European Commission

JRC TECHNICAL REPORT

LUCAS SOIL 2015 Site Data

Overview and analysis of ancillary environmental dataset

Scarpa, S; Ugalde-Fernandez, O., & Jones, A.

2020

Contact information
Name: Arwyn Jones
Address: European Commission Joint Research Centre, Sustainable Resources Directorate – Land Resources Unit, Via Fermi 2749, 21027 Ispra (VA), Italy
Email: arwyn.jones@ec.europa.eu
Tel.: +390332 78 9162

EU Science Hub
https://ec.europa.eu/jrc

JRC122144

Ispra: European Commission, 2020

How to cite this report: Scarpa, S; Ugalde-Fernandez, O., & Jones, A., *LUCAS SOIL 2015 Site Data: Overview and analysis of ancillary environmental dataset*, European Commission: Ispra, 2020, JRC122144.

Contents

Abstract

The Statistical Office of the European Union (Eurostat) undertakes a regular survey to monitor the situation of land use, land cover and changes in these over time across the European Union (EU). This exercise is known as Land Use and Coverage Area frame Survey (LUCAS).

In 2009, the scope of the survey was extended to include a topsoil component (i.e. samples taken from the uppermost 20 cm of soil). The aim of the LUCAS soil component was to create a harmonised and comparable dataset of physical and chemical properties of topsoil across the EU to monitor the impact of land related policies on soil condition and to support new policy development.

The soil component was carried out on approximately 10% of the main LUCAS Survey control points to provide a population of 25 000 soil samples (at the end around 22 000 samples were actually collected). At each site, approximately 500 grams of soil is collected according to a standard protocol and analysed at an external laboratory for key soil characteristics (particle size distribution, pH, organic carbon, CEC, total N-P-K, metals, etc.). The results from the 2009 survey have been extensively used by the JRC and external groups in modelling and the development of key policy indicators (for instance soil erosion, organic carbon stocks, nutrient dynamics and soil pollution).

The survey was repeated in 2015 (maintaining around 90% of the sites visited in 2009) where samples were collected from all EU Member States Additionally, in 2015 soil samples were collected from Albania, Bosnia-Herzegovina, Croatia, North Macedonia, Montenegro and Serbia under the Joint Research Centre's (JRC) Enlargement and Integration Programme. In parallel, Switzerland also decided to collect soil samples according to the LUCAS methodology and sampling protocols in order that their national soil monitoring programme would be concurrent and compliant with that of the EU.

This report presents a description of a set of ancillary environmental data for locations from where soil samples were collected and analysed during the 2015 LUCAS survey. In addition, some basic statistical analysis are presented to help the user understand the broad regional distribution of soil characteristics.

Some basic analysis shows that:

- Over half of LUCAS Soil points are found in temperate humid climates (i.e. Dfb and Cfb) while just over 10% of soil samples reflect semi-arid or arid conditions (B* climates) with a single point reflecting very cold Tundra conditions.

- Soils of the desert climates display the highest salt content, pH and carbonate values while the tundra and cool oceanic climate the lowest (probably reflecting greater soil leaching and acidic vegetation types). Interestingly, salt concentrations are slightly elevated in cool oceanic climates.

- Organic carbon content levels are highest under cool oceanic climates and lowest in the arid regions.

- Soil nutrient levels are broadly similar in all climate regions. However, phosphorous levels are higher in dry climates while lowest in temperate continental, nitrogen values are much higher in cool oceanic climates while potassium is higher in warm semi-arid climates.

- Mean cation exchange capacity level are also broadly similar across all climate zone but with large differences in all but the dry climates.

- Italy has the highest soil point (>2 000 m) while close to 50% of points lie below 200 m elevation. In addition, around half the points are found on level ground (<2% gradient). Aspect is generally evenly distributed, with a slight bias towards the east and the south.

- In terms of biogeographical regions, most soil points fall in the Continental Region, followed by the Mediterranean, with an equal distribution between the Atlantic and the Boreal. Investigations of the laboratory analysis for biogeographical regions broadly mirrors that described by climate where

    - pH is highest in the warm climates of the Black Sea and Mediterranean Region
    - Electrical Conductivity is highest in the Atlantic Region
    - Organic matter content is highest in the Boreal region, but with large differences
    - Carbonates are higher in the Mediterranean, but with large variations.

- Over 25% of LUCAS Soil points fall in NATURA 2000 sites, with Spain having the most. The majority of 'protected' LUCAS Soil points occur in woodlands, followed by grasslands.

- Most LUCAS Soil points occur in areas where Cambisols tend to predominate, followed by Luvisols and Podzols. Cambisols are soils that show only limited soil profile development and are often considered as 'young' soils that are still in the processes of development (widespread in the Mediterranean and areas glaciated during the last Ice Age). Luvisols display an increase in clay concentrations in the subsoil and are generally found in conditions that facilitate the movement of clay participles (i.e. sloping land in humid climates). Podzols are coarse textures soils, generally found under conifer forests or healthlands, where acid litter drives the leaching of iron and organic matter to leave a bleached topsoil and subsoil accumulation of iron and organic matter (typical of large areas of Scandinavia). It should be stressed that due to the very small scale of the European Soil Regions dataset (1:5 000 000), the assigned soil type is purely indicative of regional characteristics and does not necessarily reflect local conditions at the actual LUCAS point. However, the analysis of statistics interestingly shows some general correspondence. For example, soil types with high salt contents (e.g. Calcisols, Gypsisols, Solonchaks) all display high pH values while Podzols and Histosols have low pH, reflecting their acidic characteristics.

- The majority of LUCAS Soil Points have a mean annual temperature of 7-12oC, but with quite a pronounced annual temperature range, whereas the annual precipitation for most points is relatively low (< 1 000 mm).

- Around 1 000 points of the EU dataset fall within the boundary of the Alpine Convention (i.e. excluding Switzerland), the majority of which are in Austria. Most 'Alpine' soil points are under woodland.

Data are presented only for points that occur in the EU. Corresponding data for the remaining non-EU points will be added in the near future, as will data for the new points sampled during the 2018 Survey.

Acknowledgements

The JRC wishes to acknowledge the support provided by colleagues from Eurostat, DG AGRI, DG CLIMA and DG ENV, both in terms of technical contributions and financial support for the collection and analysis of the LUCAS soil samples.

Authors

Simone Scarpa, Oihane Ugalde-Fernandez, Arwyn Jones

1. Introduction

This report presents an overview of a series of environmental data that have been used to describe locations where LUCAS Soil samples have been collected to help users understand some of the main drivers of soil characteristics (initially this covers only the LUCAS Points were soil samples were collected during the 2015 survey).

The complete dataset (LUCAS_Soil_ancillary.csv) is available to download from the European Soil Data Centre (ESDAC[1]). Other variables may be added in the future.

The main descriptors include:

- Climatic Zones
- Topography (elevation, aspect and slope gradient)
- Biogeographic regions
- NATURA 2000 sites
- European Soil Regions
- Bioclimatic variables
- Alpine Region

The intention is to update this list with additional parameters (suggestions for additions or offers of contributions can be made to arwyn.jones@ec.europa.eu).

Summary observations can be found in the "**Conclusions**" section.

[1] https:// https://esdac.jrc.ec.europa.eu/content/lucas2015-topsoil-data

2. Description of attributes

Table 1 Description of the individual fields in the ancillary dataset

Field Name	***Description***	***Unit***
Point_ID	Unique ID to be linked to other LUCAS datasets (on ESDAC or EUROSTAT)	-
Clima_COD	Climatic Code based on Köppen-Geiger classification	-
Elevation	Height extracted from EuDEM v1.0	m
Slope	Slope gradient	degree
Aspect	Orientation of slope	Compass degree
BioGeo	Biogeographic Region	-
Natura2000_sitecode1	Code of Natura2000 site in which the point is located	-
Natura2000_sitecode2	Code of second Natura2000 site in which the point is located	-
Soil_Group	Estimation of dominant reference soil group	-
Soil_Code	WRB Code of the first dominant soil group	-
BIO1	Annual Mean Temperature	°C
BIO2	Mean Diurnal Range (Mean of monthly (max temp - min temp))	°C
BIO3	Isothermality (BIO2/BIO7) (×100)	°C
BIO4	Temperature Seasonality (standard deviation ×100)	°C
BIO5	Max Temperature of Warmest Month	°C
BIO6	Min Temperature of Coldest Month	°C
BIO7	Temperature Annual Range (BIO5-BIO6)	°C
BIO8	Mean Temperature of Wettest Quarter	°C
BIO9	Mean Temperature of Driest Quarter	°C
BIO10	Mean Temperature of Warmest Quarter	°C
BIO11	Mean Temperature of Coldest Quarter	°C
BIO12	Annual Precipitation	mm
BIO13	Precipitation of Wettest Month	mm
BIO14	Precipitation of Driest Month	mm
BIO15	Precipitation Seasonality (Coefficient of Variation)	mm

Field Name	***Description***	***Unit***
BIO16	Precipitation of Wettest Quarter	mm
BIO17	Precipitation of Driest Quarter	mm
BIO18	Precipitation of Warmest Quarter	mm
BIO19	Precipitation of Coldest Quarter	mm
AlpsConv	Lucas point included within the Alpine Convention Area (Y/N)	-

3. Methodology and data sources

In simple terms, the geographic coordinate of the location from where a soil sample was taken during the 2015 LUCAS Survey was overlain by a spatial dataset describing an environmental variable. The intersect value from the environmental variable was then assigned to the LUCAS Point. The relevant data sources and some additional considerations are presented below.

- **Köppen-Geiger climate zones** were automatically assigned to each LUCAS Soil point by extracting raster values corresponding to each LUCAS points (in R). Climatic zones were provided by the "Present and future Köppen-Geiger climate classification maps at 1-km resolution" produced by Beck et al, 2018, available for download from

  https://figshare.com/articles/Present_and_future_K_ppen-Geiger_climate_classification_maps_at_1-km_resolution/6396959/2

  For the 12 points not intersecting the raster map (see below for an example), the climatic zone were assigned manually.

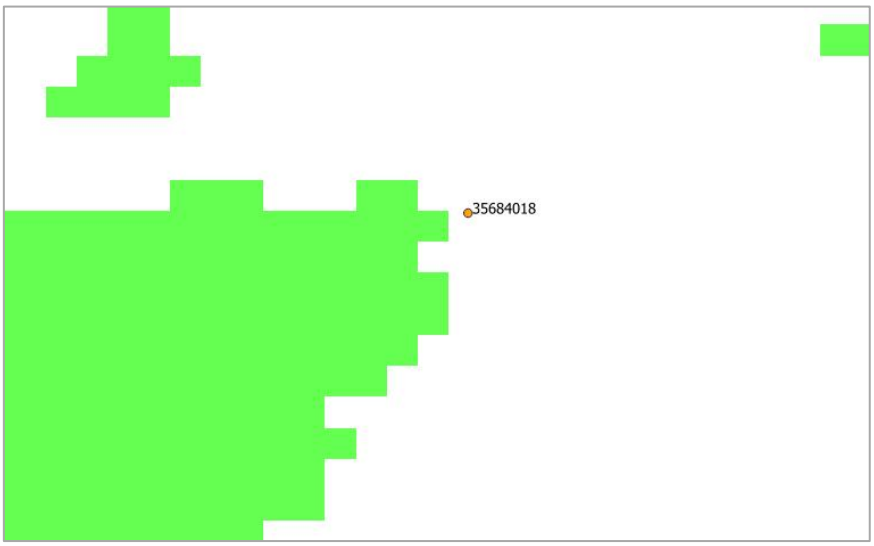


Figure 1. Example of LUCAS point falling outside of coverage of climate zone data

- **Topographic data** consist of elevation, slope gradient and aspect.

  Elevation values were automatically assigned by extracting raster values corresponding to the location of the LUCAS points (in R). Elevation data were provided by the EU-Digital Elevation Model [EU_DEM v1.0], which was been created by the EEA, available for download from:

  https://land.copernicus.eu/user-corner/technical-library/eu-dem-v1.0

  Slope orientation was calculated according to the classification described by https://gisgeography.com/slope-aspect-microclimate-south-facing/ while aspect and slope gradient data were calculated in R using the GDAL library (https://gdal.org/index.html)

- **Biogeographical Regions** were automatically assigned by extracting values from EEA Biogeographical Regions dataset (EEA 2002) for each LUCAS points (in R). For three points not intersecting the raster map (see below an example), the value was updated manually.

Figure 2. Example of LUCAS point falling outside of coverage of biogeographical region data

- **Natura 2000** sites (EC) were automatically assigned by extracting values from EEA Natura 2000 data 2020 (EEA 2020).

- **Soil Regions (BGR 2005) and Dominant Soil Group** was automatically assigned by extracting values from the Soil Regions of the European Union and Adjacent Countries dataset (BGR 2005) at a scale of 1:5 000 000 for each LUCAS points (in R).

- **Bioclimatic variables** were calculated from the WorldClim V2 dataset (Fick & Hijmans, 2017) using the R package "Dismo" (by Robert J. Hijmans) using the "biovars" function

  https://www.rdocumentation.org/packages/dismo/versions/1.1-4

  https://www.rdocumentation.org/packages/dismo/versions/1.1-4/topics/biovar
  The WordlClim version 2 dataset contains average monthly climatic gridded data for the period 1970-2000. The dataset includes the main climatic variables (monthly minimum, mean and maximum temperature, precipitation, solar radiation, wind speed and water vapour pressure) as well as 19 derived bioclimatic variables (annual mean temperature, mean diurnal range, isothermality, temperature seasonality, max. temperature of warmest month, min. temperature of coldest month, temperature annual range, mean temperature of wettest quarter, mean temperature of driest quarter, mean temperature of warmest quarter, mean temperature of coldest quarter, annual precipitation, precipitation of wettest month, precipitation of driest month, precipitation seasonality (coefficient of variation), precipitation of wettest quarter, precipitation of driest quarter, precipitation of warmest quarter, precipitation of coldest quarter).

4. Climatic Zones

Climatic zones have been assigned on the basis of the Köppen–Geiger climate classification, which uses five main climate groups: A (tropical), B (dry), C (temperate), D (continental), and E (polar).

Each group is further divided into subgroups according to seasonal precipitation and temperature patterns.

Each group and subgroup is represented by a single letter.

The first letter (uppercase) defines the main group (as described in the first paragraph). Apart for the E group, all climates are assigned a seasonal precipitation subgroup (the second lowercase letter). For example, Af indicates a tropical rainforest climate.

Apart from the A group, the system also assigns a temperature subgroup that is indicated by the third lowercase letter (i.e. for climate groups B, C, and D). A second lowercase letter is used for E climate.

For example, Cfb indicates a "Temperate oceanic climate with warm summers" as indicated by the ending b.

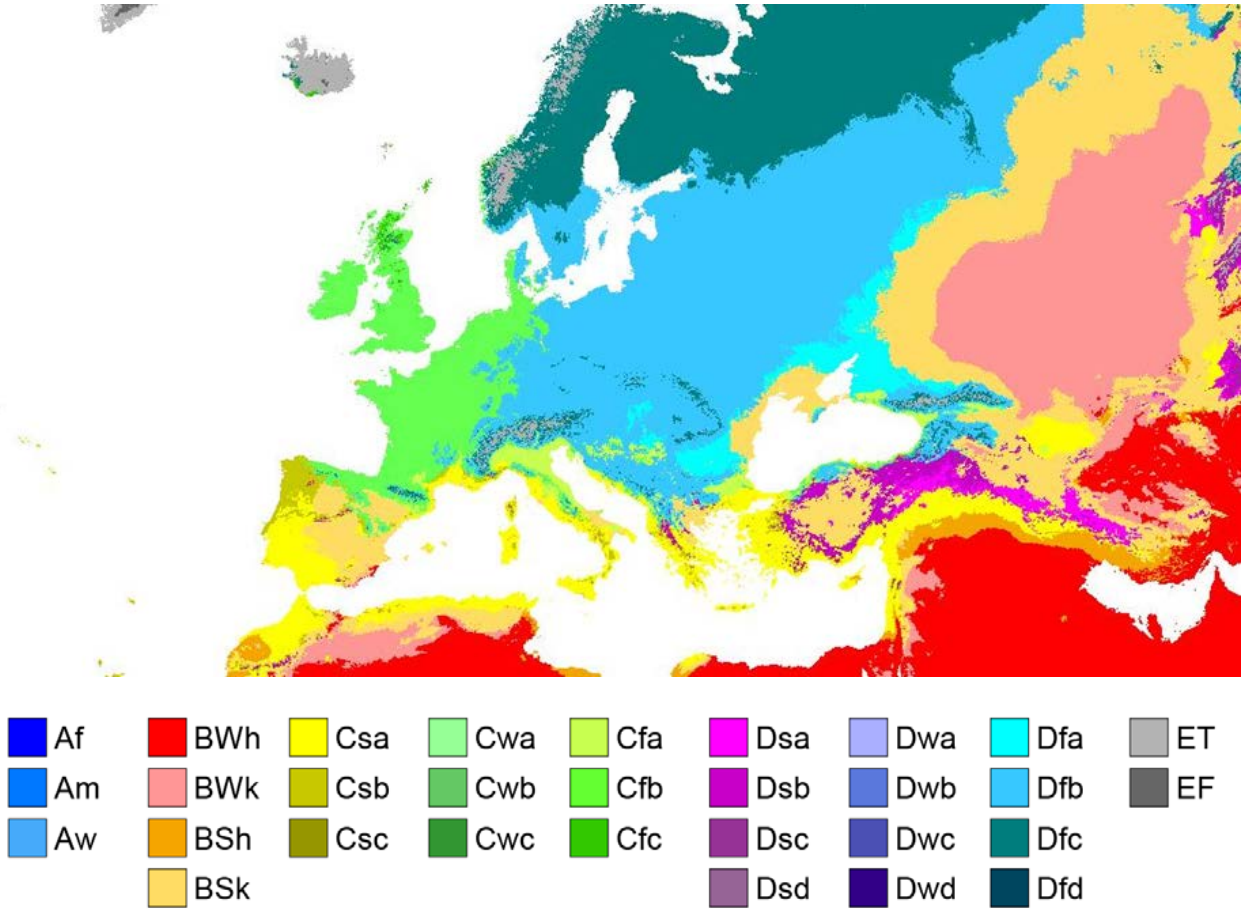
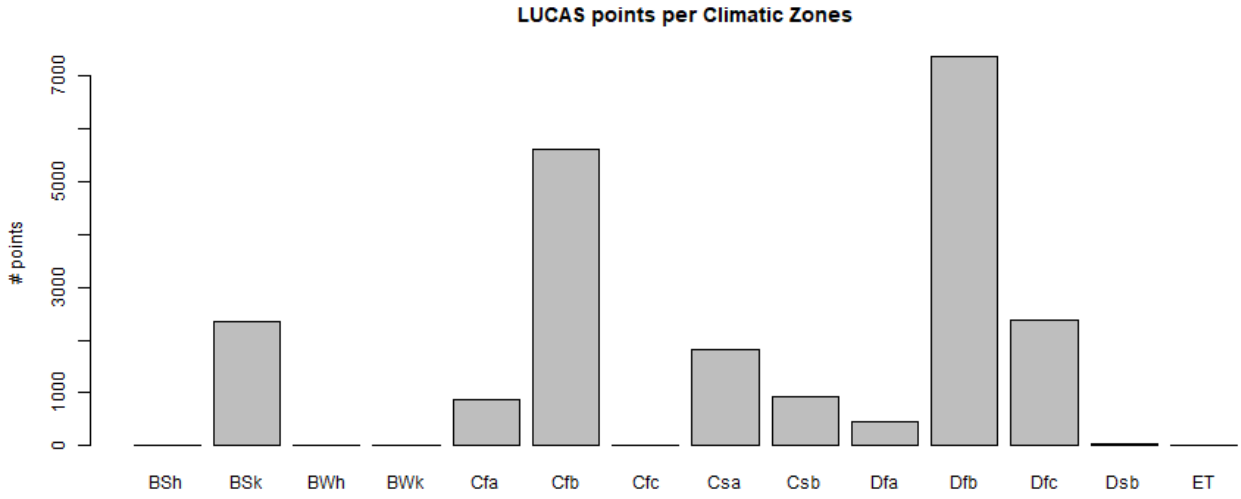


Figure 3 Map of main climate zones for Europe (after Beck et al 2018).

See footnote for an explanation of the codes[2]

[2] https://en.wikipedia.org/wiki/K%C3%B6ppen_climate_classification#:~:text=The%20K%C3%B6ppen%20climate%20classification%20divides,is%20represented%20by%20a%20letter



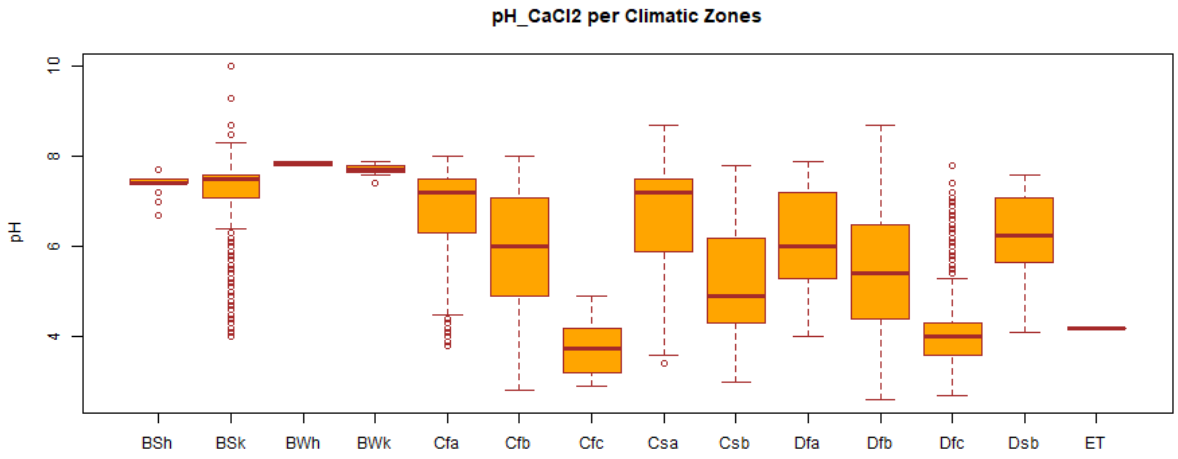
Over half of LUCAS Soil points are found in occur in temperate humid climates (i.e. Dfb and Cfb)

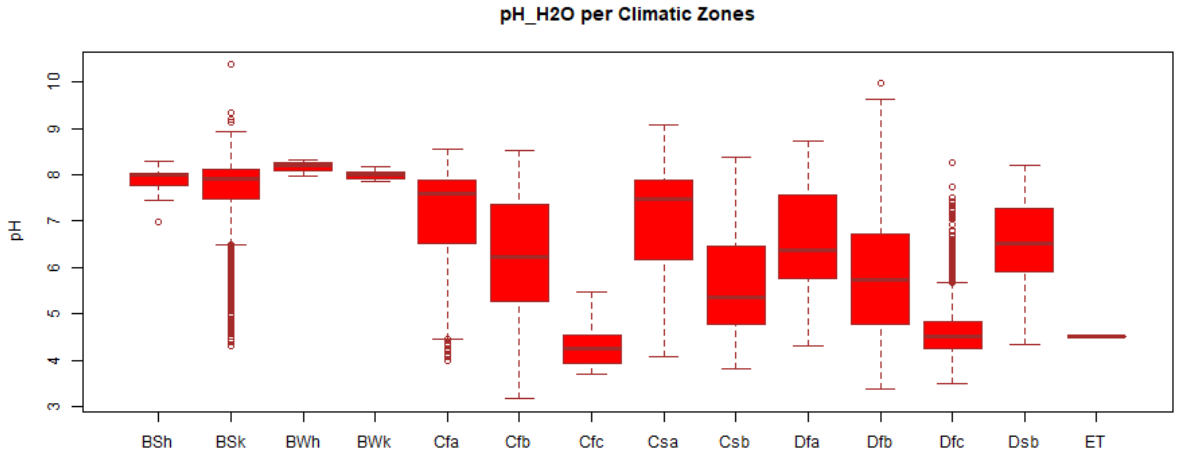
> Dfb / Cfb = Warm-summer humid continental climate / Temperate oceanic climate; Both have coldest month averaging below −0°C, all months with average temperatures below 22°C, and at least four months averaging above 10°C. No significant precipitation difference between seasons.

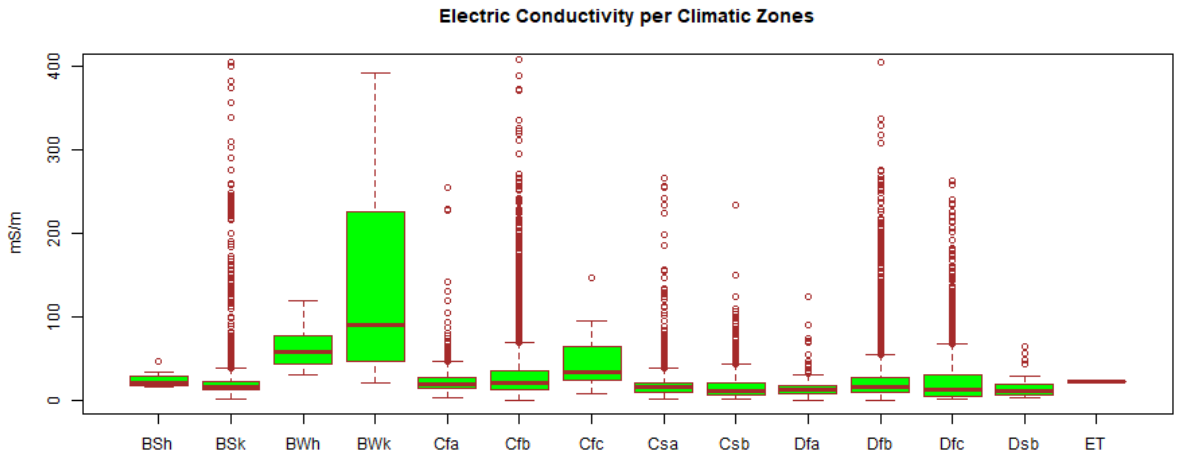
Just over 10% of soil samples reflect semi-arid or arid conditions (B* climates) with just a single point on Tundra.

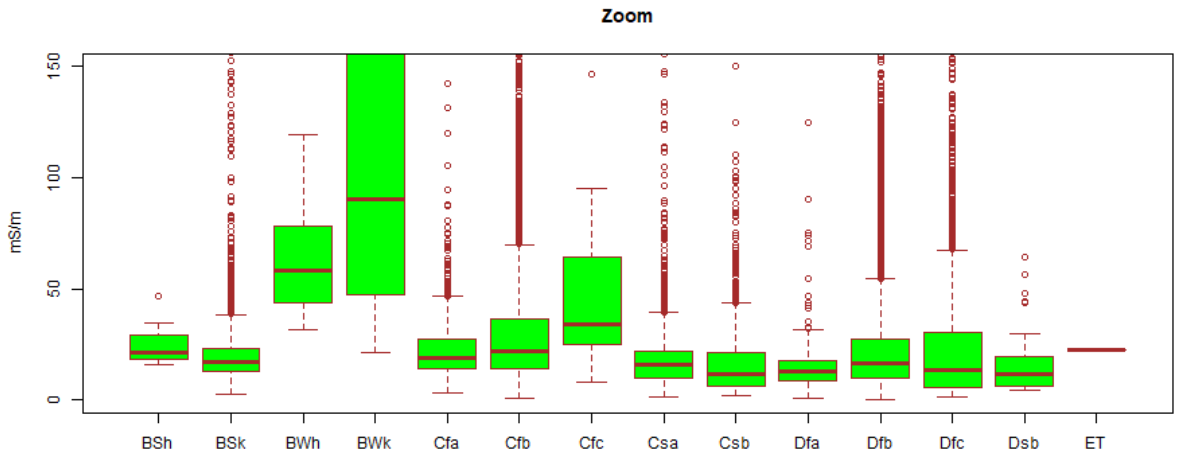
Table 2. Descriptions of KOPPEN-GEIGER climate zone codes with count of LUCAS Soil points

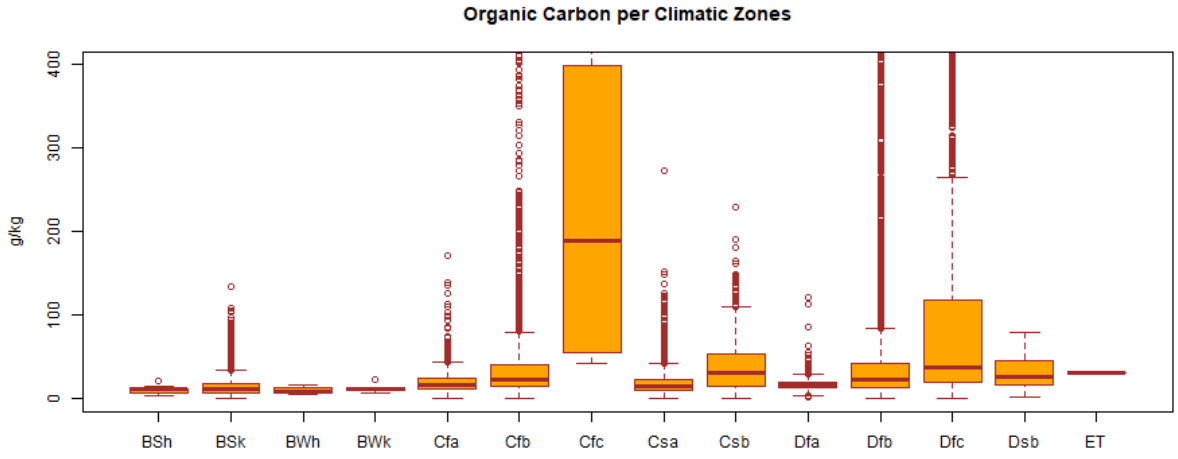
Cod	Description	n points
Dfb	Temperate continental/humid continental	7367
Cfb	Temperate oceanic	5612
Dfc	Cool continental/subarctic	2383
BSk	Cold semi-arid	2360
Csa	Warm Mediterranean	1818
Csb	Temperate Mediterranean	927
Cfa	Warm oceanic/humid subtropical	860
Dfa	Warm continental/humid continental	455
Dsb	Temperate continental/Mediterranean continental	36
Cfc	Cool oceanic	14
BSh	Warm semi-arid	13
BWk	Cold desert	7
BWh	Warm desert	6
ET	Tundra	1

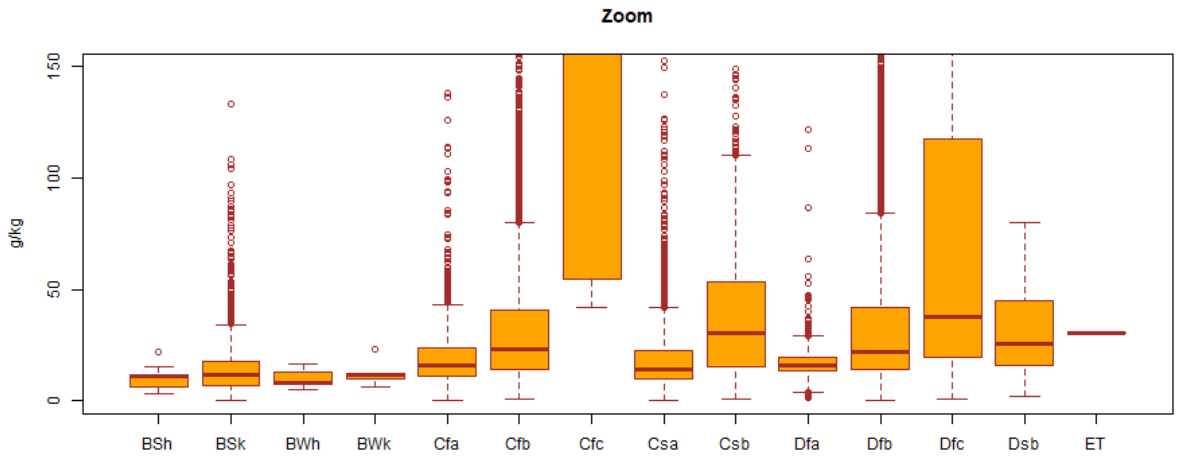

pH_CaCl2 per Climatic Zones
pH
4
6
8
10
BSh
BSk
BWh
BWk
Cfa
Cfb
Cfc
Csa
Csb
Dfa
Dfb
Dfc
Dsb
ET

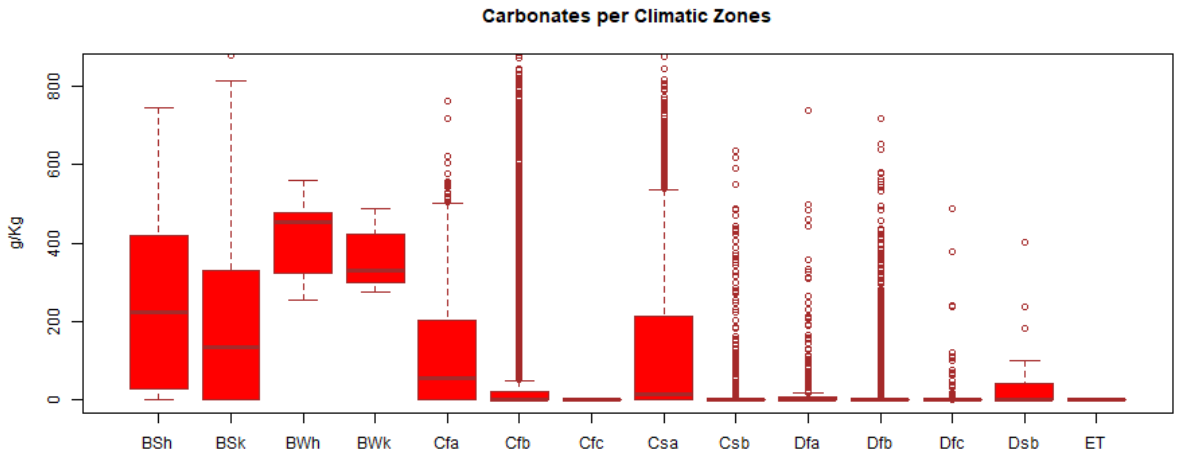

pH_H2O per Climatic Zones
pH
3
4
5
6
7
8
9
10
BSh
BSk
BWh
BWk
Cfa
Cfb
Cfc
Csa
Csb
Dfa
Dfb
Dfc
Dsb
ET

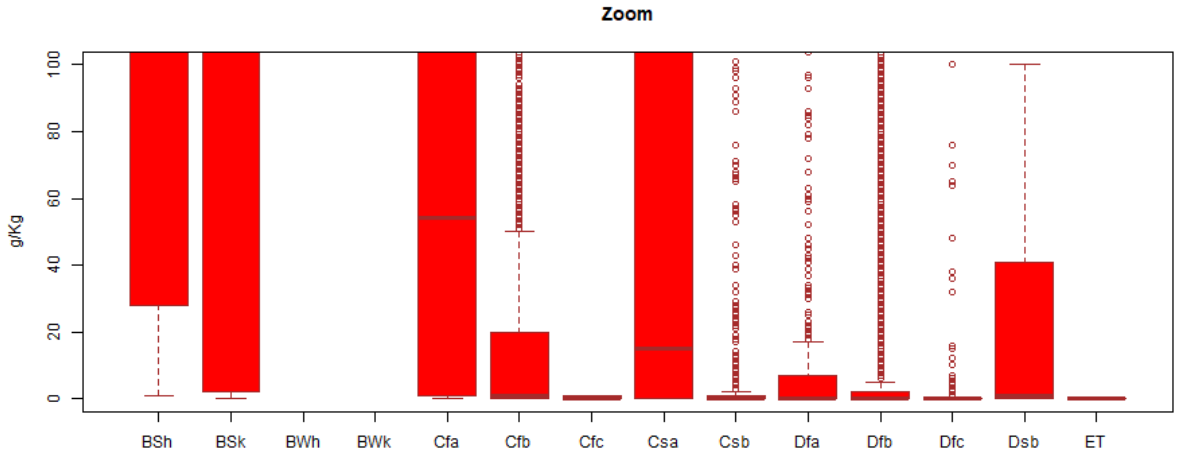

Electric Conductivity per Climatic Zones
mS/m
0
100
200
300
400
BSh
BSk
BWh
BWk
Cfa
Cfb
Cfc
Csa
Csb
Dfa
Dfb
Dfc
Dsb
ET

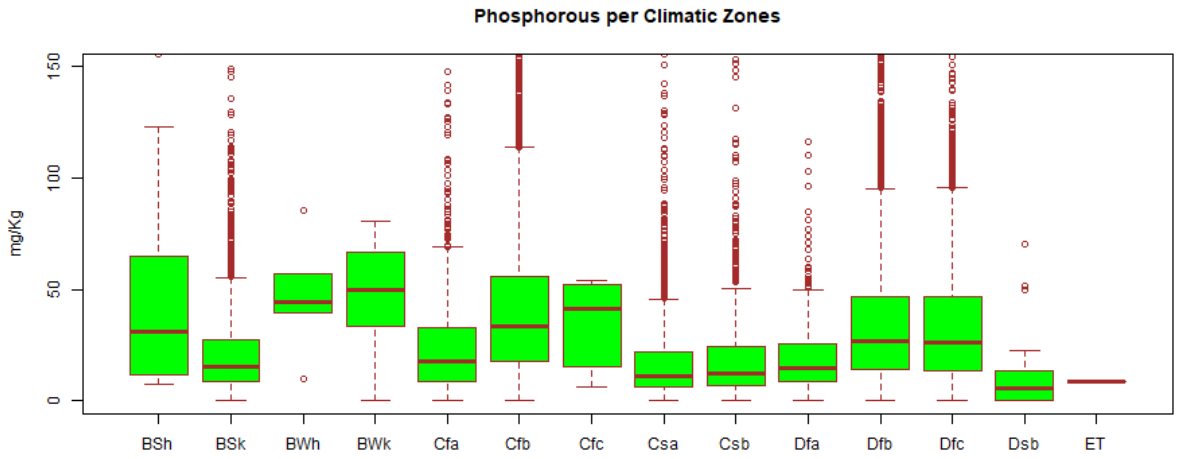

Zoom
mS/m
0
50
100
150
BSh
BSk
BWh
BWk
Cfa
Cfb
Cfc
Csa
Csb
Dfa
Dfb
Dfc
Dsb
ET

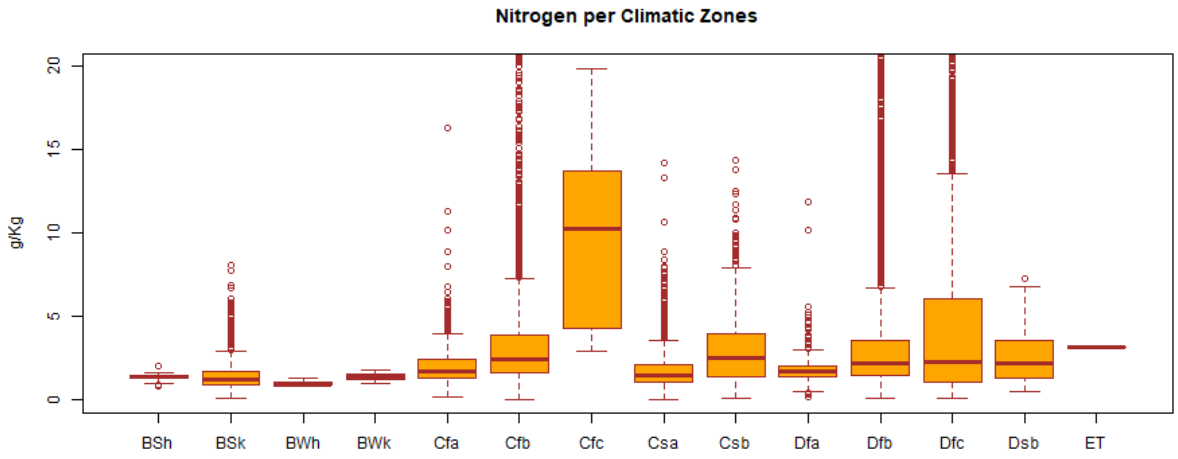

Organic Carbon per Climatic Zones
g/kg
0
100
200
300
400
BSh
BSk
BWh
BWk
Cfa
Cfb
Cfc
Csa
Csb
Dfa
Dfb
Dfc
Dsb
ET

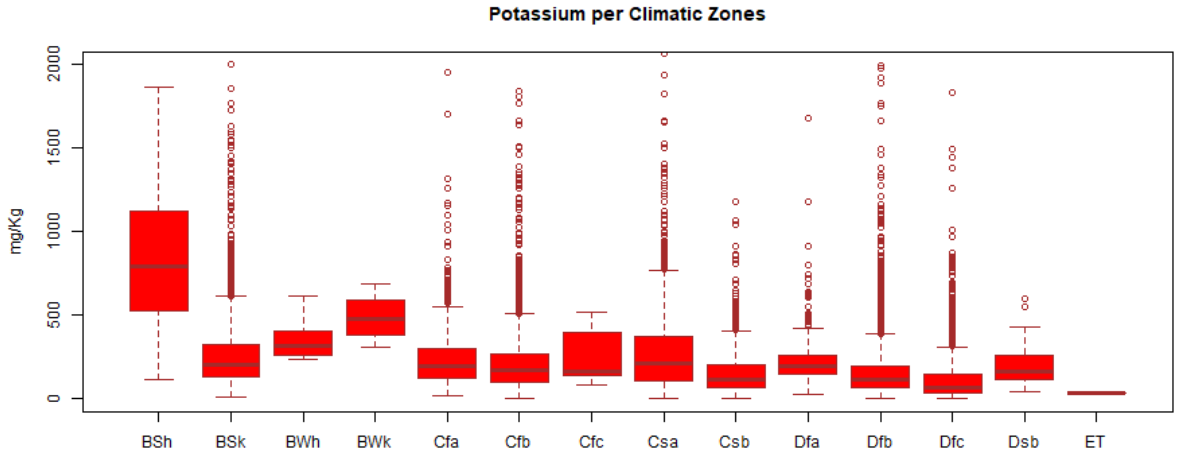

Zoom
g/kg
0
50
100
150
BSh
BSk
BWh
BWk
Cfa
Cfb
Cfc
Csa
Csb
Dfa
Dfb
Dfc
Dsb
ET

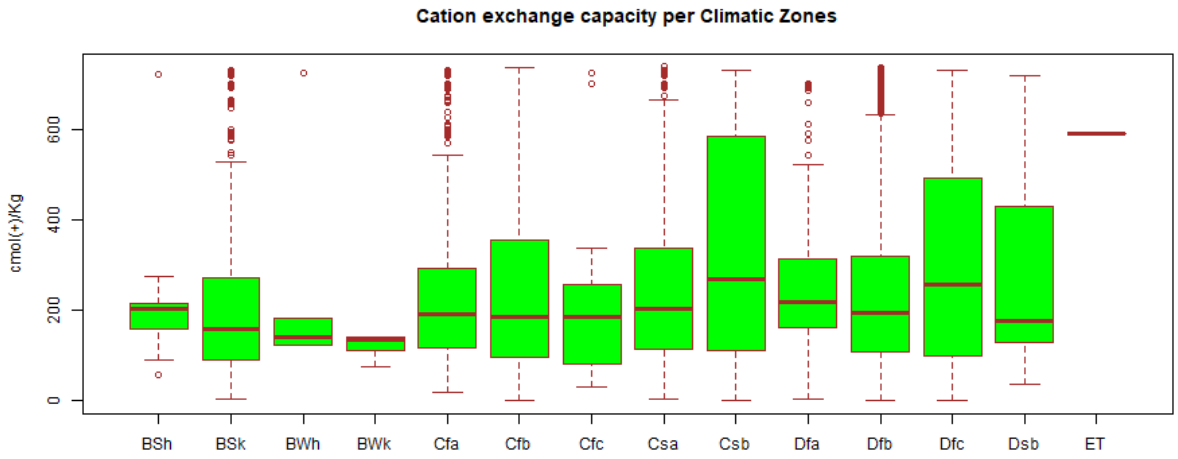

Carbonates per Climatic Zones
g/Kg
0
200
400
600
800
BSh
BSk
BWh
BWk
Cfa
Cfb
Cfc
Csa
Csb
Dfa
Dfb
Dfc
Dsb
ET


Zoom
g/Kg
0
20
40
60
80
100
BSh
BSk
BWh
BWk
Cfa
Cfb
Cfc
Csa
Csb
Dfa
Dfb
Dfc
Dsb
ET


Phosphorous per Climatic Zones
mg/Kg
0
50
100
150
BSh
BSk
BWh
BWk
Cfa
Cfb
Cfc
Csa
Csb
Dfa
Dfb
Dfc
Dsb
ET


Nitrogen per Climatic Zones
g/Kg
0
5
10
15
20
BSh
BSk
BWh
BWk
Cfa
Cfb
Cfc
Csa
Csb
Dfa
Dfb
Dfc
Dsb
ET


Potassium per Climatic Zones
mg/Kg
0
500
1000
1500
2000
BSh
BSk
BWh
BWk
Cfa
Cfb
Cfc
Csa
Csb
Dfa
Dfb
Dfc
Dsb
ET


Cation exchange capacity per Climatic Zones
cmol(+)/Kg
0
200
400
600
BSh
BSk
BWh
BWk
Cfa
Cfb
Cfc
Csa
Csb
Dfa
Dfb
Dfc
Dsb
ET

5. Topography

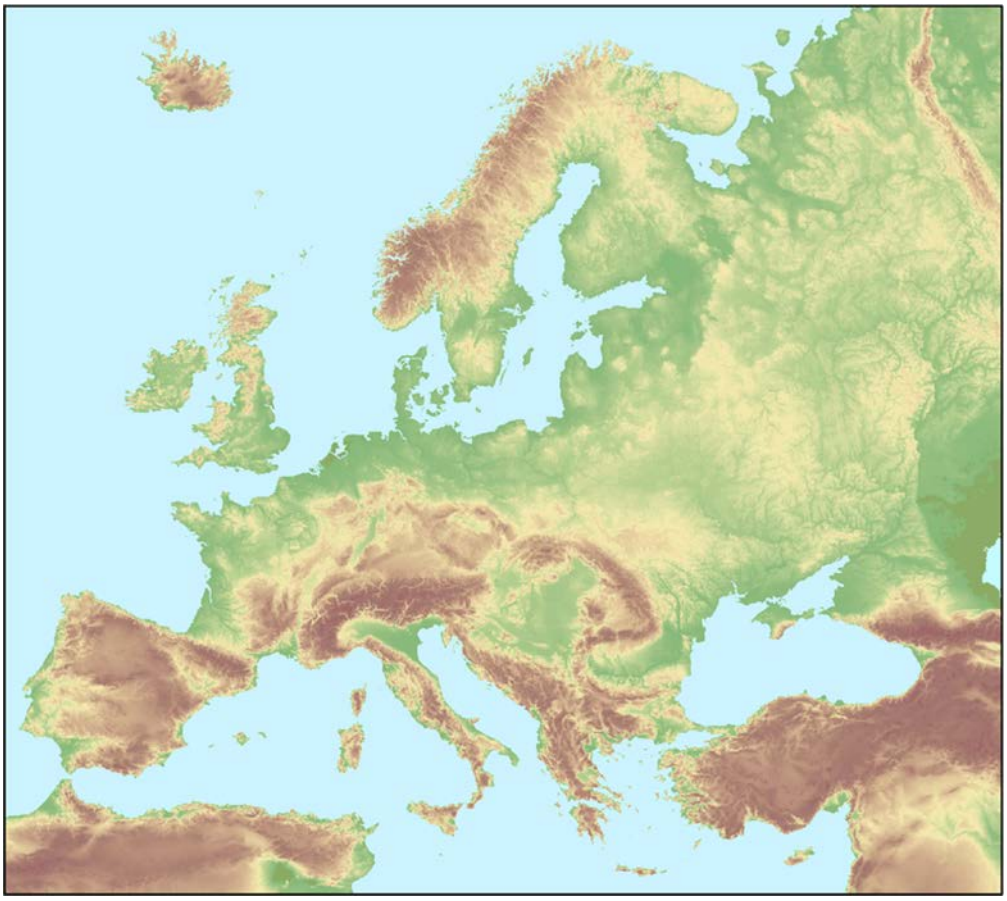
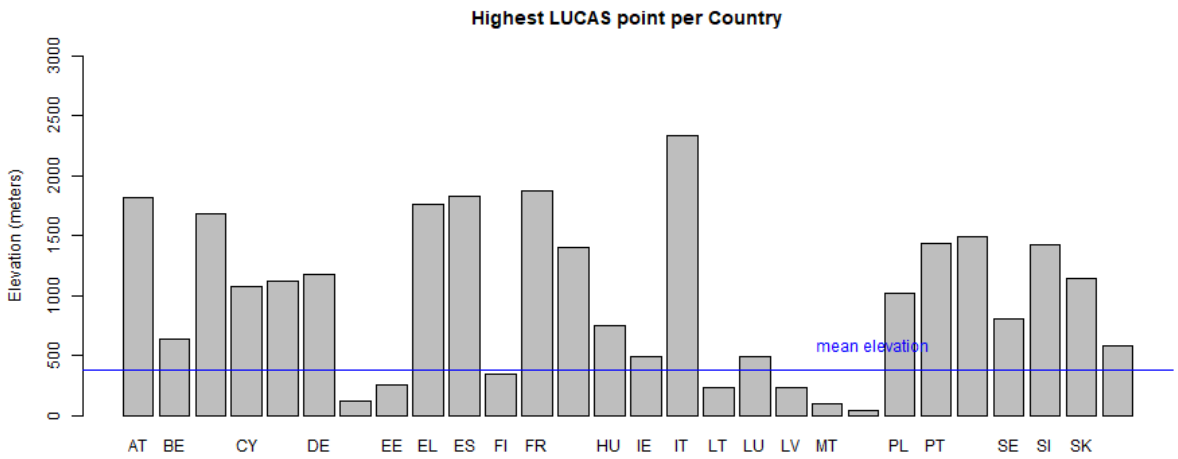
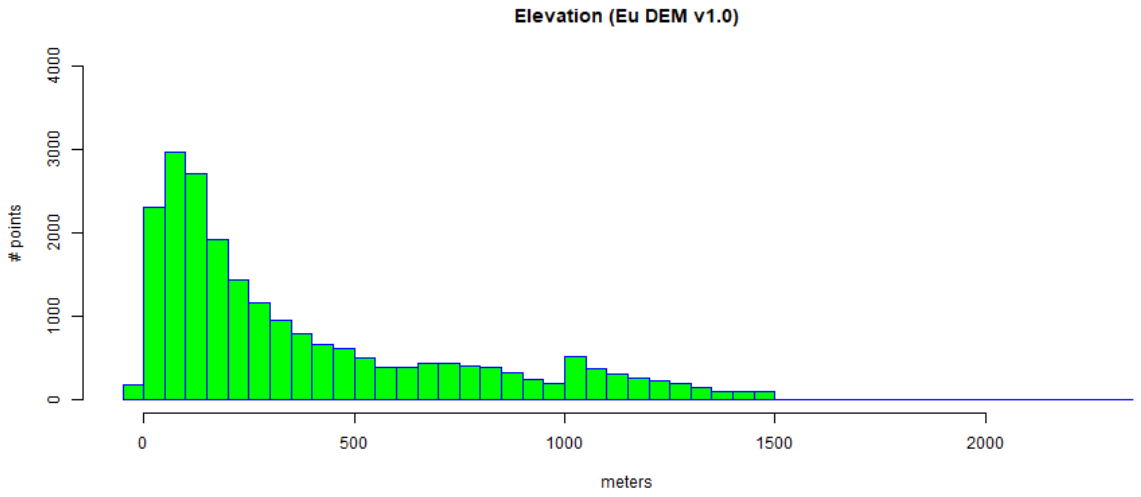
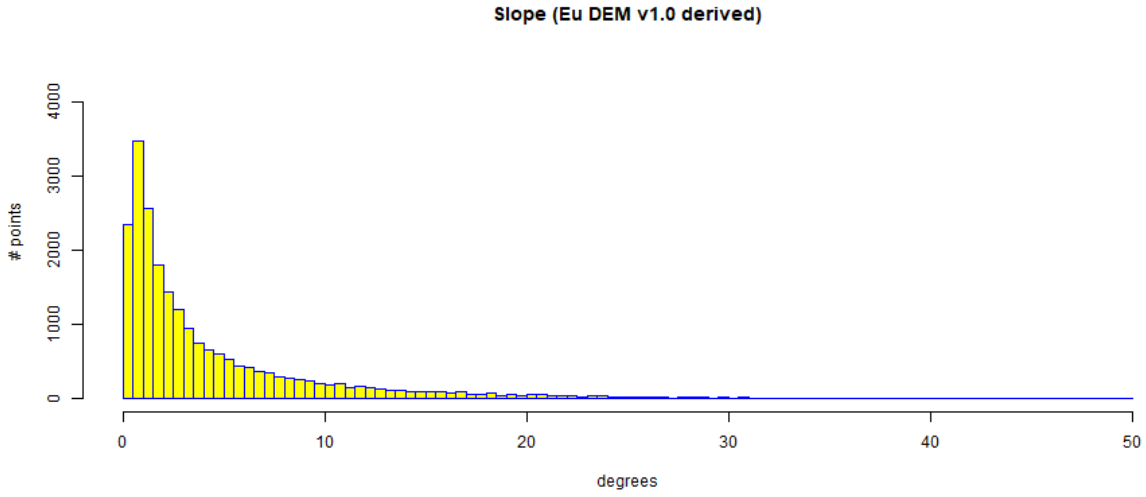
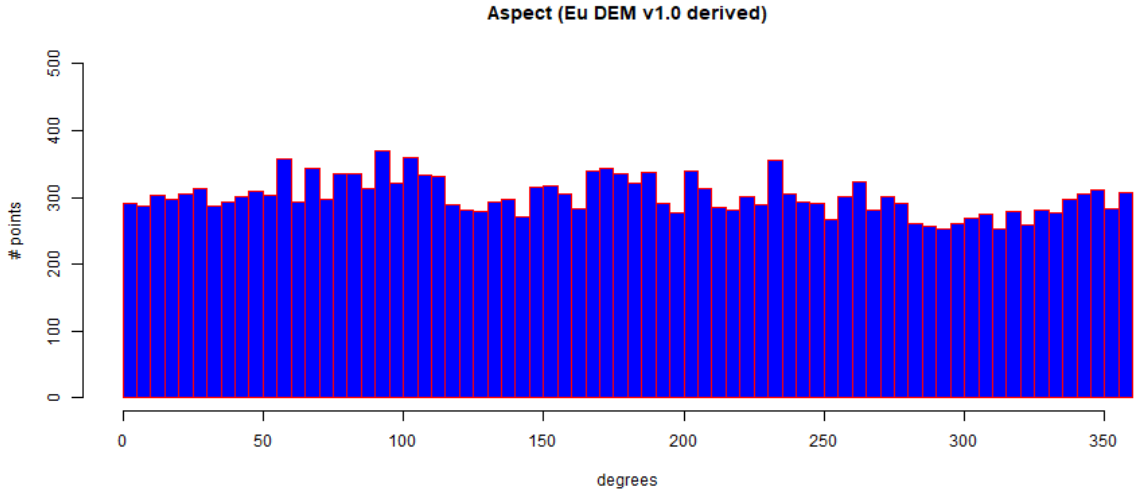


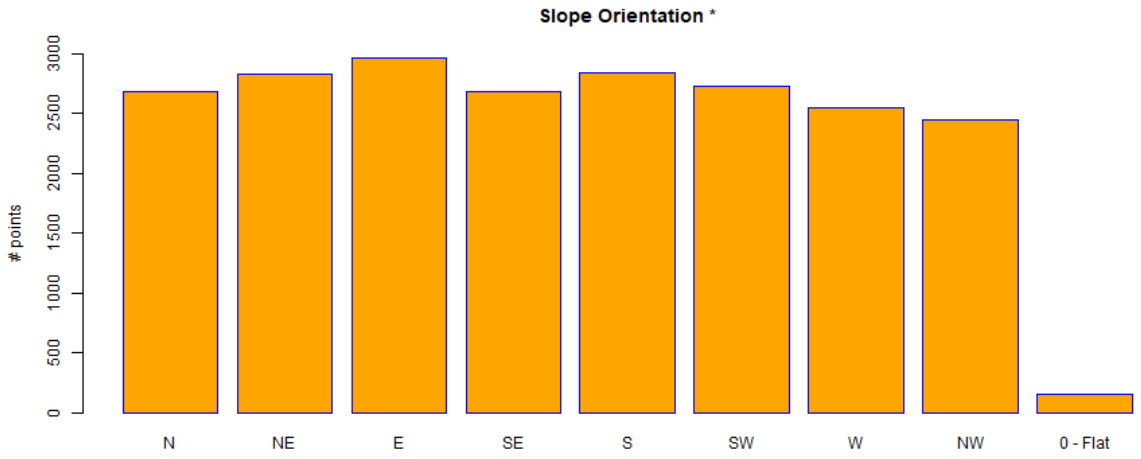
Figure 4. Map of elevation (dark brown areas have higher values, dark green lower elevations). From EEA/COPERNICUS




Elevation (Eu DEM v1.0)
points
0
1000
2000
3000
4000
0
500
1000
1500
2000
meters


Slope (Eu DEM v1.0 derived)
points
0
1000
2000
3000
4000
0
10
20
30
40
50
degrees


Aspect (Eu DEM v1.0 derived)
points
0
100
200
300
400
500
0
50
100
150
200
250
300
350
degrees



*=Measured clockwise in degrees from 0 to 360, where 0 is north-facing, 90 is east-facing, 180 is south-facing, and 270 is west-facing

6. Biogeographic regions

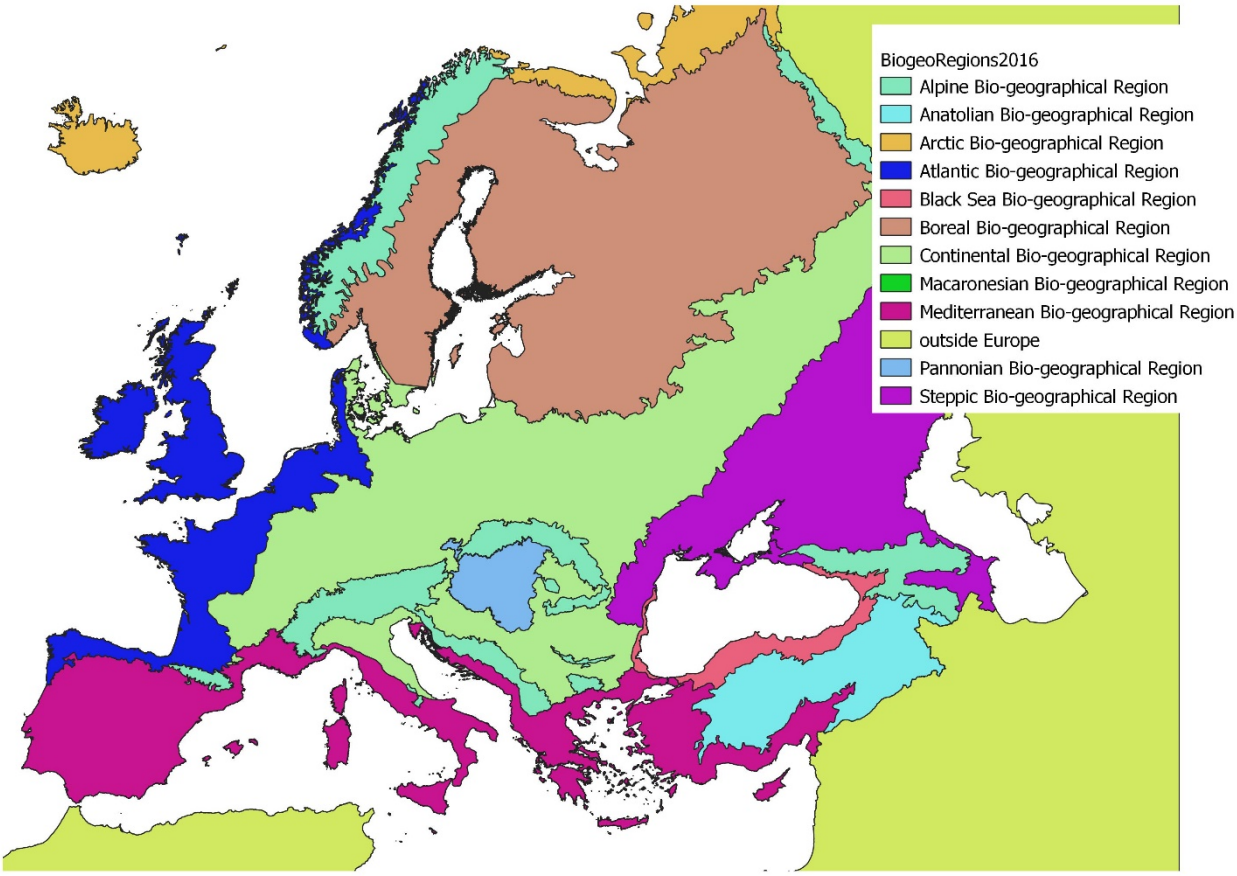
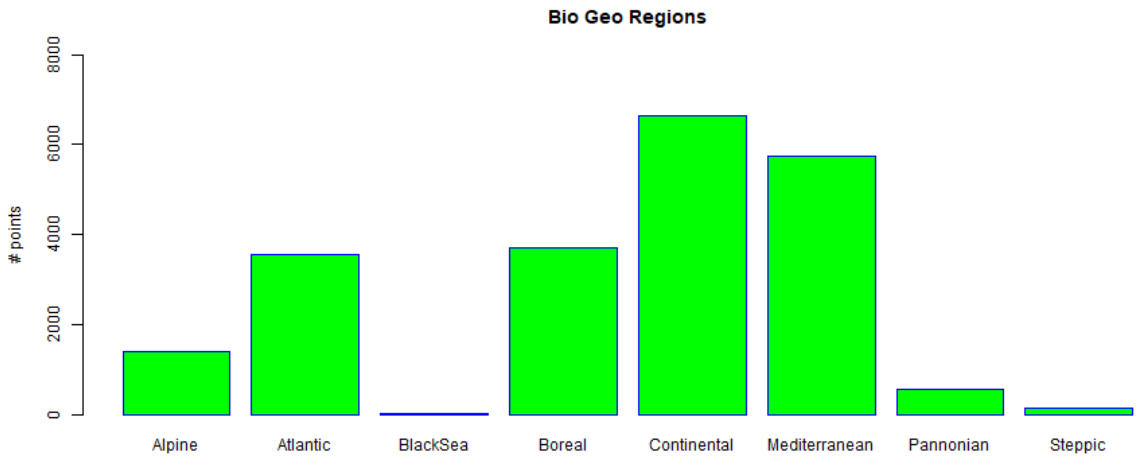
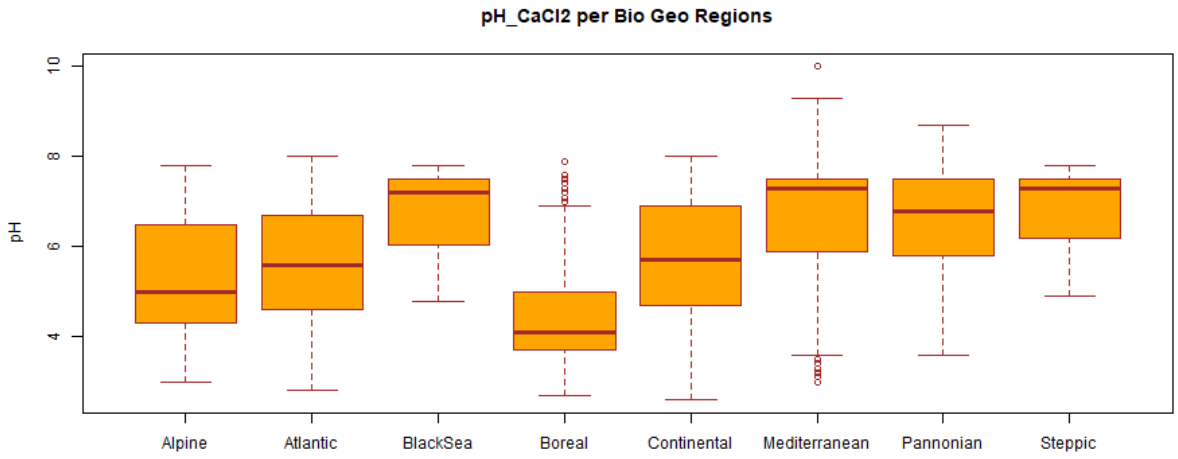
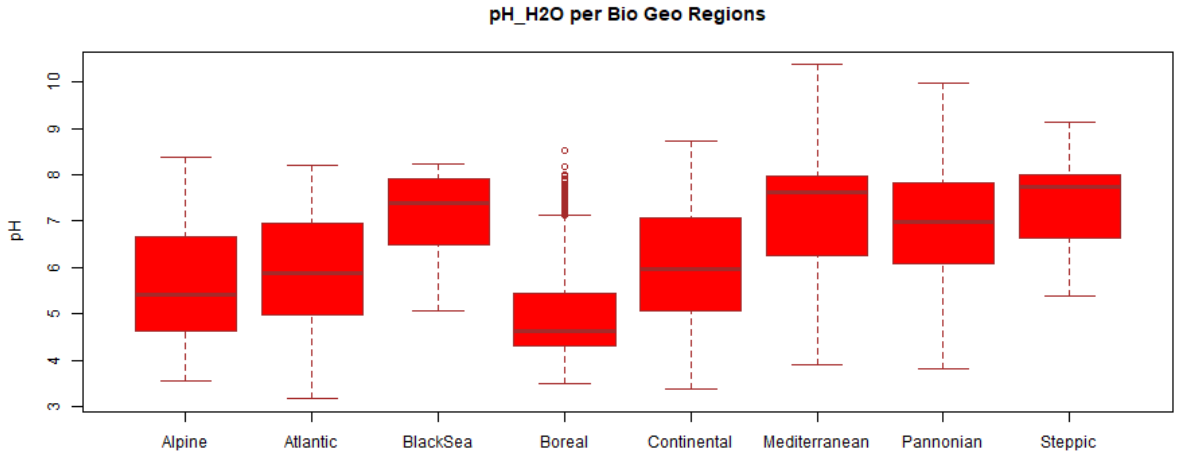
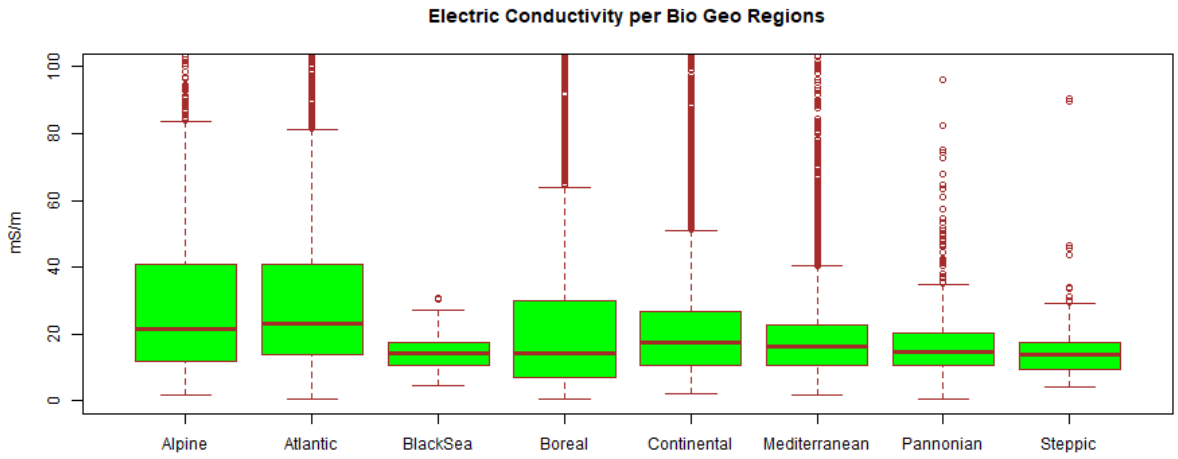


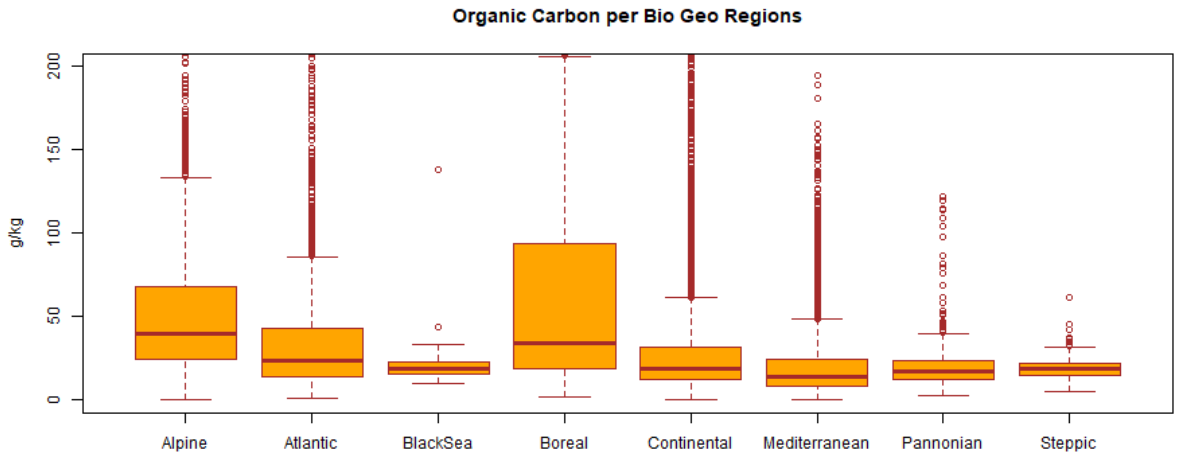
Figure 5. Map of main biogeographical regions (after EEA 2002).

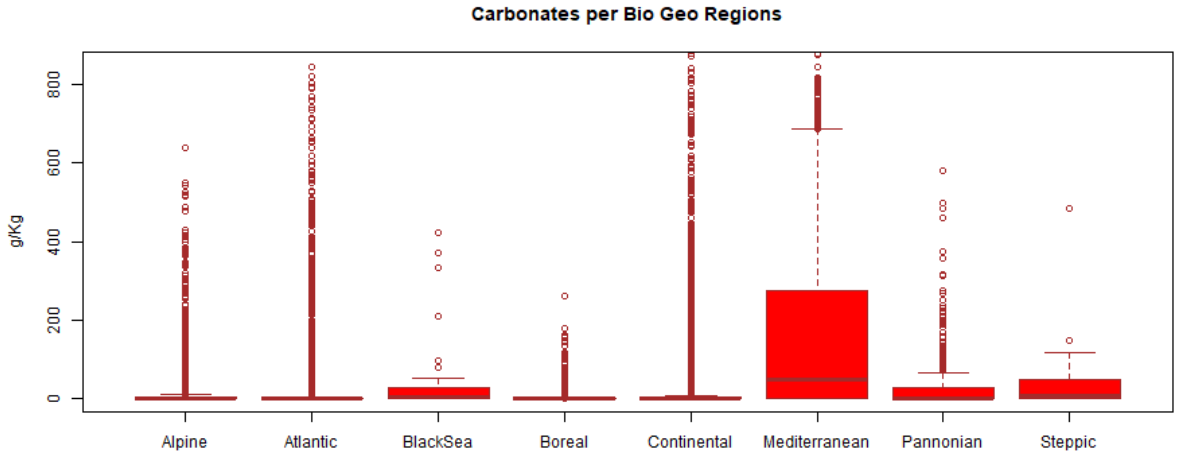


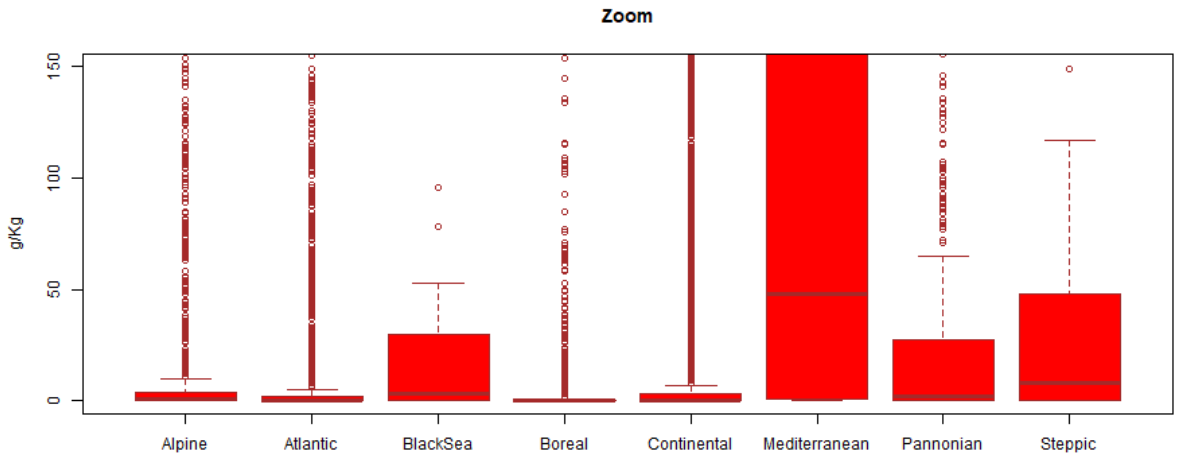

pH_CaCl2 per Bio Geo Regions
pH
4
6
8
10
Alpine
Atlantic
BlackSea
Boreal
Continental
Mediterranean
Pannonian
Steppic

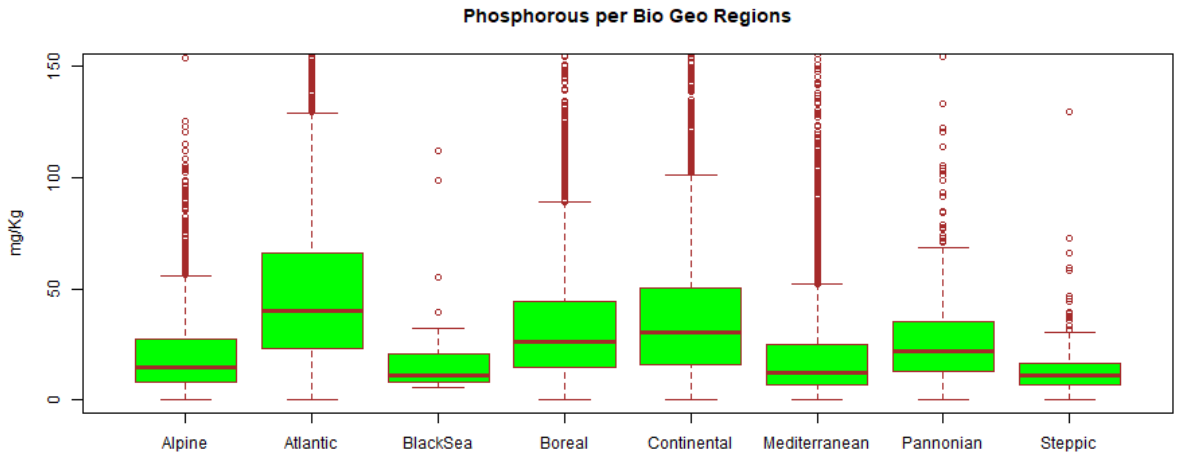

pH_H2O per Bio Geo Regions
pH
3
4
5
6
7
8
9
10
Alpine
Atlantic
BlackSea
Boreal
Continental
Mediterranean
Pannonian
Steppic

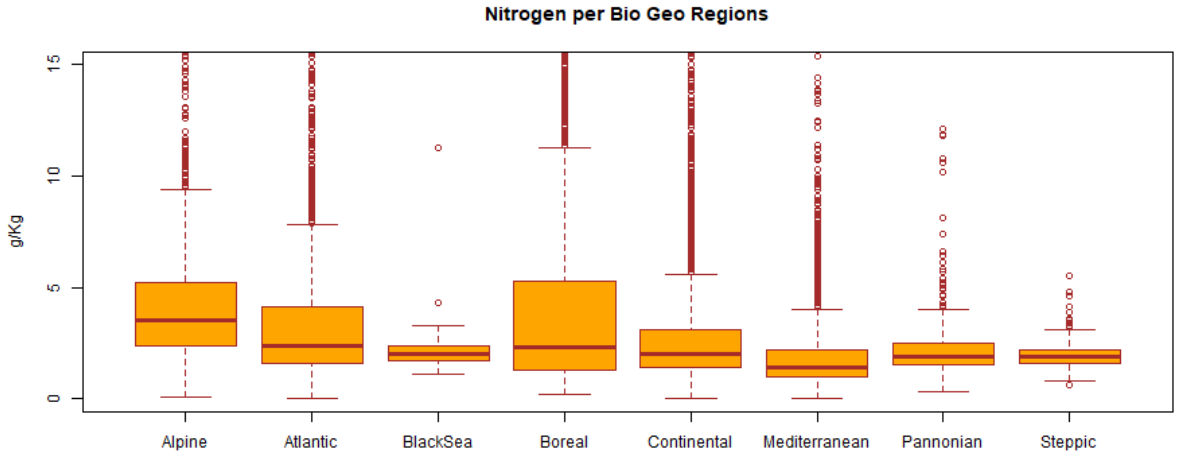

Electric Conductivity per Bio Geo Regions
mS/m
0
20
40
60
80
100
Alpine
Atlantic
BlackSea
Boreal
Continental
Mediterranean
Pannonian
Steppic

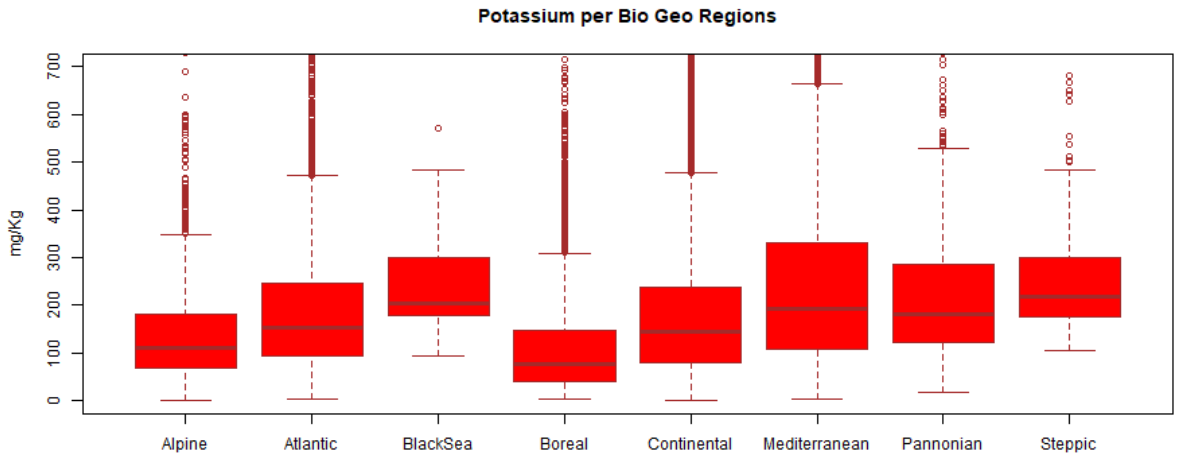

Organic Carbon per Bio Geo Regions
g/kg
0
50
100
150
200
Alpine
Atlantic
BlackSea
Boreal
Continental
Mediterranean
Pannonian
Steppic

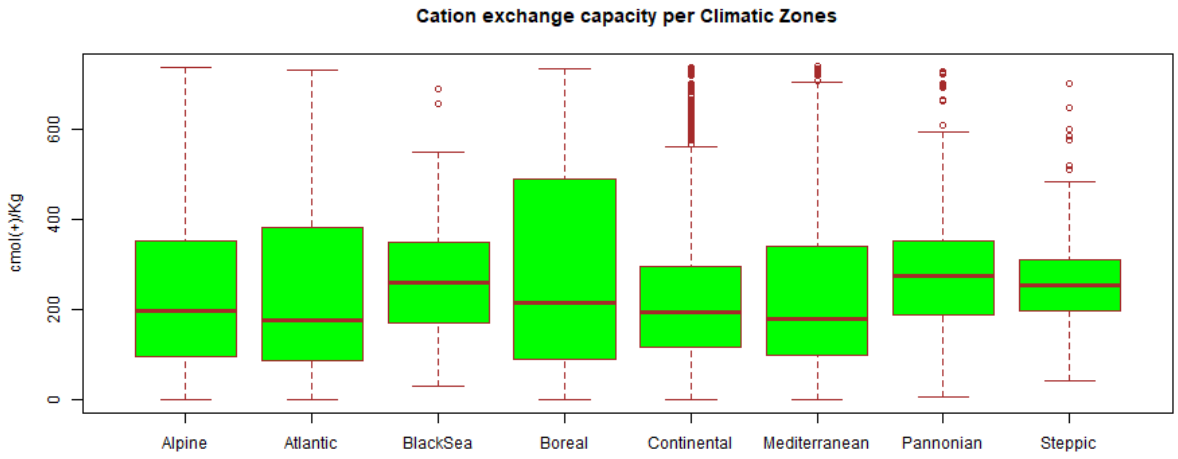

Carbonates per Bio Geo Regions
g/Kg
0
200
400
600
800
Alpine
Atlantic
BlackSea
Boreal
Continental
Mediterranean
Pannonian
Steppic


Zoom
g/Kg
0
50
100
150
Alpine
Atlantic
BlackSea
Boreal
Continental
Mediterranean
Pannonian
Steppic


Phosphorous per Bio Geo Regions
mg/Kg
0
50
100
150
Alpine
Atlantic
BlackSea
Boreal
Continental
Mediterranean
Pannonian
Steppic


Nitrogen per Bio Geo Regions
g/Kg
0
5
10
15
Alpine
Atlantic
BlackSea
Boreal
Continental
Mediterranean
Pannonian
Steppic


Potassium per Bio Geo Regions
mg/Kg
0
100
200
300
400
500
600
700
Alpine
Atlantic
BlackSea
Boreal
Continental
Mediterranean
Pannonian
Steppic


Cation exchange capacity per Climatic Zones
cmol(+)/Kg
0
200
400
600
Alpine
Atlantic
BlackSea
Boreal
Continental
Mediterranean
Pannonian
Steppic

7. Natura 2000 sites

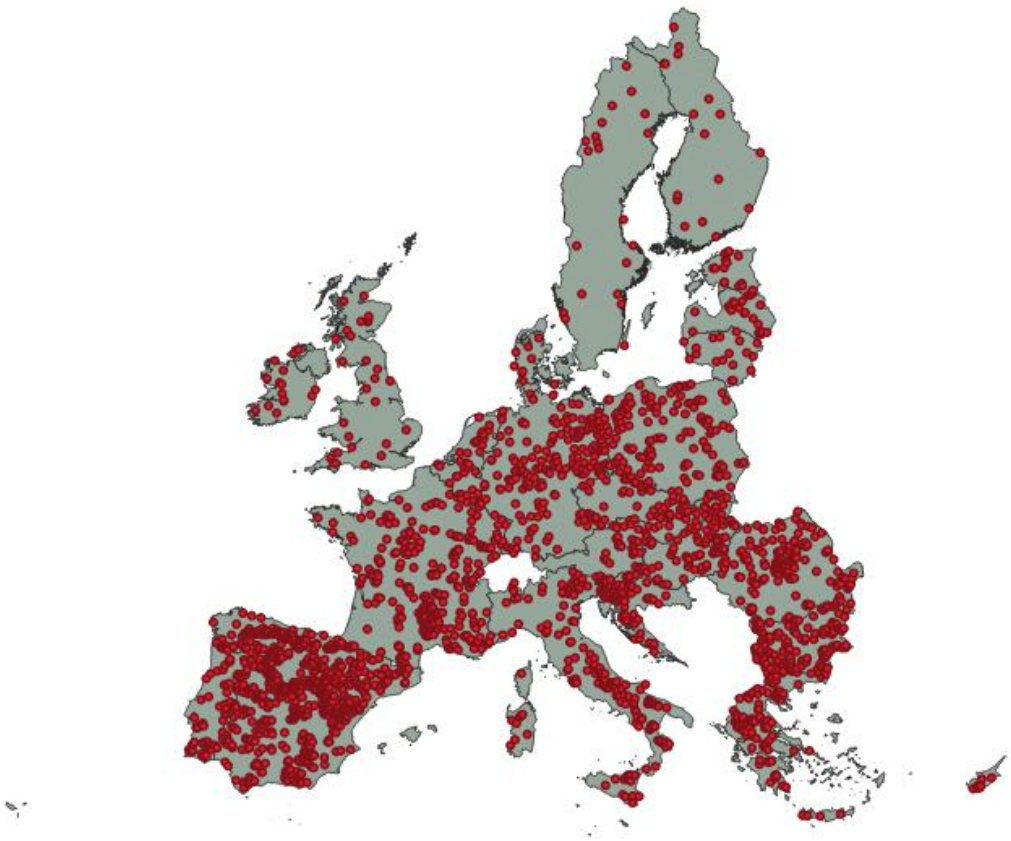
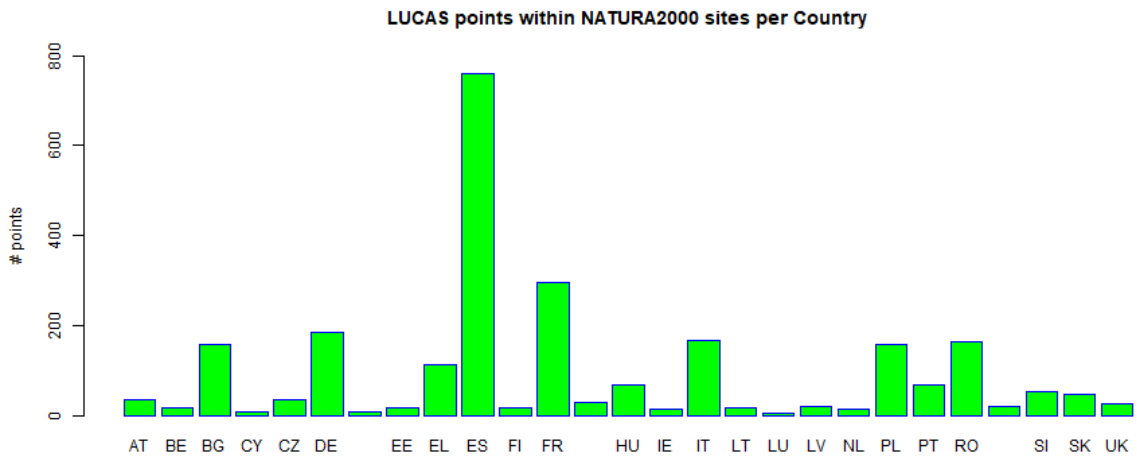


Figure 6. Map of terrestrial Natura 2000 sites (after EEA 2020)



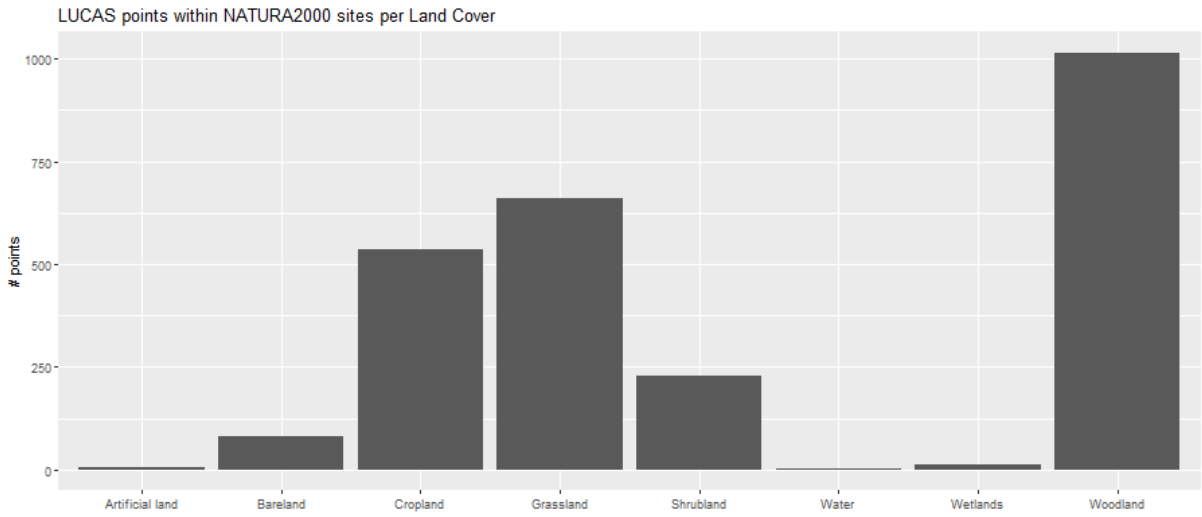


Table 3 LUCAS points within NATURA2000 sites by Land Use category

Land Use *	# points
Agriculture (excluding fallow land and kitchen gardens)	1135
Forestry	852
Semi-natural and natural areas not in use	382
Fallow land	99
Abandoned areas	32
Amenities, museum, leisure (e.g. parks, botanical gardens)	16
Road transport	5
Residential	4
Community services	3
Electricity, gas and thermal power distribution	2
Energy production	2
Mining and quarrying	2
Protection infrastructures	2
Other primary production	1
Sport	1
Water transport	1

*=based on LUCAS field survey

8. European Soil Regions

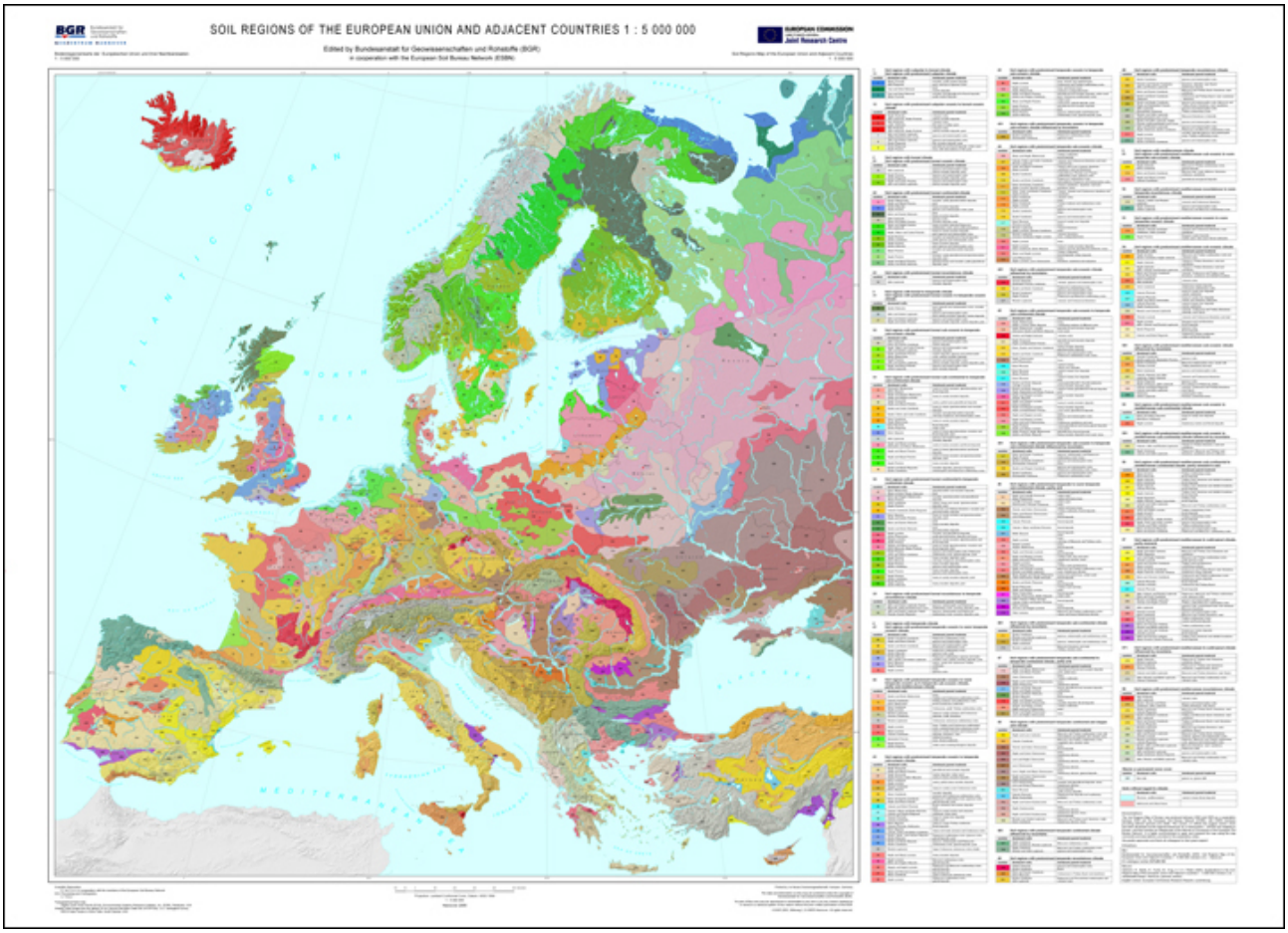


Figure 7 Map of soil regions (BGR 2005)

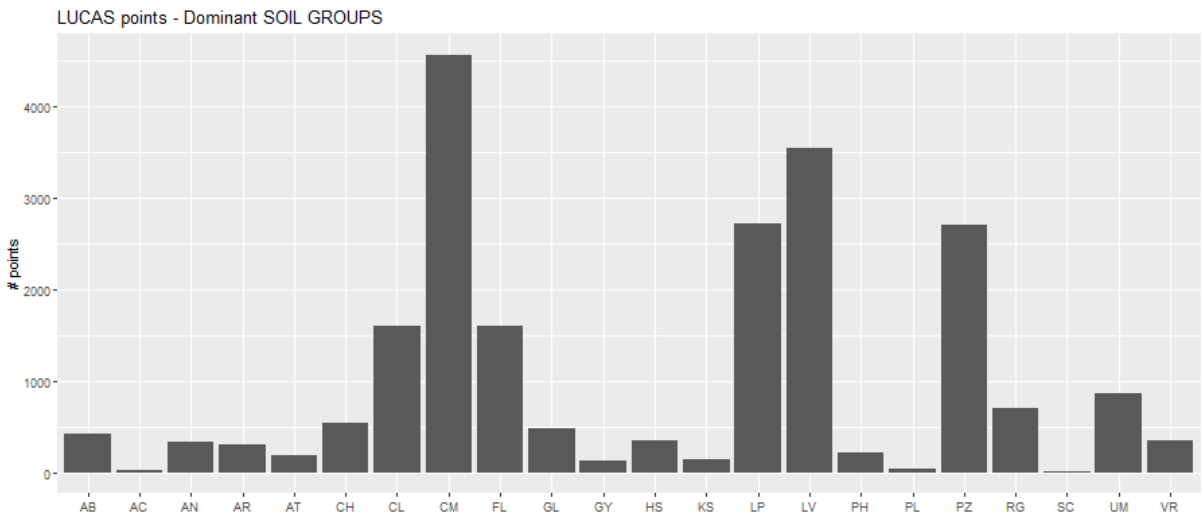
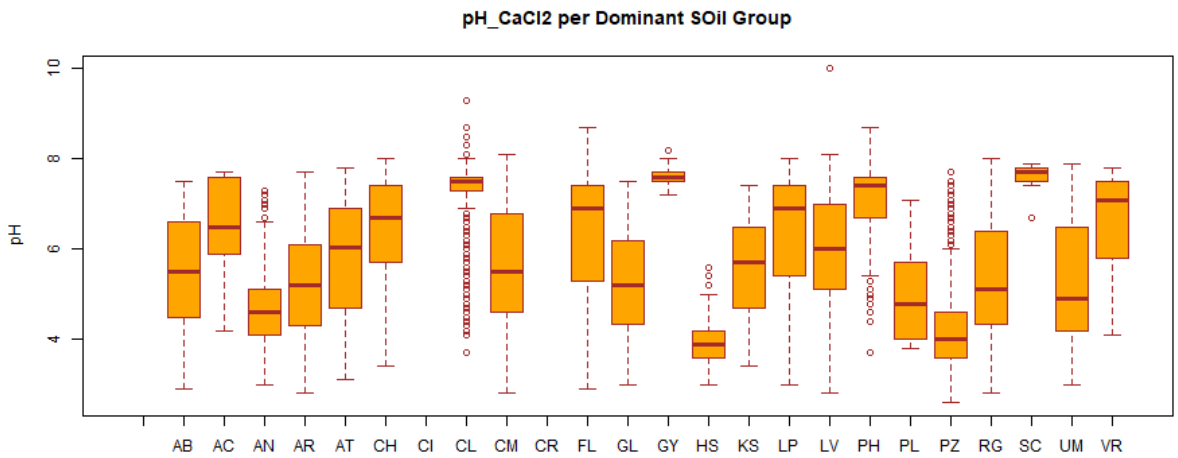
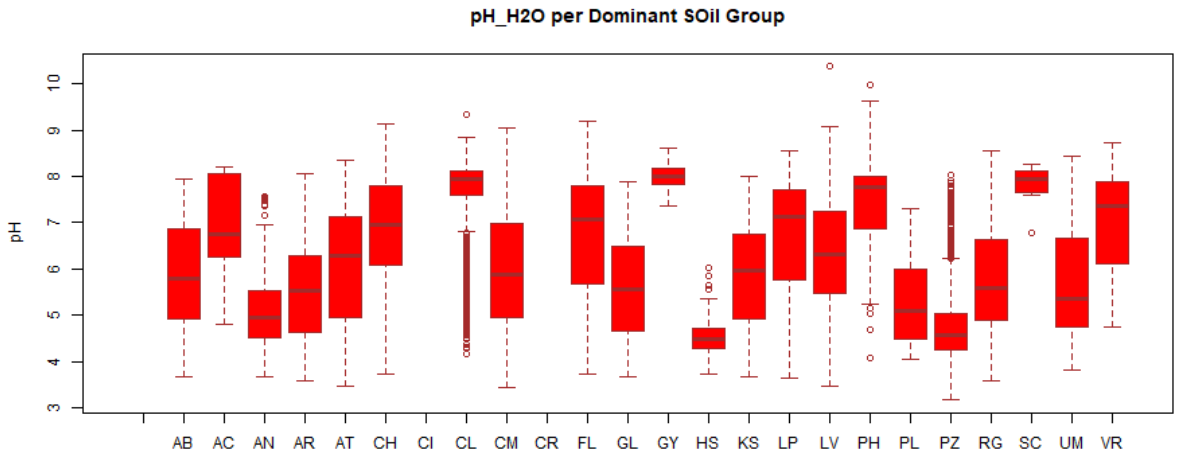


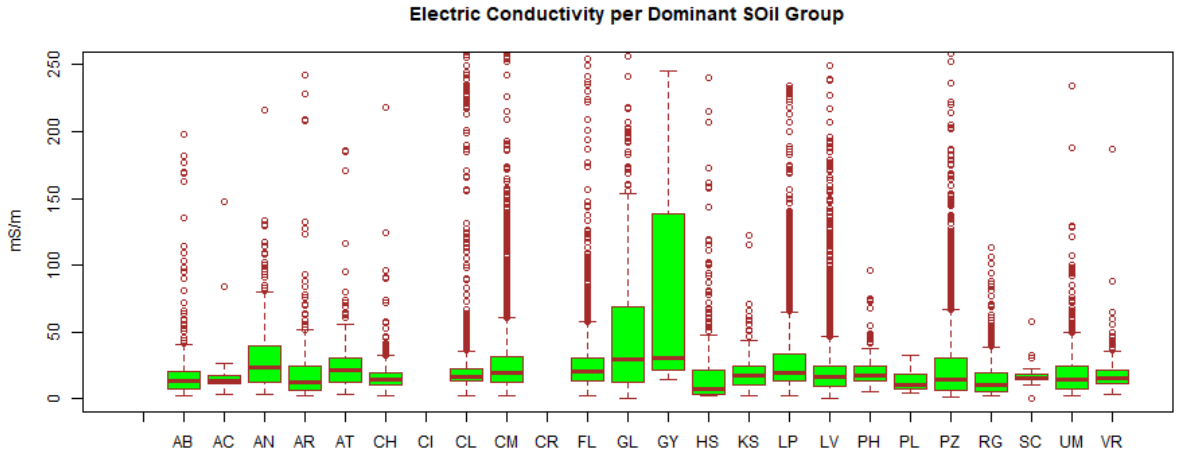
Table 4 World Reference Base Soil Group and potential LUCAS points count*

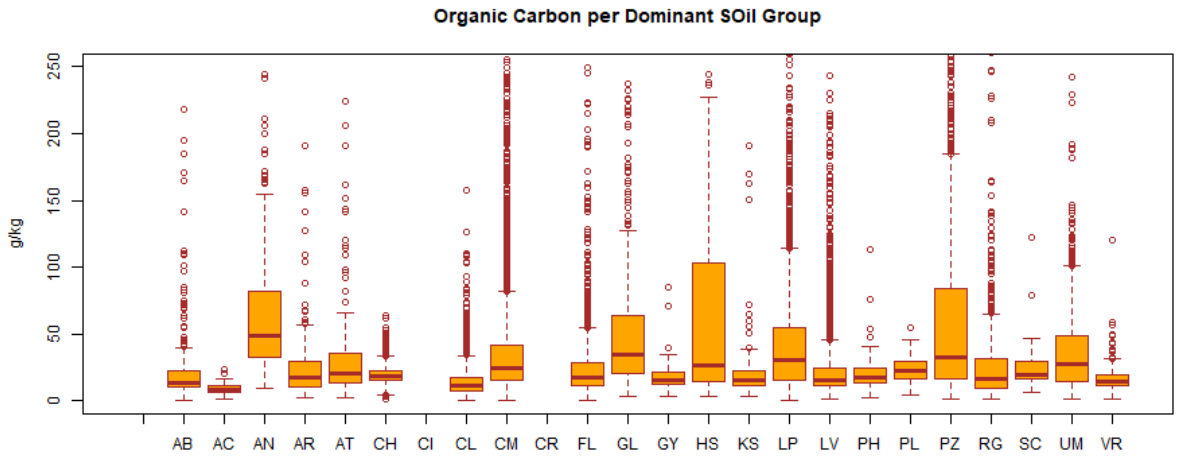
Dominant Soil Group	Cod	# points
Acrisols	AC	29
Albeluvisols	AB	419
Andosols	AN	341
Anthrosols and Urban Areas	AT	188
Arenosols	AR	310
Calcisols	CL	1608
Cambisols	CM	4558
Chernozems	CH	538
Fluvisols	FL	442
Fluvisols, undifferentiated	FL	1165
Gleysols	GL	479
Gypsisols	GY	127
Histosols	HS	354
Kastanozems	KS	138
Leptosols	LP	2356
Leptosols (partly permanent snow cover)	LP	357
Luvisols	LV	3546
Phaeozems	PH	220
Planosols	PL	47
Podzols	PZ	2702
Regosols	RG	704
Solonchaks	SC	19
Umbrisols	UM	865
Vertisols	VR	347

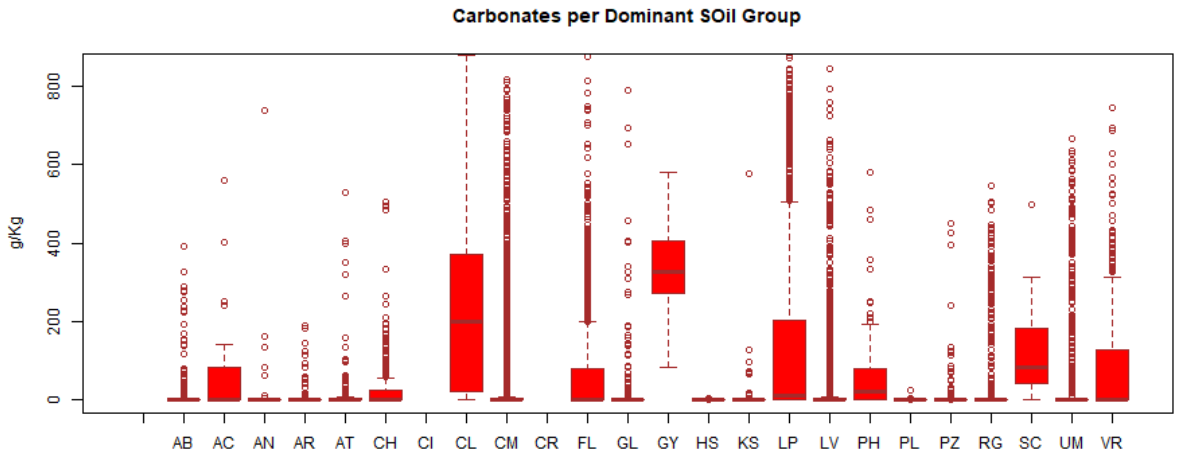
*=As the small scale of the European Soil Regions dataset (1:5.000.000) the assigned soil type does not necessarily reflect local conditions at the actual LUCAS point.

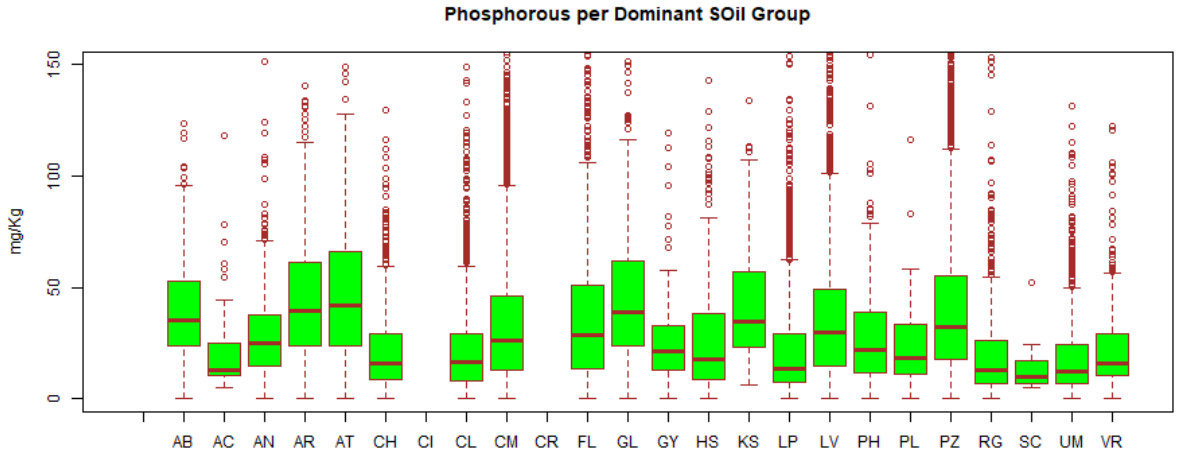


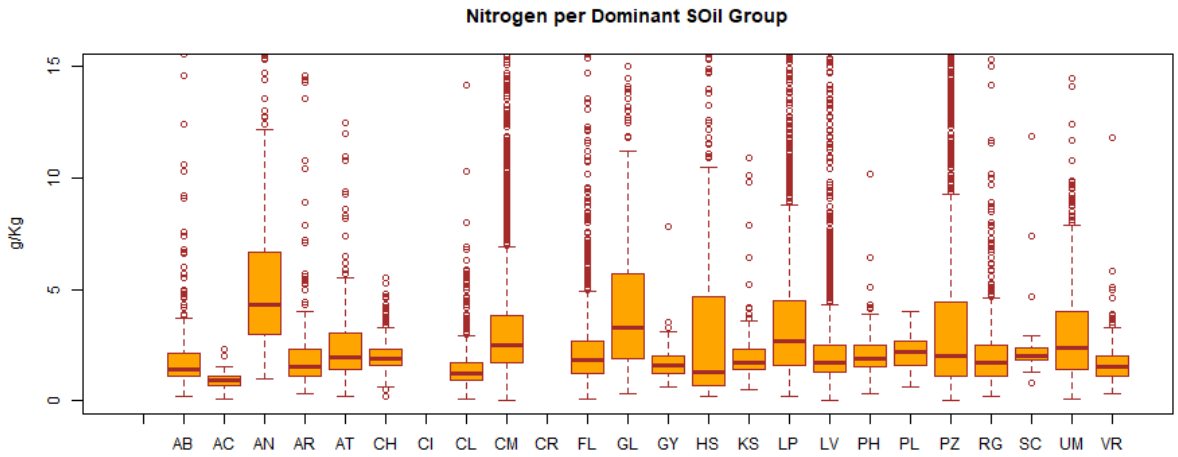

pH_H2O per Dominant SOil Group
pH
3
4
5
6
7
8
9
10
AB AC AN AR AT CH CI CL CM CR FL GL GY HS KS LP LV PH PL PZ RG SC UM VR

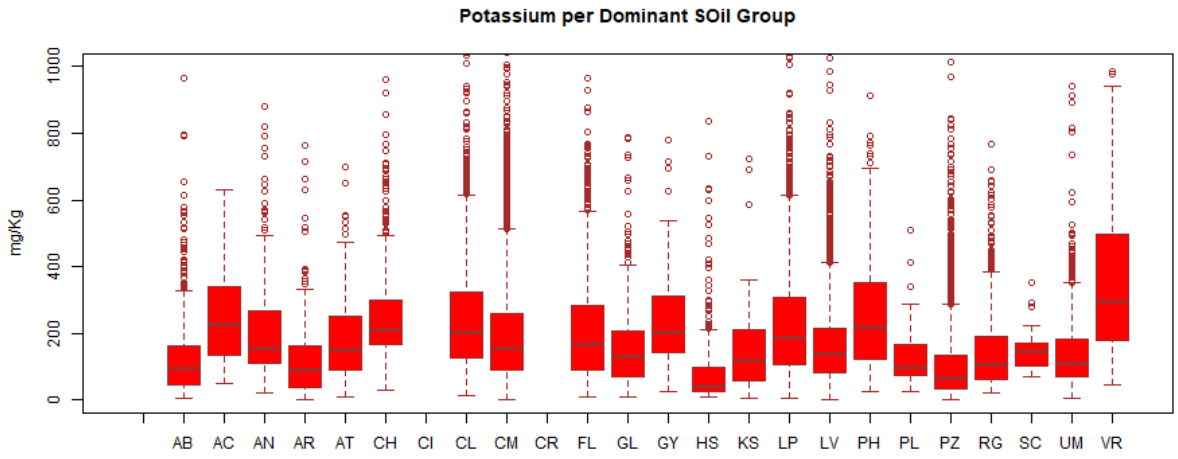

Electric Conductivity per Dominant SOil Group
mS/m
0
50
100
150
200
250
AB AC AN AR AT CH CI CL CM CR FL GL GY HS KS LP LV PH PL PZ RG SC UM VR

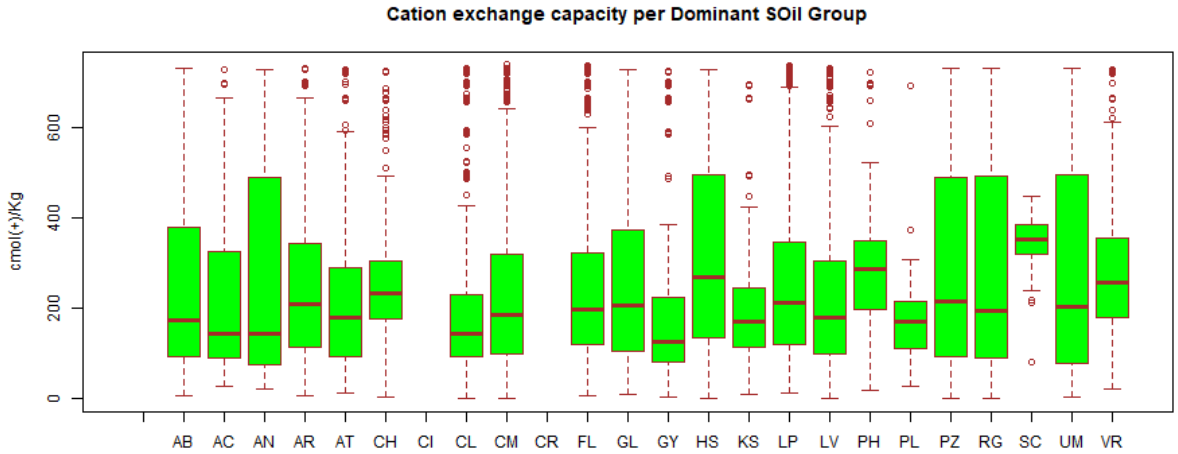

Organic Carbon per Dominant SOil Group
g/kg
0
50
100
150
200
250
AB AC AN AR AT CH CI CL CM CR FL GL GY HS KS LP LV PH PL PZ RG SC UM VR


Carbonates per Dominant SOil Group
g/Kg
0
200
400
600
800
AB AC AN AR AT CH CI CL CM CR FL GL GY HS KS LP LV PH PL PZ RG SC UM VR


Phosphorous per Dominant SOil Group
mg/Kg
0
50
100
150
AB AC AN AR AT CH CI CL CM CR FL GL GY HS KS LP LV PH PL PZ RG SC UM VR

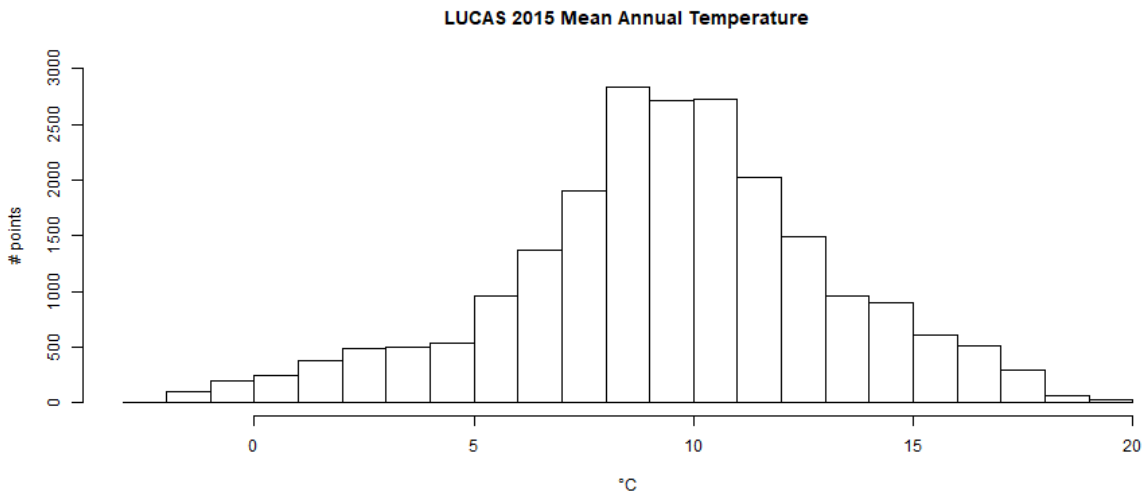

Nitrogen per Dominant SOil Group
g/Kg
0
5
10
15
AB AC AN AR AT CH CI CL CM CR FL GL GY HS KS LP LV PH PL PZ RG SC UM VR

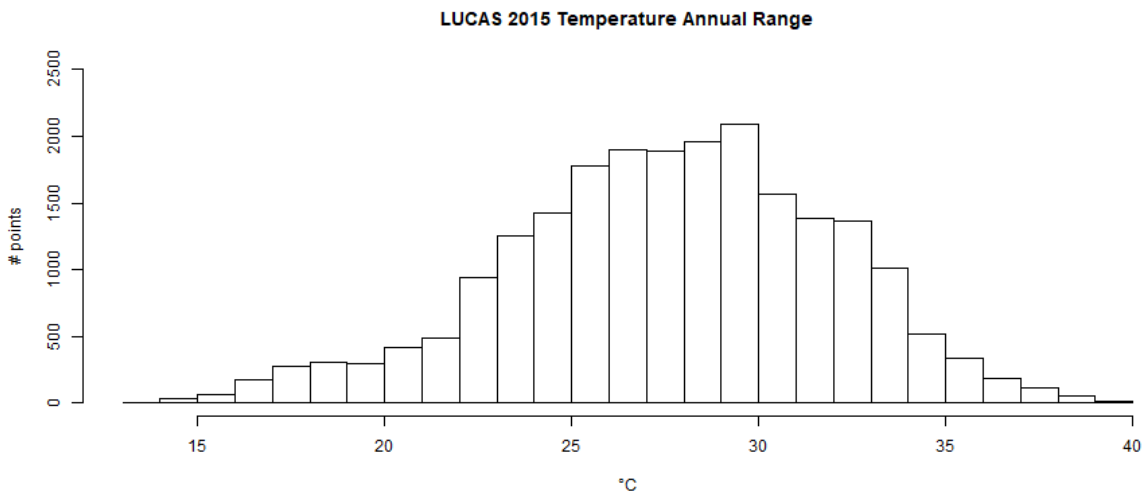

Potassium per Dominant SOil Group
mg/Kg
0
200
400
600
800
1000
AB AC AN AR AT CH CI CL CM CR FL GL GY HS KS LP LV PH PL PZ RG SC UM VR


Cation exchange capacity per Dominant SOil Group
cmol(+)/Kg
0
200
400
600
AB AC AN AR AT CH CI CL CM CR FL GL GY HS KS LP LV PH PL PZ RG SC UM VR

9. Bioclimatic variables

For illustrative purposes, mean annual temperature, annual temperature range and mean annual precipitation values for all LUCAS SOIL sampling sites are presented below (from the WorldClim V2 dataset - Fick & Hijmans, 2017).





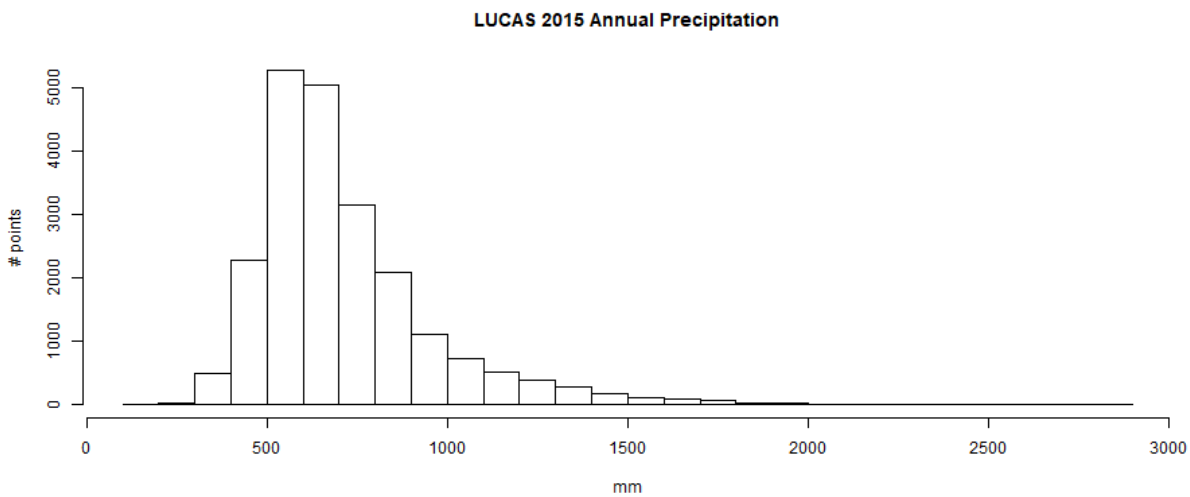
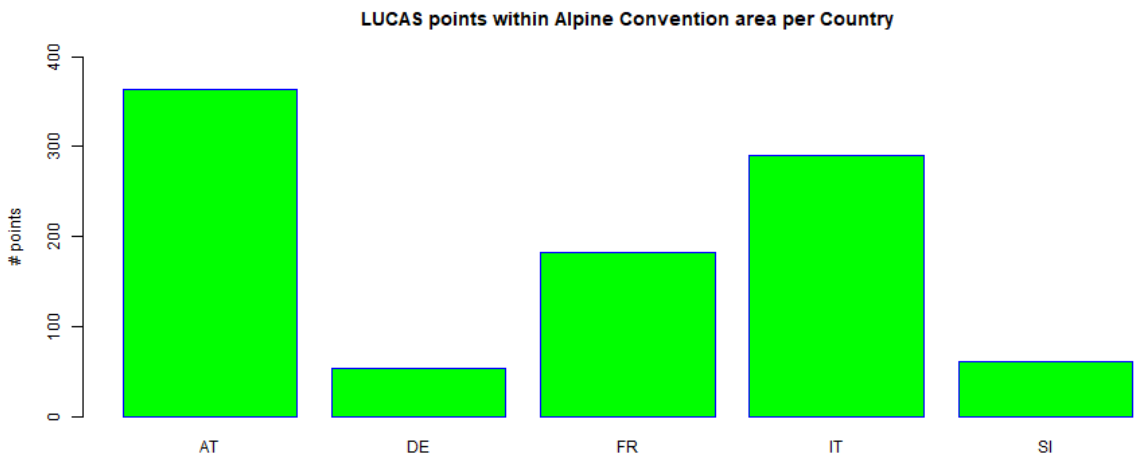


Table 5 WorldClim bioclimatic variables

Field Name	***Description***
BIO1	Annual Mean Temperature
BIO2	Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3	Isothermality (BIO2/BIO7) (×100)
BIO4	Temperature Seasonality (standard deviation ×100)
BIO5	Max Temperature of Warmest Month
BIO6	Min Temperature of Coldest Month
BIO7	Temperature Annual Range (BIO5-BIO6)
BIO8	Mean Temperature of Wettest Quarter
BIO9	Mean Temperature of Driest Quarter
BIO10	Mean Temperature of Warmest Quarter
BIO11	Mean Temperature of Coldest Quarter
BIO12	Annual Precipitation
BIO13	Precipitation of Wettest Month
BIO14	Precipitation of Driest Month
BIO15	Precipitation Seasonality (Coefficient of Variation)
BIO16	Precipitation of Wettest Quarter
BIO17	Precipitation of Driest Quarter
BIO18	Precipitation of Warmest Quarter
BIO19	Precipitation of Coldest Quarter

10. Alpine points

Figure 8 Map of the Alpine Convention area and boundary (https://www.alpconv.org/en/home/)



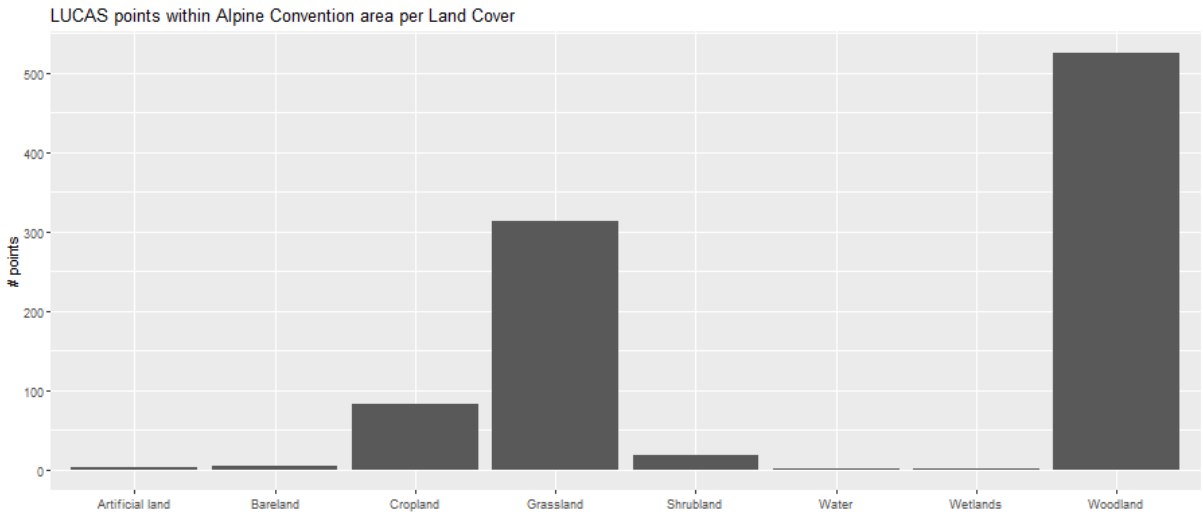


Table 6 Count of LUCAS Soil Points per Land Use category in Alpine Convention area

Land Use *	# points
Abandoned areas	2
Agriculture (excluding fallow land and kitchen gardens)	375
Amenities, museum, leisure (e.g. parks, botanical gardens)	2
Electricity, gas and thermal power distribution	2
Fallow land	7
Forestry	471
Kitchen gardens	3
Residential	10
Road transport	1
Semi-natural and natural areas not in use	76
Sport	2

*=based on LUCAS field survey

11. Conclusions

Over half of LUCAS Soil points are found in temperate humid climates (i.e. Dfb and Cfb) while just over 10% of soil samples reflect semi-arid or arid conditions (B* climates) with a single point reflecting very cold Tundra conditions.

Soils of the desert climates display the highest salt content, pH and carbonate values while the Tundra and Cool oceanic climate the lowest (probably reflecting greater soil leaching and acidic vegetation types). Interestingly, salt concentrations are slightly elevated in Cool oceanic climates.

Organic carbon content levels are highest under Cool oceanic climates and lowest in the arid regions.

Soil nutrient levels are broadly similar in all climate regions. However, phosphorous levels are higher in dry climates while lowest in Temperate Continental, nitrogen values are much higher in Cool oceanic climates while Potassium is higher in Warm semi-arid climates.

Mean cation exchange capacity level are also broadly similar across all climate zone but with large differences in all but the dry climates.

Italy has the highest soil point (>2 000 m) while close to 50% of points lie below 200 m elevation. In addition, around half the points are found on level ground (<2% gradient). Aspect is generally evenly distributed, with a slight bias towards the east and the south.

In terms of biogeographical regions, most soil points fall in the Continental Region, followed by the Mediterranean, with an equal distribution between the Atlantic and the Boreal. Investigations of the laboratory analysis for biogeographical regions broadly mirrors that described by climate where

- pH is highest in the warm climates of the Black Sea and Mediterranean Region
- Electrical Conductivity is highest in the Atlantic Region
- Organic matter content is highest in the Boreal region, but with large differences
- Carbonates are higher in the Mediterranean, but with large variations.

Over 25% of LUCAS Soil points fall in NATURA 2000 sites, with Spain having the most. The majority of 'protected' LUCAS Soil points occur in woodlands, followed by grasslands.

Most LUCAS Soil points occur in areas where Cambisols tend to predominate, followed by Luvisols and Podzols. Cambisols are soils that show only limited soil profile development and are often considered as 'young' soils that are still in the processes of development (widespread in the Mediterranean and areas glaciated during the last Ice Age). Luvisols display an increase in clay concentrations in the subsoil and are generally found in conditions that facilitate the movement of clay participles (i.e. sloping land in humid climates). Podzols are coarse textures soils, generally found under conifer forests or healthlands, where acid litter drives the leaching of iron and organic matter to leave a bleached topsoil and subsoil accumulation of iron and organic matter (typical of large areas of Scandinavia). It should be stressed that due to the very small scale of the European Soil Regions dataset (1:5.000.000), the assigned soil type is purely indicative of regional characteristics and does not necessarily reflect local conditions at the actual LUCAS point. However, the analysis of statistics interestingly shows some general correspondence. For example, soil types with high salt contents (e..g Calcisols, Gypsisols,

Solonchaks) all display high pH values while Podzols and Histosols have low pH, reflecting their acidic characteristics.

The majority of LUCAS Soil Points have a mean annual temperature of 7-12oC, but with quite a pronounced annual temperature range, whereas the annual precipitation for most points is relatively low (< 1 000 mm).

Around 1 000 points of the EU dataset fall within the boundary of the Alpine Convention (i.e. excluding Switzerland), the majority of which are in Austria. Most 'Alpine' soil points are under woodland.

References

Beck, H.E., N.E. Zimmermann, T.R. McVicar, N. Vergopolan, A. Berg, E.F. Wood: Present and future Köppen-Geiger climate classification maps at 1 km resolution, Scientific Data 5:180214, doi:10.1038/sdata.2018.214 (2018)

BGR [Bundesanstalt für Geowissenschaften und Rohstoffe] (2005). Soil Regions Map of the European Union and Adjacent Countries 1:5,000,000 (Version 2.0). Special Publication, Ispra. EU catalogue number S.P.I.05.134.
https://www.bgr.bund.de/EN/Themen/Boden/Projekte/Informationsgrundlagen_abgeschlossen/EUSR5000/EUSR5000_en.html

European Environment Agency. EU-DEM v1.0 Statistical validation report.
https://land.copernicus.eu/user-corner/technical-library/eu-dem-v1.0

European Environment Agency. 2002. Europe's biodiversity - biogeographical regions and seas. EEA Report No 1/2002
https://www.eea.europa.eu/data-and-maps/data/biogeographical-regions-europe-3

European Environment Agency. 2020. Natura 2000 data - the European network of protected sites. EEA Report No 1/2002
https://www.eea.europa.eu/data-and-maps/data/natura-11

EC, Natura 2000
https://ec.europa.eu/environment/nature/natura2000/index_en.htm

Fick, S.E. and R.J. Hijmans, 2017. WorldClim 2: new 1km spatial resolution climate surfaces for global land areas. International Journal of Climatology 37 (12): 4302-431
http://biogeo.ucdavis.edu/data/worldclim/v2.1

Routines
https://gdal.org/programs/gdaldem.html

List of figures

List of tables

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

- by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

- at the following standard number: +32 22999696, or

- by electronic mail via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications
You can download or order free and priced EU publications from EU Bookshop at: https://publications.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en).

The European Commission's science and knowledge service

Joint Research Centre

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

EU Science Hub
ec.europa.eu/jrc

@EU_ScienceHub

EU Science Hub - Joint Research Centre

EU Science, Research and Innovation

EU Science Hub

Publications Office
of the European Union