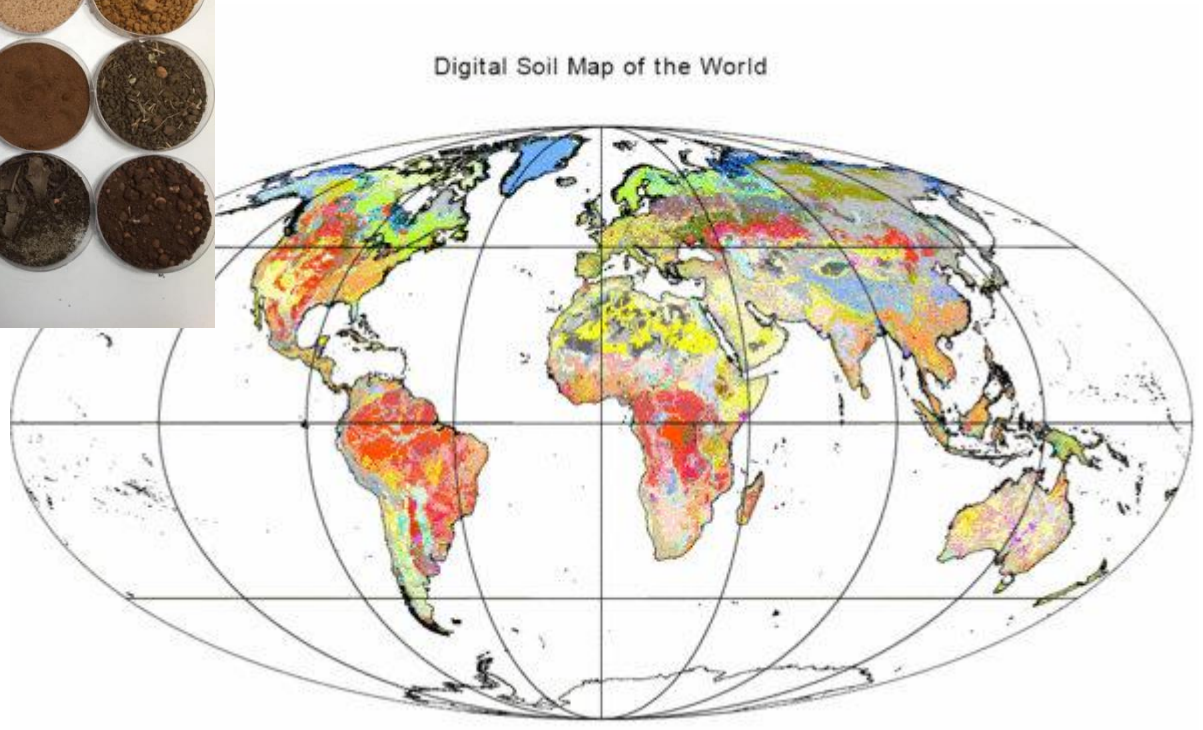
Soil science basics

Soils consist of layers called horizons, with different morphological, chemical & physical properties



Many soil classifications exixst. Among them, the FAO-WRB system

How many soils in the world?



http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/faounesco-soil-map-of-the-world/en/

Some Soil Facts (FAO)

Due to the thousands and even tens of thousand of years it needs to develop, soil is considered a non-renewable resource

A single handful of soil can contain billions of organisms

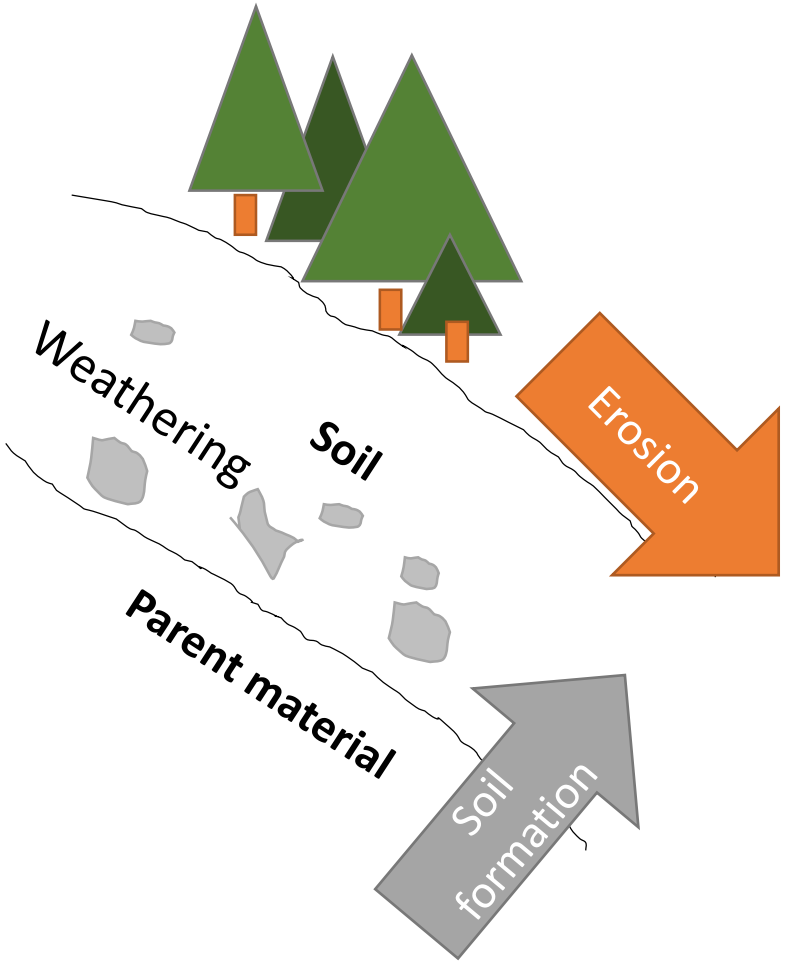
About 33% of the world's soils are degraded due to pollution, compaction, salinization, loss of organic matter and nutrients

Soil formation (pedogenesis) in mountain areas

PROGRESSIVE PEDOGENESIS
-promotes differentiation
-horizonization
-leaching
-soil deepening

vs.

REGRESSIVE PEDOGENESIS
-rejuvenation
-retardant upbuilding/ burying
-truncation/erosion



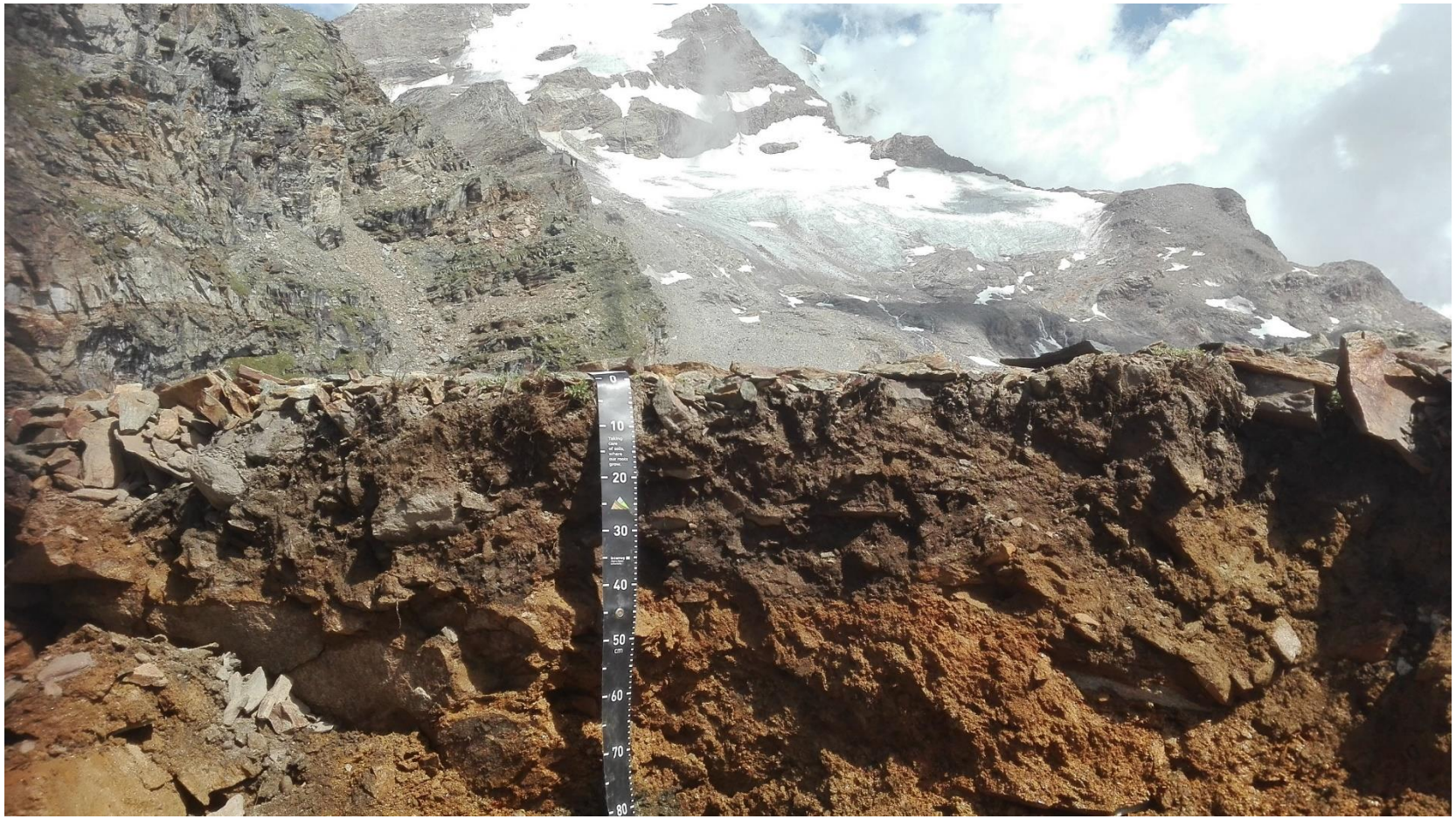
(Egli et al., 2014, modified)

Mountain soils & landscapes

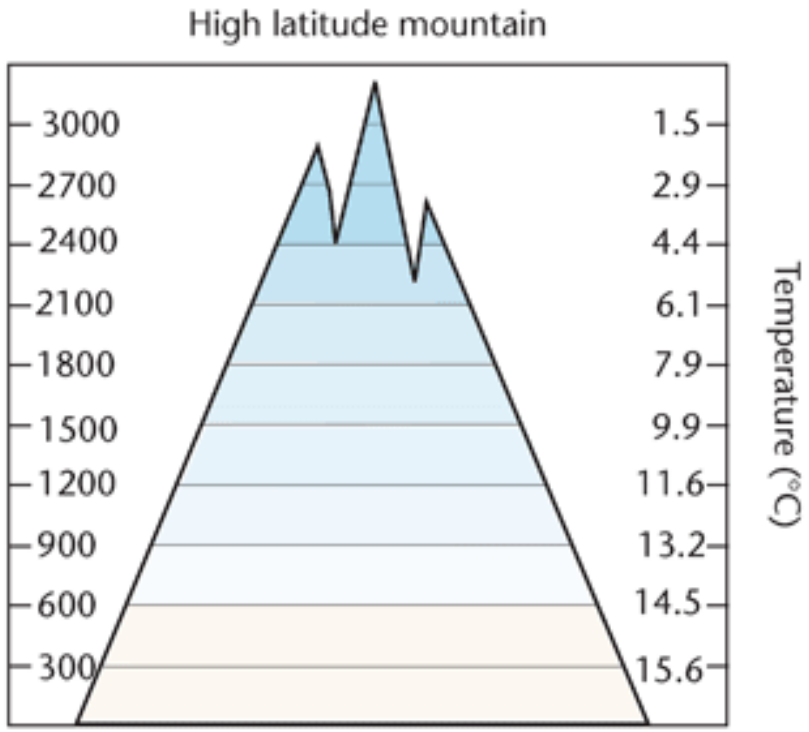


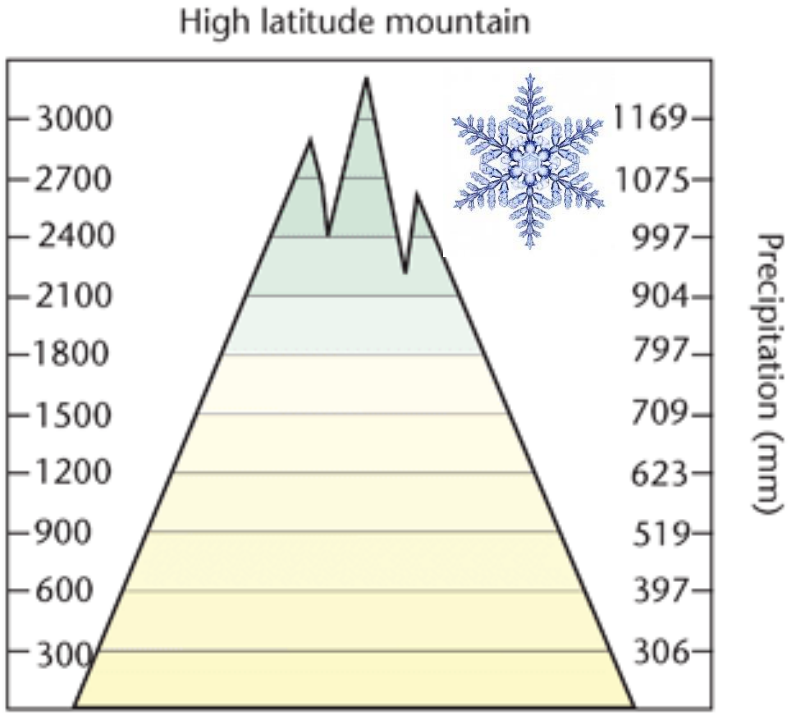



Mountain soils



CL- climate


High latitude mountain
3000
2700
2400
2100
1800
1500
1200
900
600
300
1.5
2.9
4.4
6.1
7.9
9.9
11.6
13.2
14.5
15.6
Temperature (°C)


High latitude mountain
3000
2700
2400
2100
1800
1500
1200
900
600
300
1169
1075
997
904
797
709
623
519
397
306
Precipitation (mm)

CL- climate

Snow protects soils

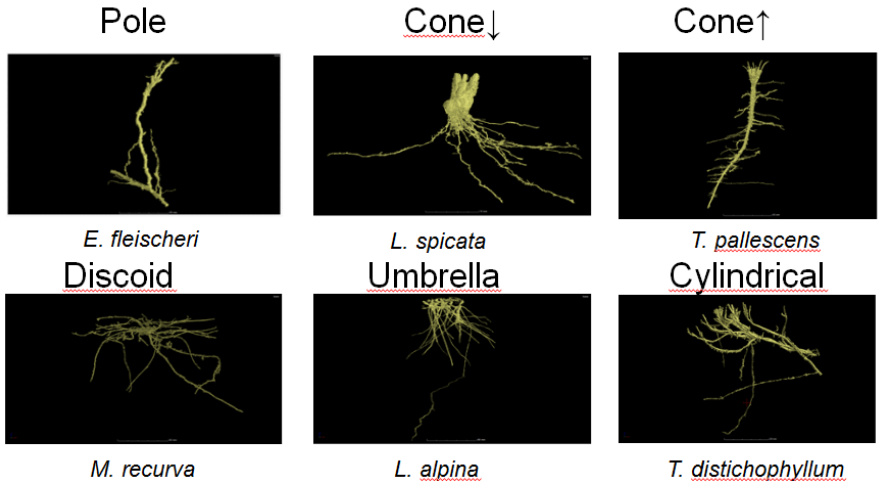
(thermal insulation)

O - organisms

Vegetation belts

Tree-line

O- organisms


Pole
Cone↓
Cone↑
E. fleischeri
L. spicata
T. pallescens
Discoid
Umbrella
Cylindrical
M. recurva
L. alpina
T. distichophyllum

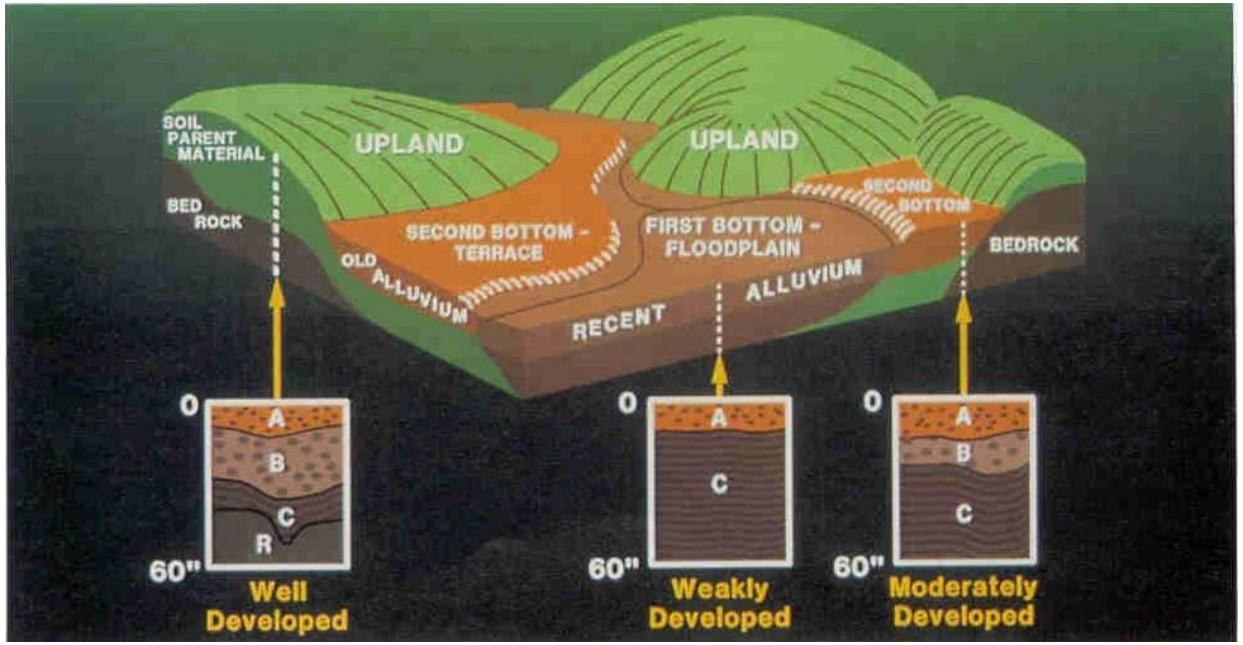
O- organisms

Soil biota

Below-ground biodiversity

http://eusoils.jrc.ec.europa.eu/library/maps/biodiversity_atlas/

R- relief


SOIL PARENT MATERIAL
BED ROCK
UPLAND
UPLAND
SECOND BOTTOM - TERRACE
FIRST BOTTOM - FLOODPLAIN
SECOND BOTTOM
BEDROCK
OLD ALLUVIUM
RECENT
ALLUVIUM
0
A
B
C
R
60"
Well Developed
0
A
C
60"
Weakly Developed
0
A
B
C
60"
Moderately Developed


Relief

P- parent material

Types of transported parent material and associated modes of transportation and deposition

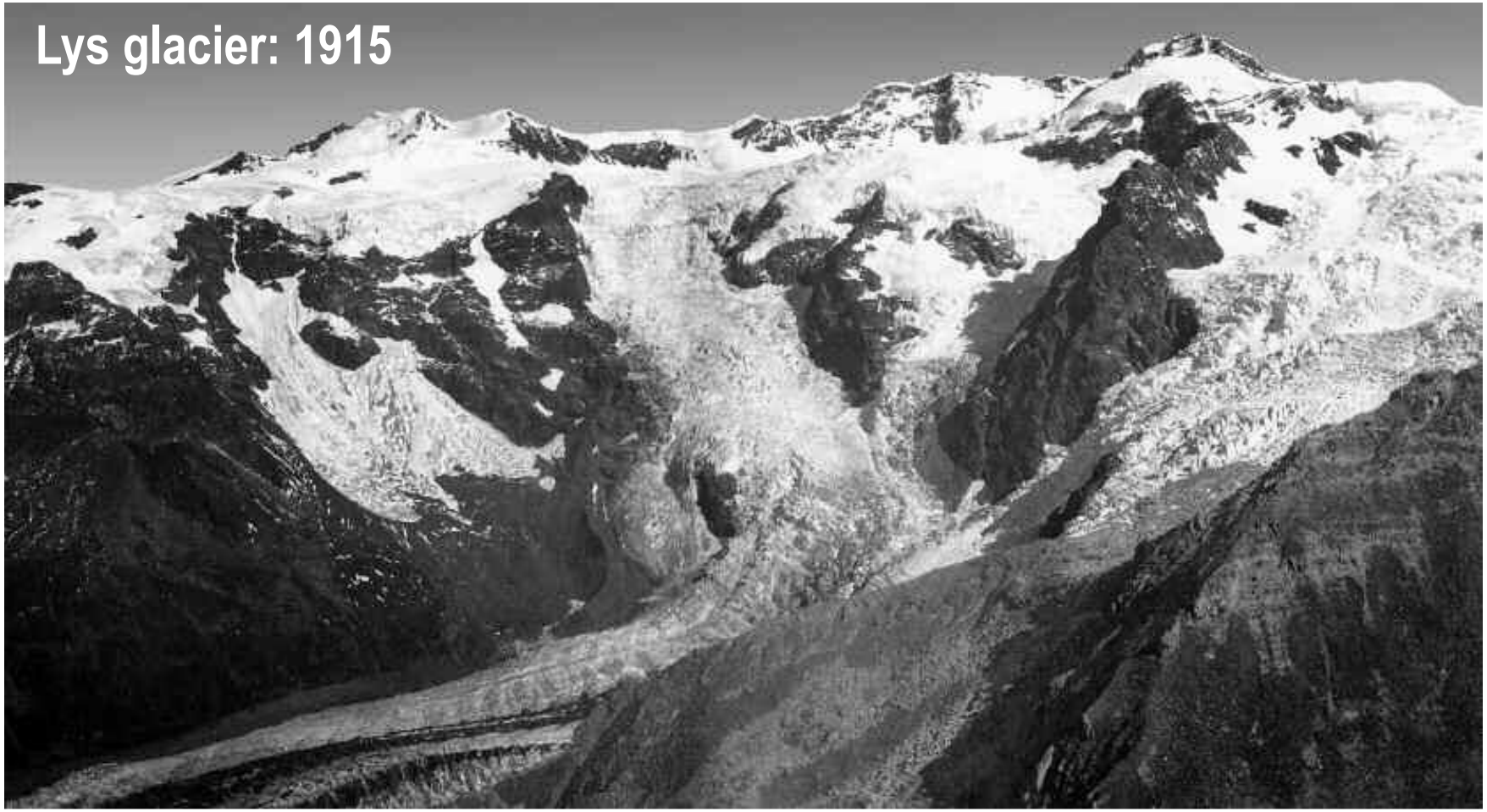
Mode of Transport	Resulting Parent Material
Water	• Alluvial or fluvial (deposited from flowing water) • Lacustrine (sediments in still water, especially lakes) • Marine (deposited in oceans or re-worked by oceans)
Water and Ice	• Glacial-fluvial (sediments deposited by glacial meltwater in a floodplain environment) • Glacial-lacustrine (sediments deposited by glacial meltwater in lake environment) • Glacial-marine (sediments deposited by glacial metlwater in an ocean environment)
Ice	• Till (sediment deposited directly by glacial ice)
Wind	• Loess (sediment composed primarily of silt-sized particles) • Volcanic tephra (sediment composed of volcanic erecta in a range of particle sizes) • Eolian sand (sediment composed primarily of sand-sized particles)
Gravity	• Colluvium (sediments found on steep slopes derived from local sources)

This is the material from which the soil has developed and can vary from solid rock to deposits like alluvium. It has been defined as ‘the initial state of the soil system’.

The parent material can influence the soil in a number of ways:

- colour
- texture
- structure
- mineral composition
- permeability/drainage

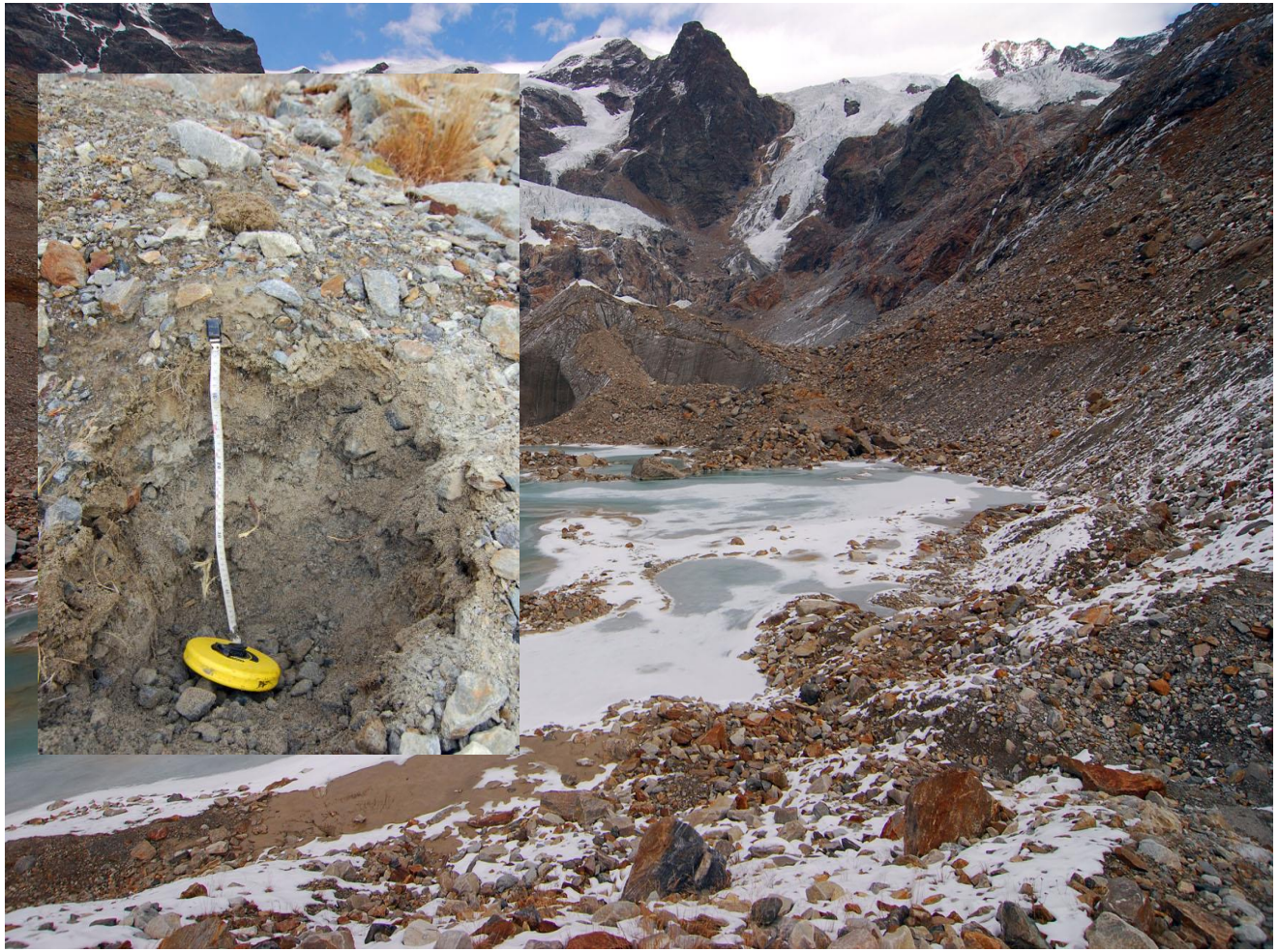
T- time



T- time

T- time

T- time



15 years

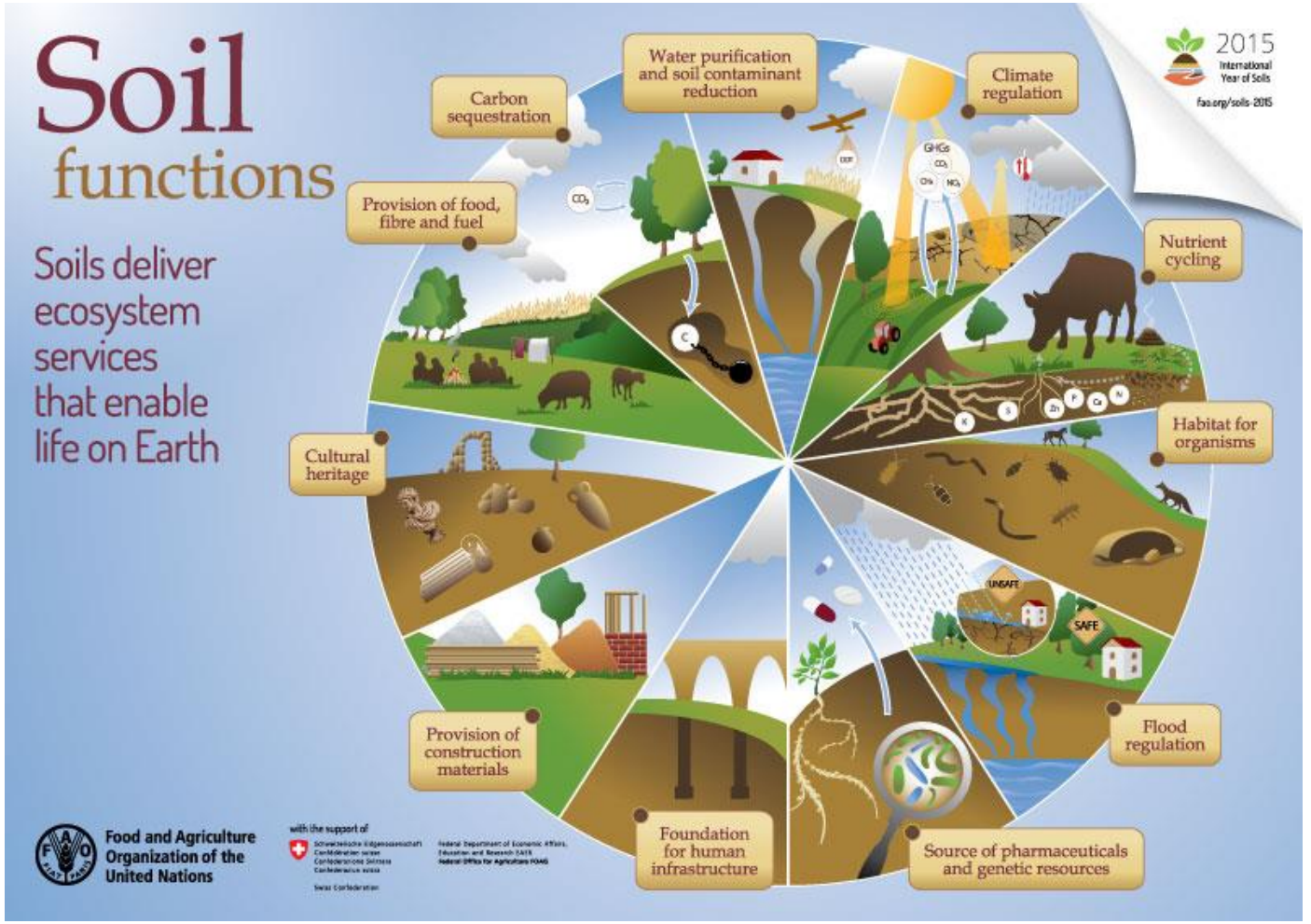
T- time

135 years

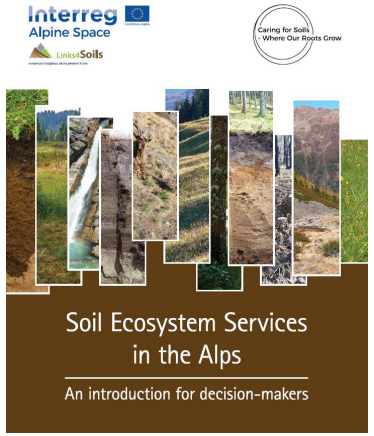
Mountain soils: functions & ecosystem services; threats

What soils can do

Credits: Links4Soils

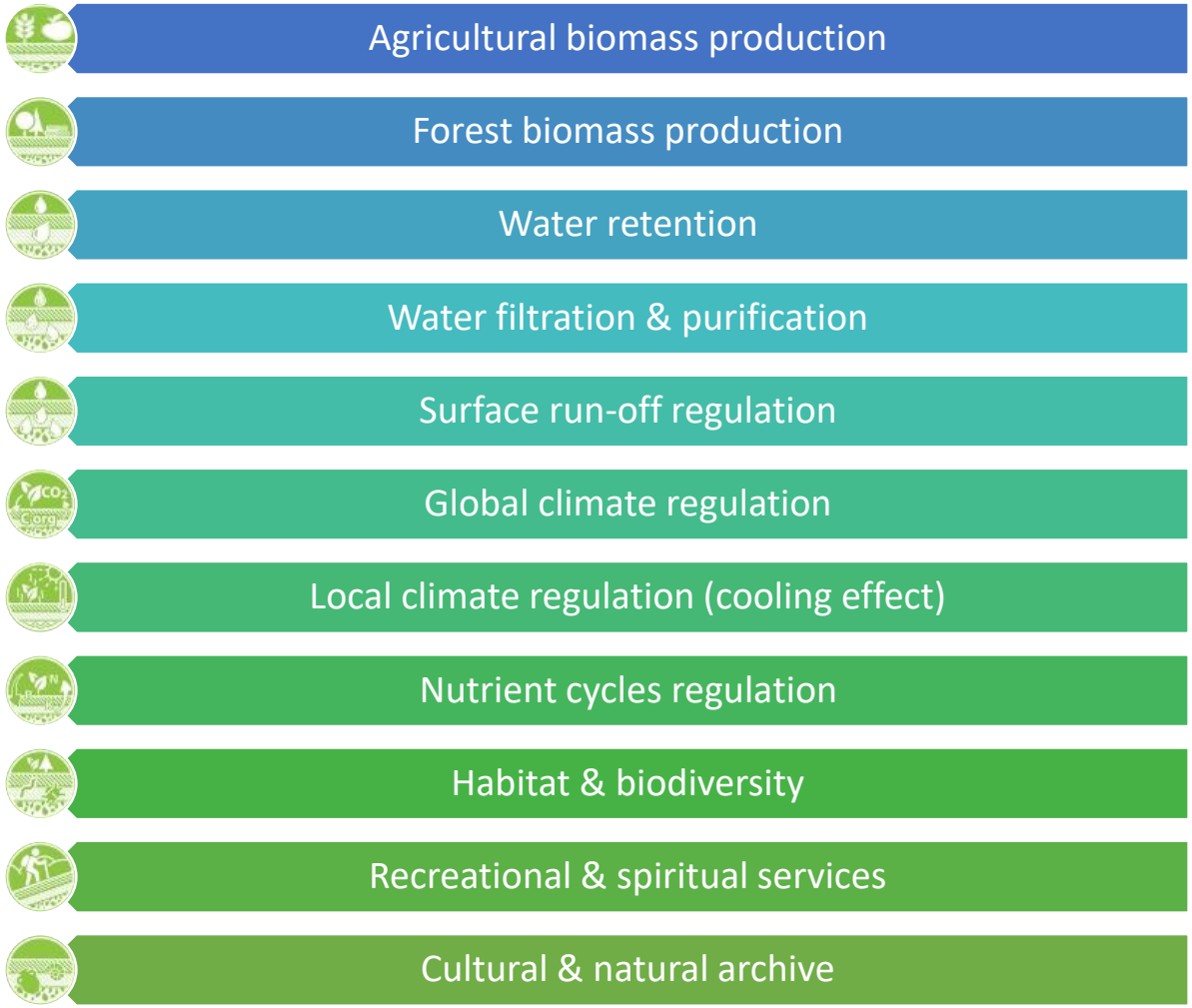


Soil Ecosystem Services in mountain regions



https://www.alpine space.eu/projects/links4soils/en/project-results

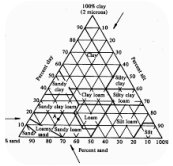
Selected Soil Ecosystem Services in mountain regions



An example

Surface run-off regulation

Reduce run-off and floodings, provide groundwater recharge, favour infiltration

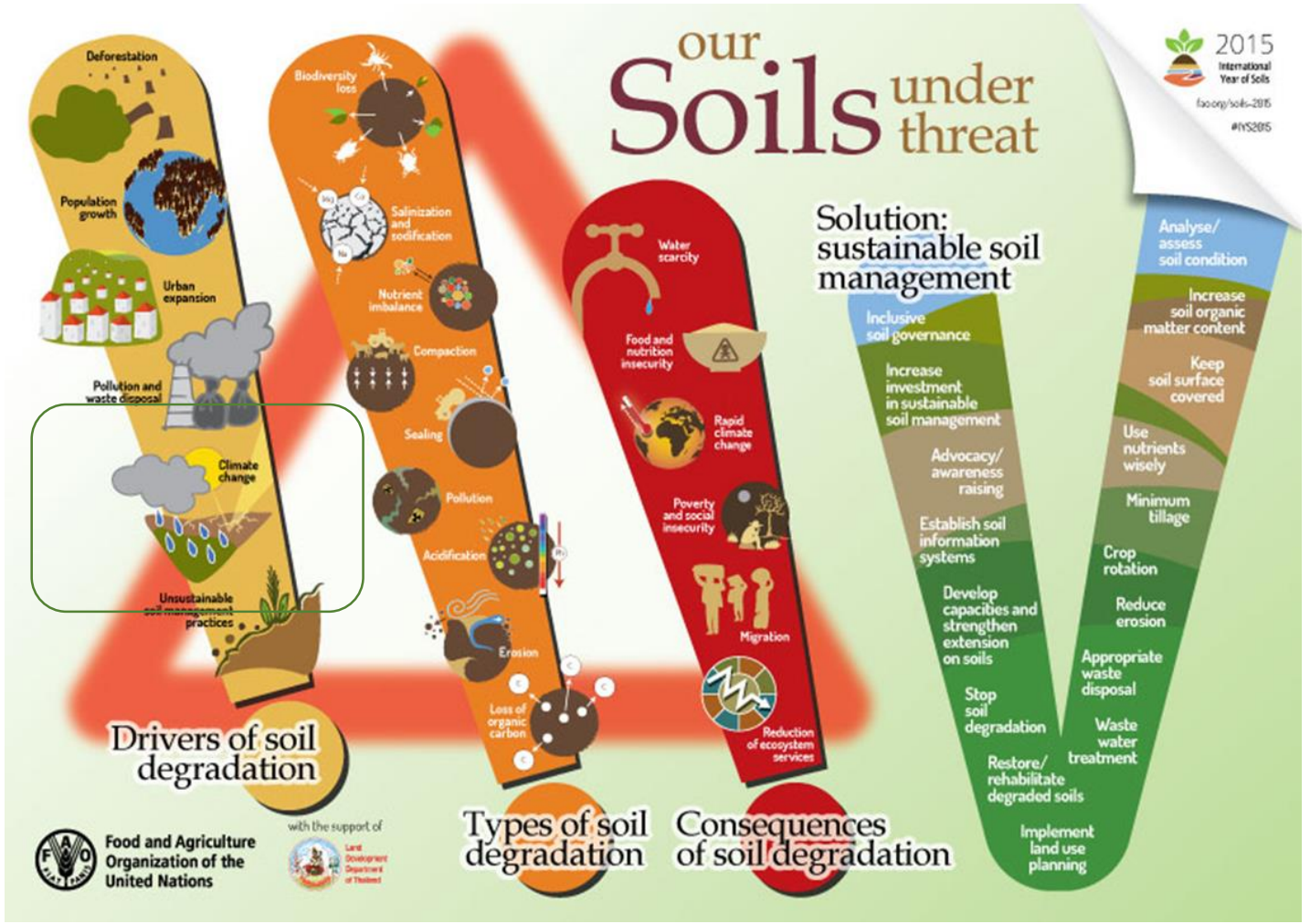


Controlling soil properties: texture, structure, porosity

Increasing frequency of extreme events

Soil sealing, unsuitable management practices may affect the soil physical properties and thus the service

Soil threats



Erosion

Soil formation

[t ha $^{-1}$ y^{-1}]

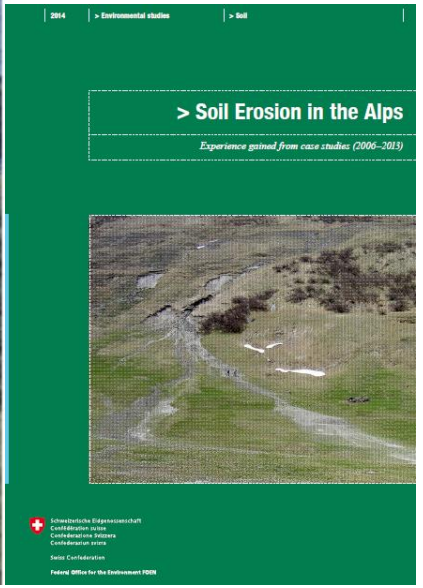
Soil erosion

[t ha $^{-1}$ y^{-1}]

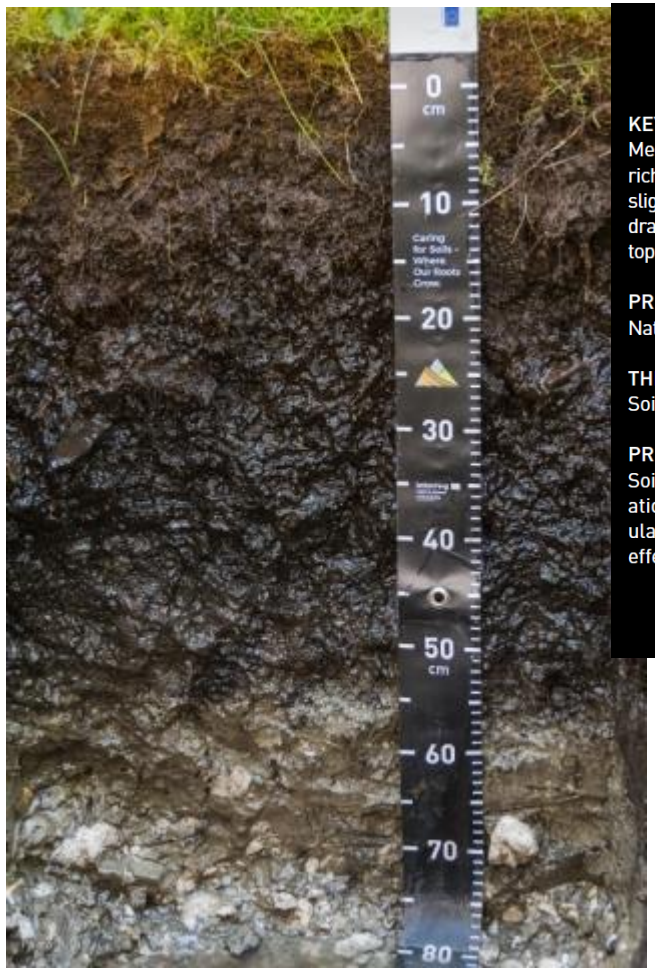
Post-fire erosion

Erosion & grazing

Fig. 48 > Long distances between stable and pastures: formation of trails



An example

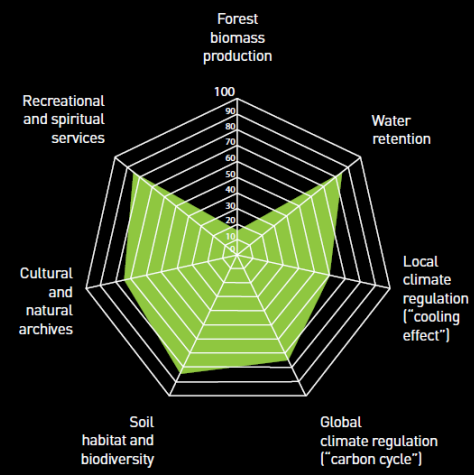


KEY SOIL PROPERTIES
Medium deep waterlogged peat soil with mineral gleyic carbonate-rich subsoil. Topsoil: organic (peat), fibrous structure, neutral to slightly alkaline; rapid permeability when peat is dry; very poorly drained – waterlogged; no surface runoff – water accumulation in a topographic depression.

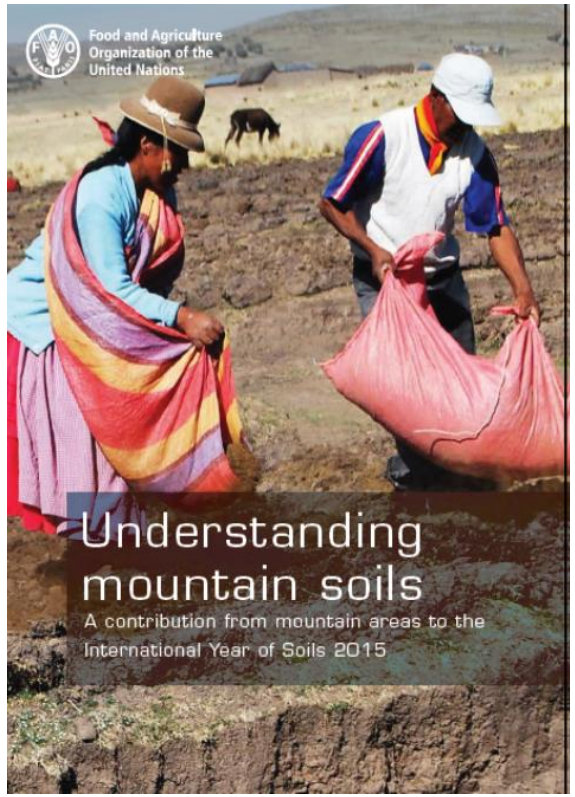
PRIMARY LAND USE
Nature and biodiversity protection area, low-production natural forest.

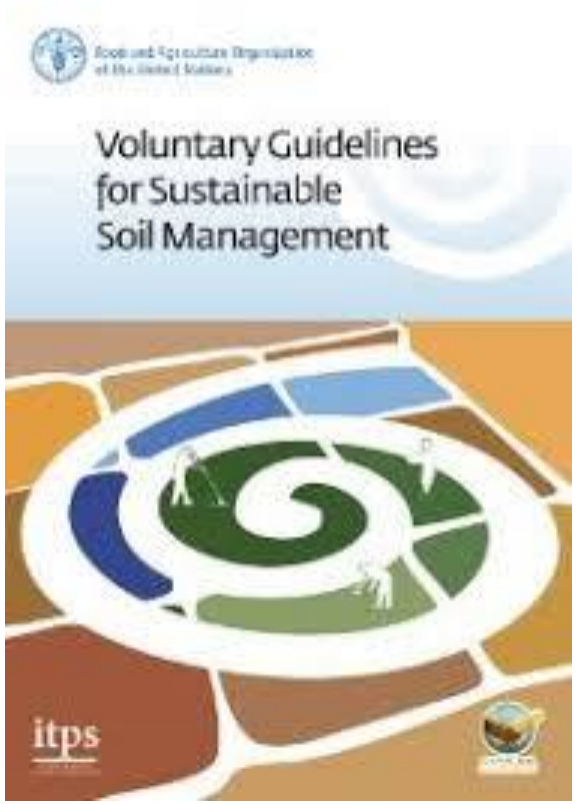
THREATS AND DEGRADATION
Soil organic matter decline if soil is drained, loss of biodiversity.

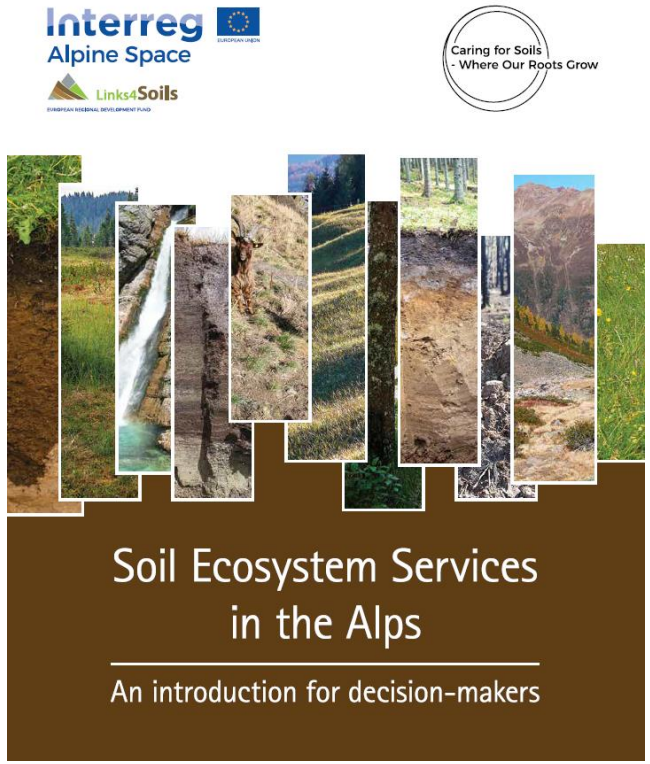
PRIMARY SOIL ECOSYSTEM SERVICES
Soil habitat and biodiversity, cultural and natural archives, recreational and spiritual services, water retention global climate regulation ("the carbon cycle"), local climate regulation ("the cooling effect"), forest biomass production.



Further readings







Thanks for your attention