



NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING AND
THE BUILT ENVIRONMENT

Production of a National Soil Map and Soil Profile Database of Namibia

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Department of Architecture, Planning and Construction

Institutional Research Week 2022

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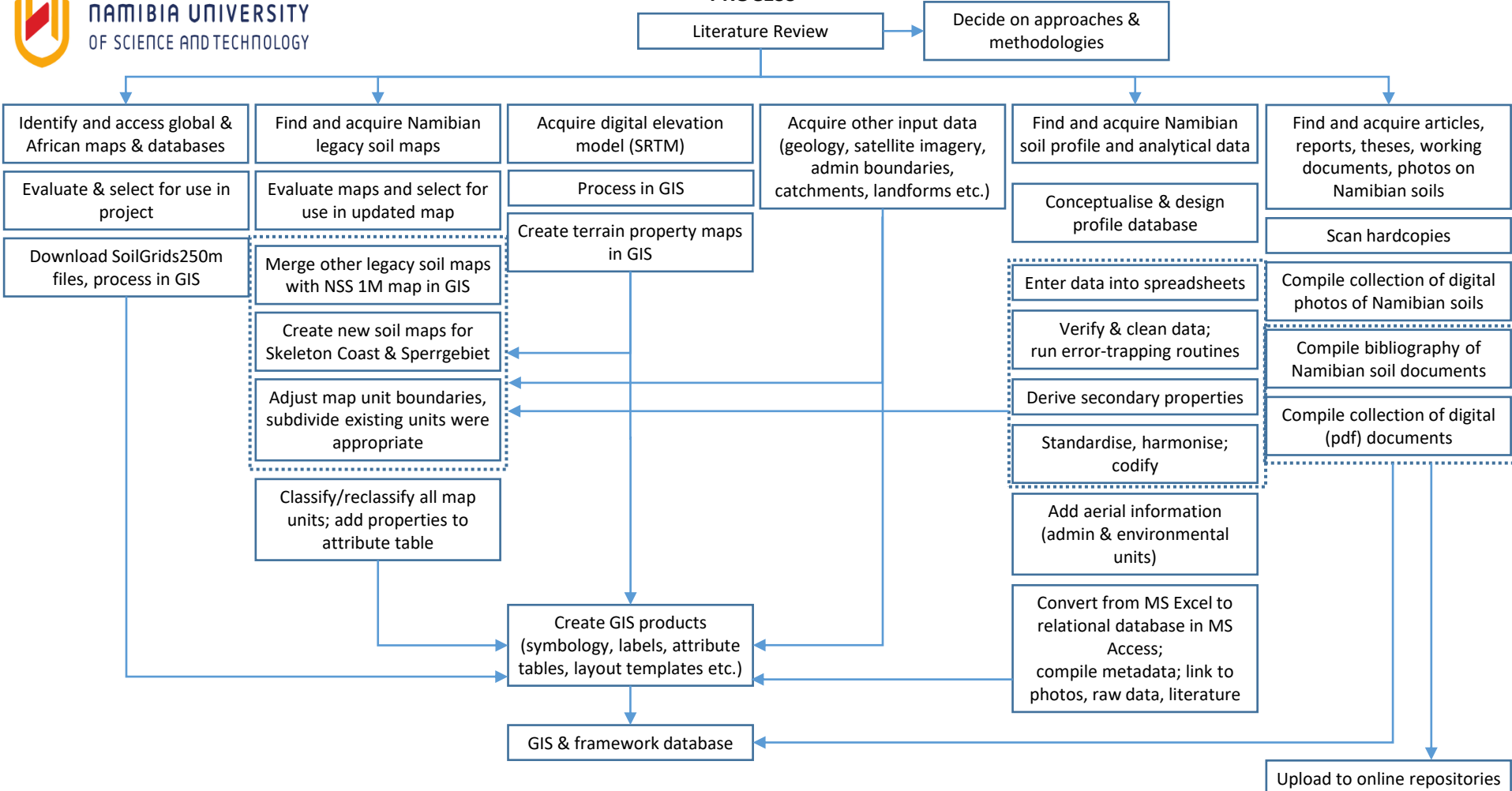




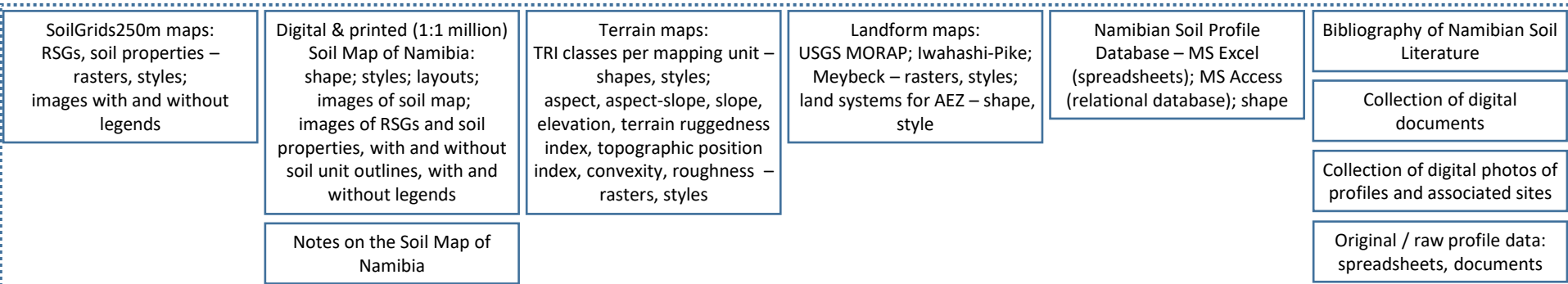
Contents

1. Introduction – Process & Products
2. Soil Profile Data
3. Terrain Characteristics
4. Soil Map
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PROCESS



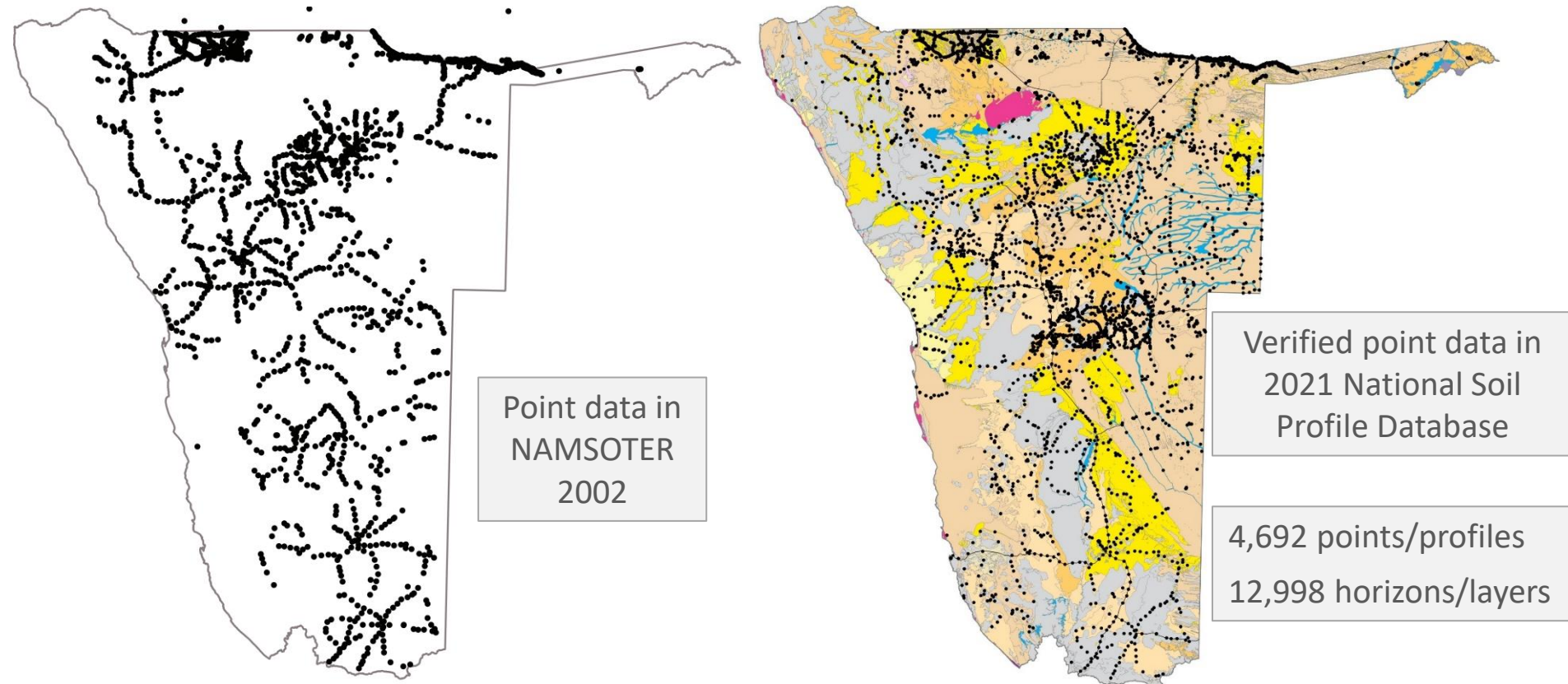
PRODUCTS



SOIL PROFILE DATA

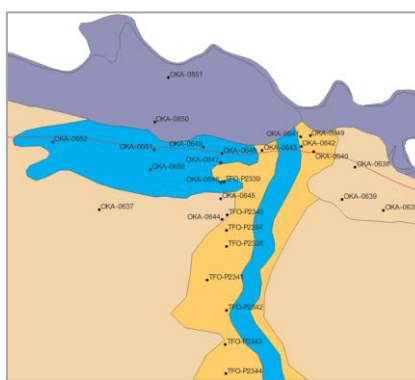
2021 National Soil Profile Database of Namibia

- site characteristics, soil horizons, chemical and physical properties
- MS Excel, MS Access, QGIS project
- Format harmonised with international standards, global collections



Profile/Point Registration

Where, when, by whom, type, classification



Environmental Covariates, derived from other maps
Soils, terrain, vegetation, AEZ, GPZ, CC, geology, ...

Site Description

Weather, terrain, land use & cover, surface characteristics, whole profile characteristics, ...



Horizons/Layers – Field Data

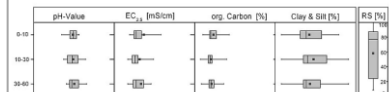
Profile description, diagnostic info



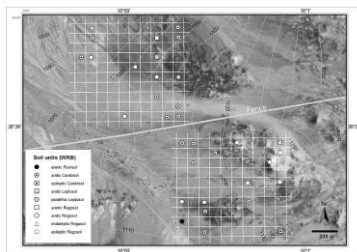
BIOTA OBSERVATORIES

Gellap Ost

The Observatories Nabaos and the Gellap Ost Research Station cover plains and washes with shale outcrops of the Karoo Sequence (Ecca Group, Prince Albert Formation). The soil parent materials are shale (partly shattered and thin calcareous layers) and colluvial materials (sand to loam). The main soil units are Leptosols, Cambisols and Regosols. The rocky outcrops and slopes are dominated by shallow Leptosols and epileptic Regosols whereas the plains and washes are characterized by weakly developed Regosols. Partly stronger developed Cambisols occur on parts with a loamy parent material (Paleosols). The soils are characterised by slightly acidic to neutral pH values and a relatively low electrical conductivity of < 0.2 mS cm⁻¹.



Box-whisker overview of selected soil properties in three depths (cm) on the observatory (RS = rooting space / m²)



Horizons/Layers – Lab Data



Metadata

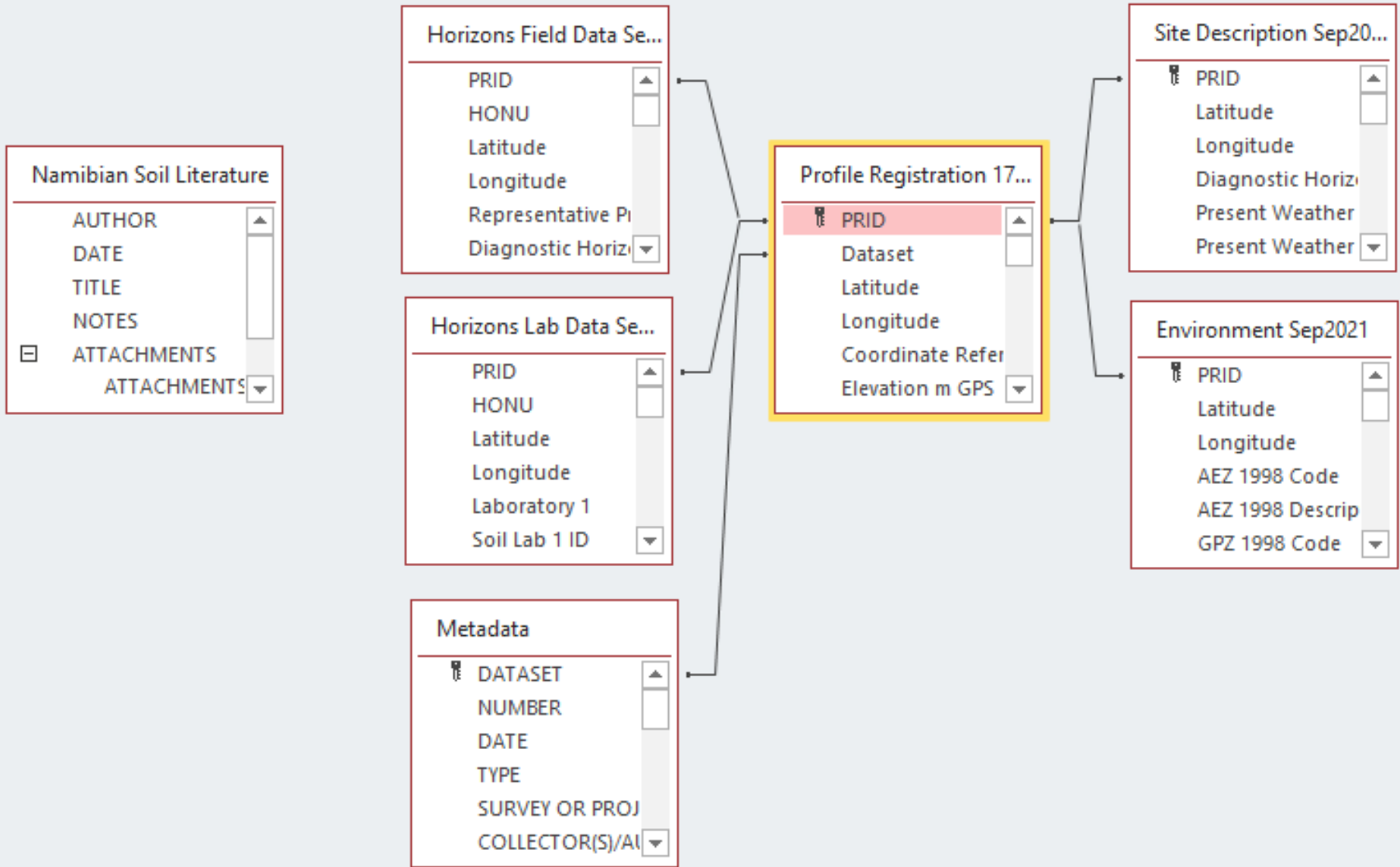
Origin, owner, analytical methods, links to articles, original data, photos, ...

PROFILE ID	RSZ	Field Name	Location
01-01	01	01-01	01-01

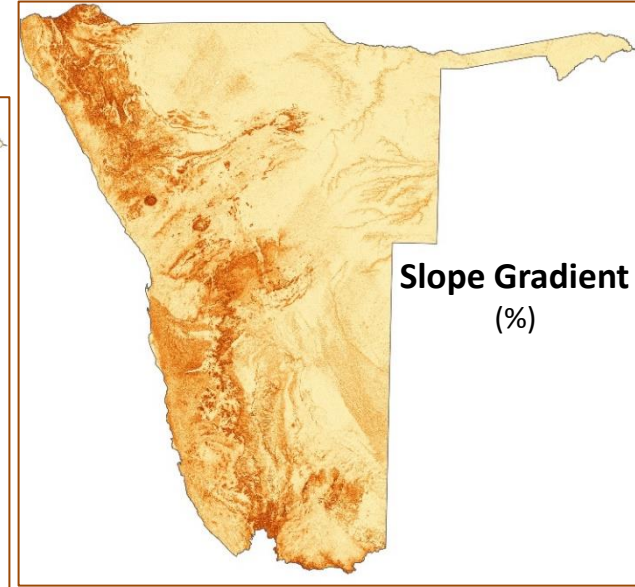
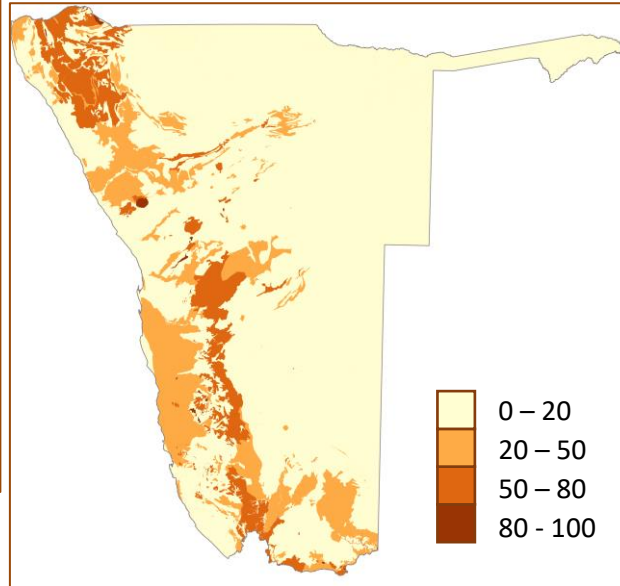
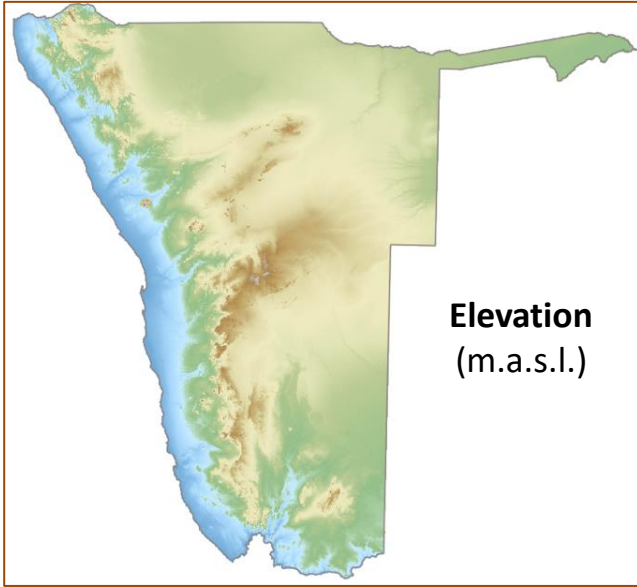
PROFILE ID	RSZ	Field Name	Location
01-01	01	01-01	01-01

PROFILE ID	RSZ	Field Name	Location
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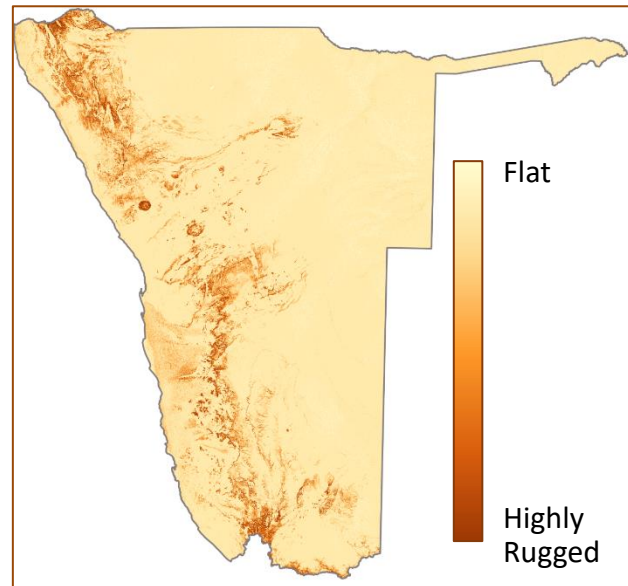
RELATIONAL DATABASE



TERRAIN CHARACTERISTICS

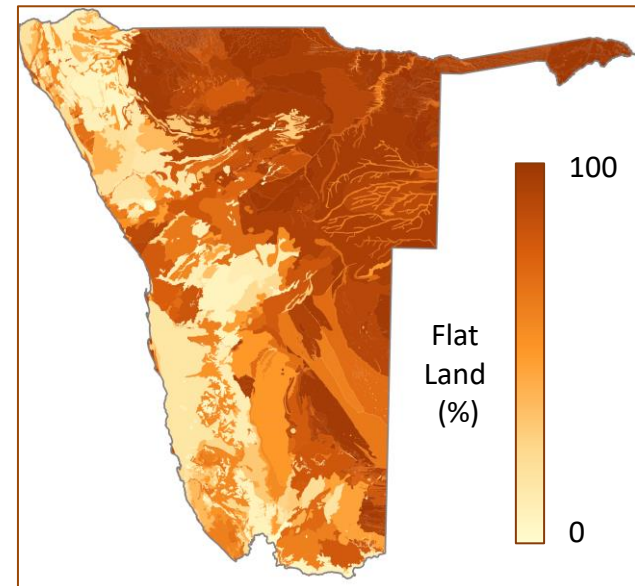


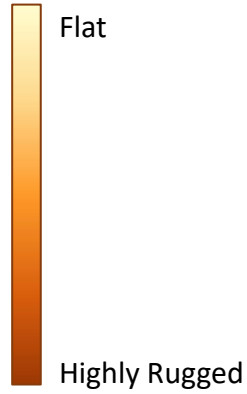
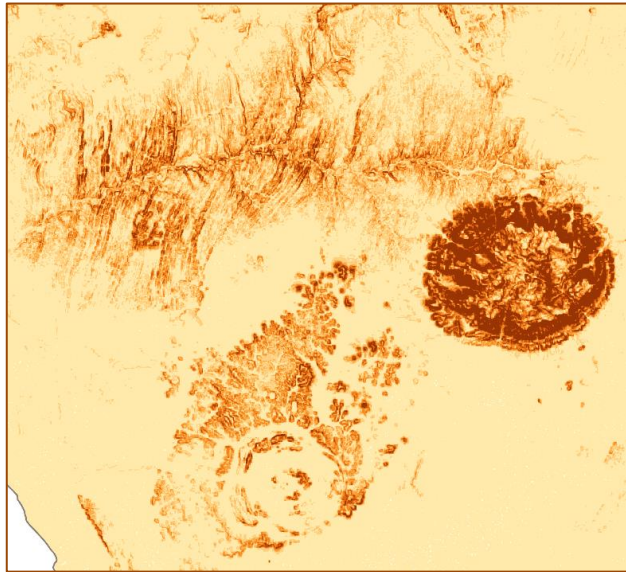
Terrain Ruggedness Index (TRI) of Riley



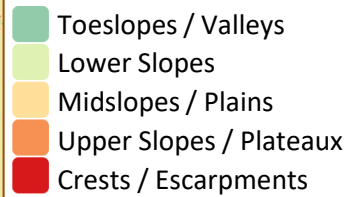
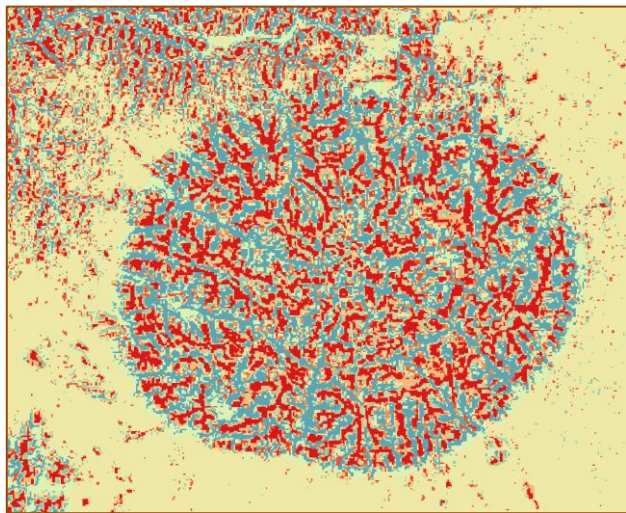
Percentage of soil mapping unit with slopes steeper than 8%

Ruggedness of each soil mapping unit

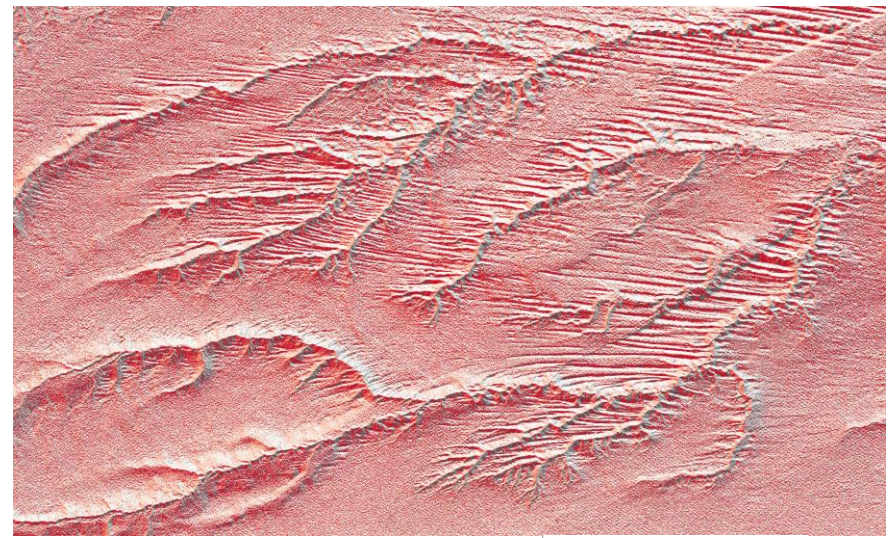




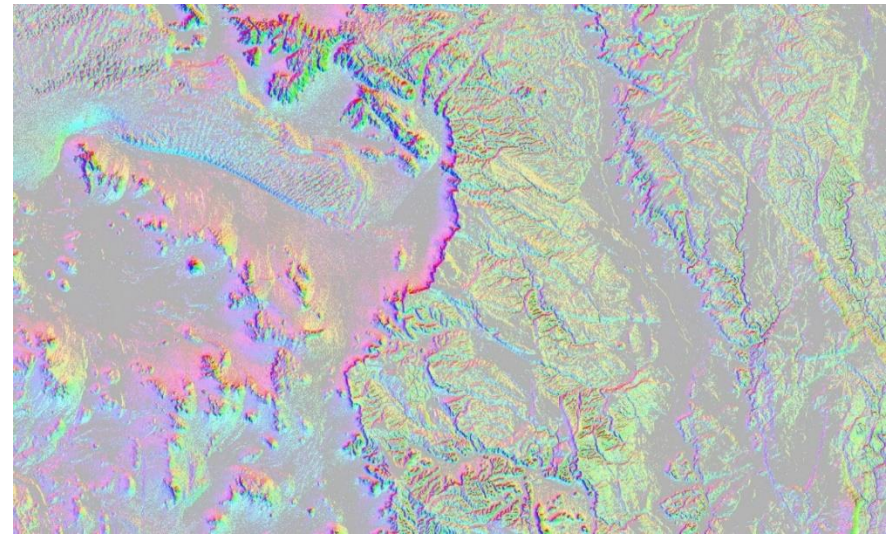
Terrain Ruggedness Index (TRI) of Riley



Position in the landscape

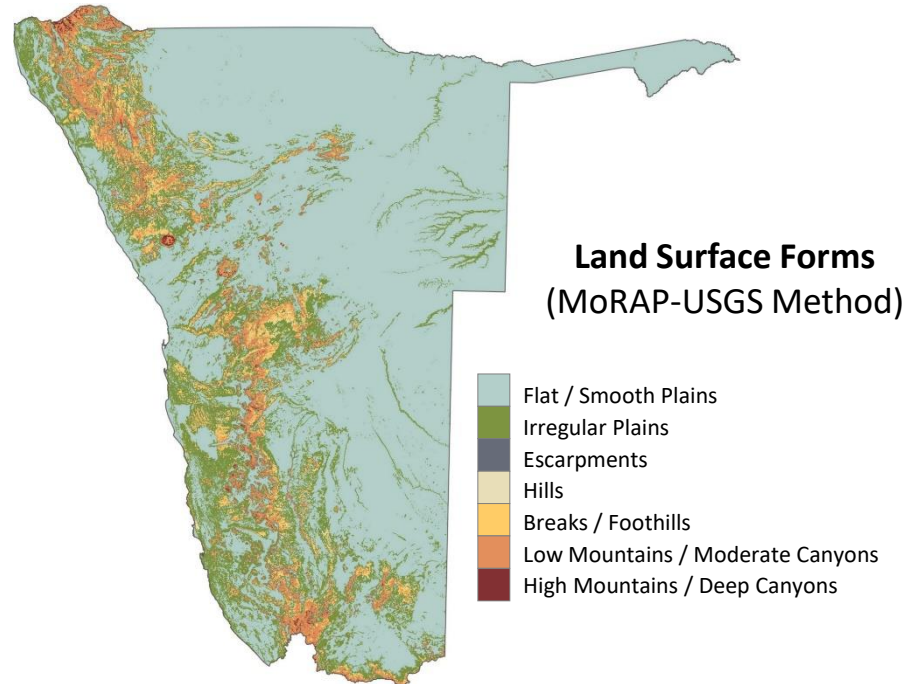
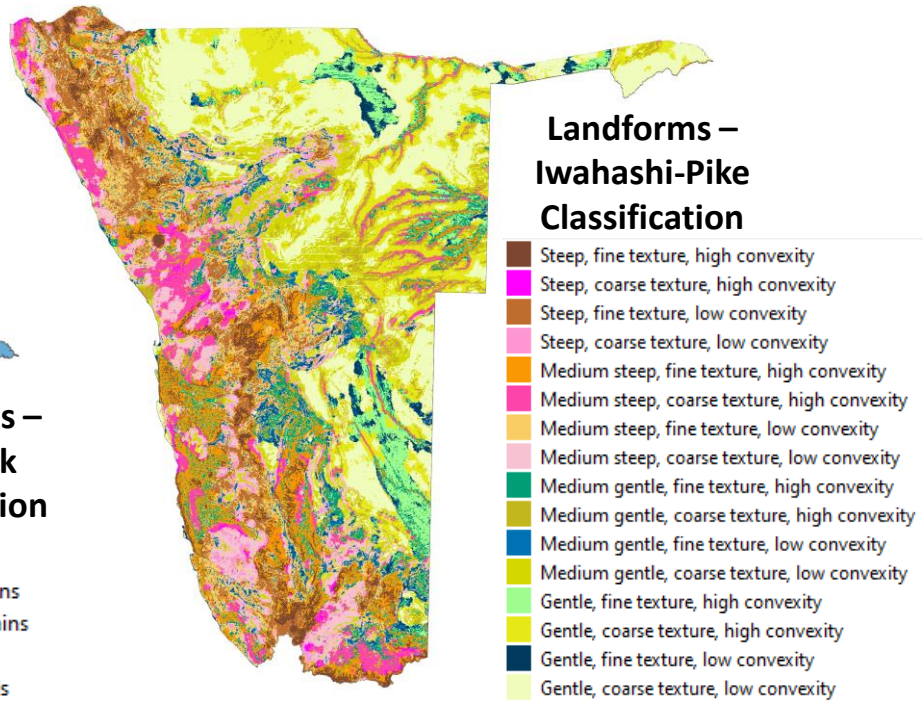
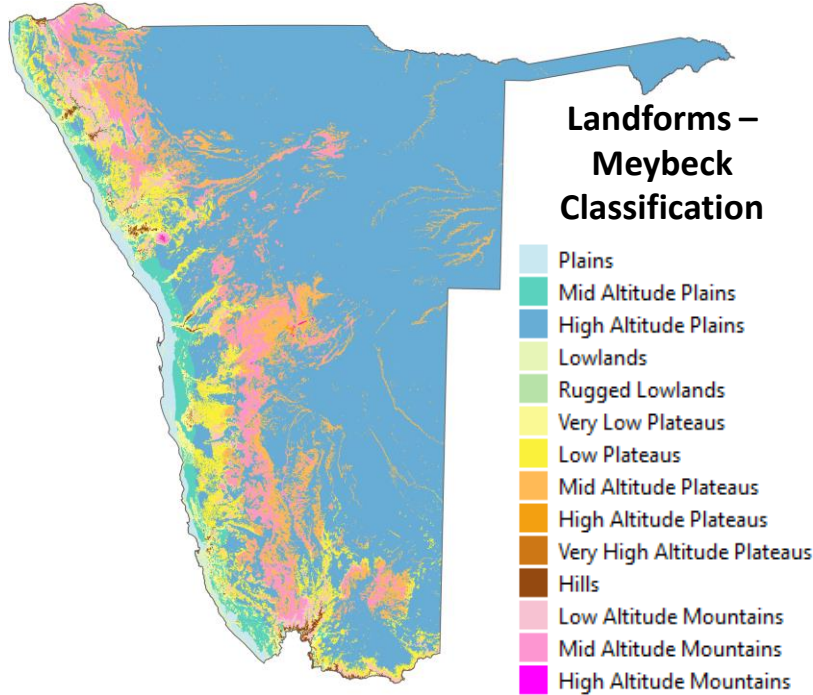


Aspect (slope direction)



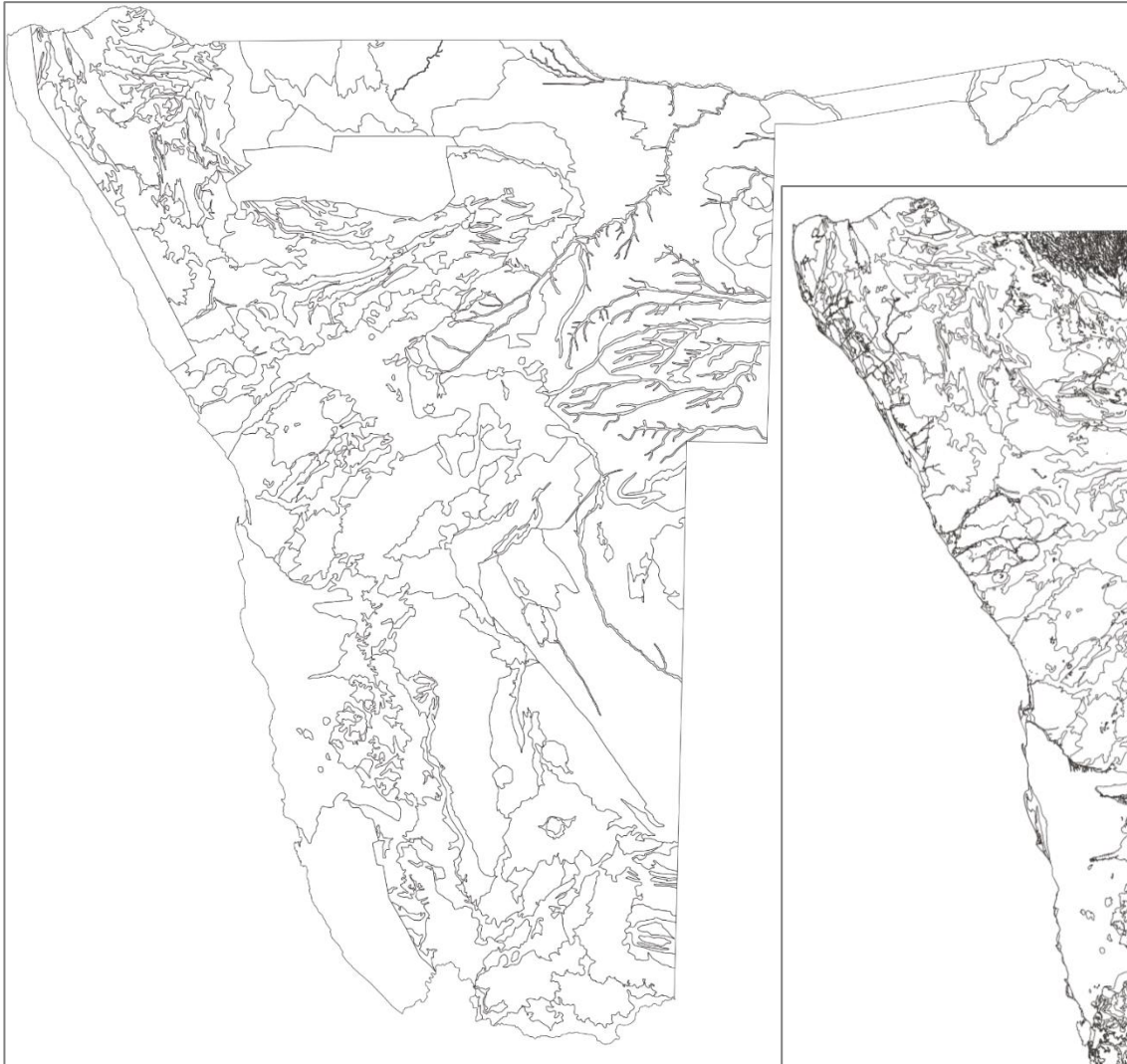
Combined Slope-Aspect

Aspect: 8 directions (N, NE, E, SE, S, SW, W, NW) represented by hues
 Slope: 0-2% (very flat – flat) – grey; increasing slope represented by increasing colour saturation

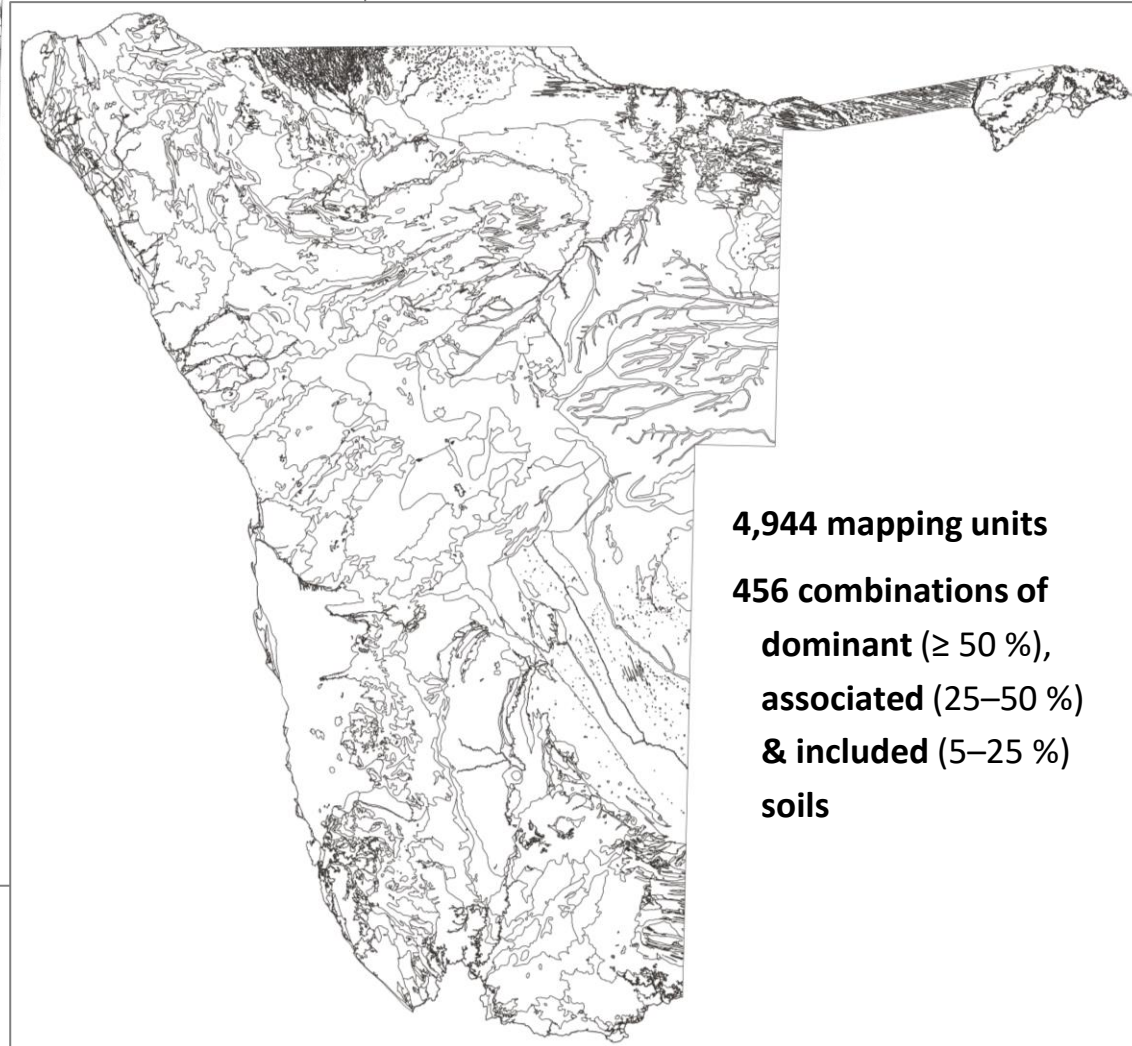


SOIL MAP

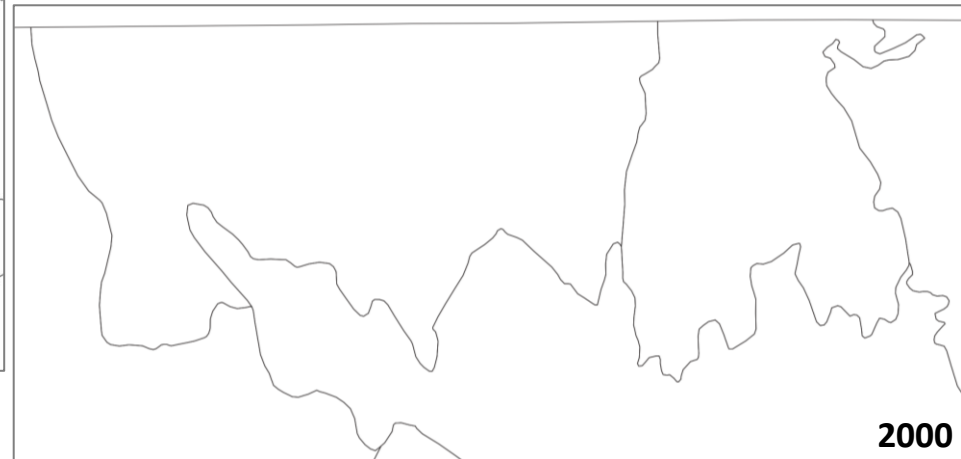
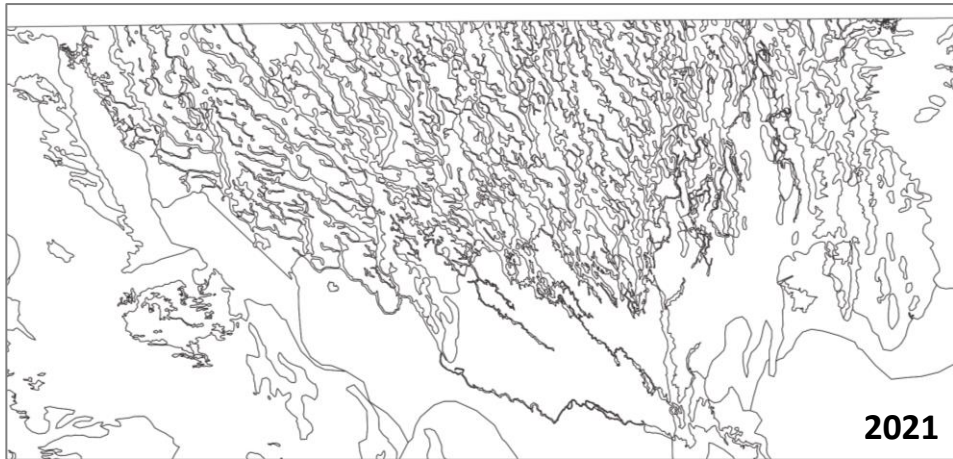
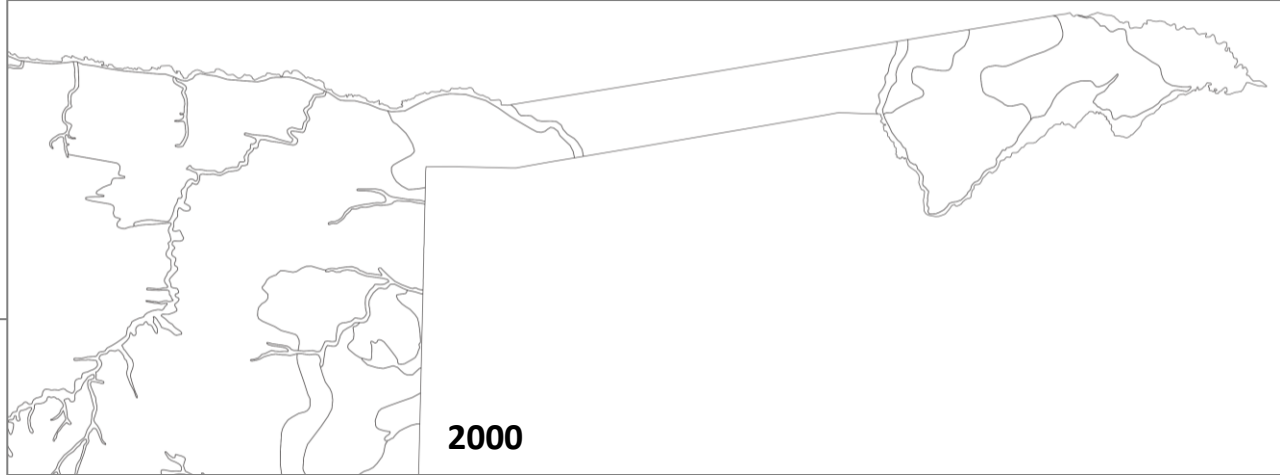
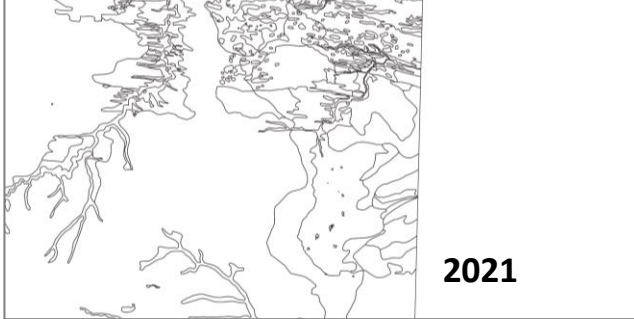
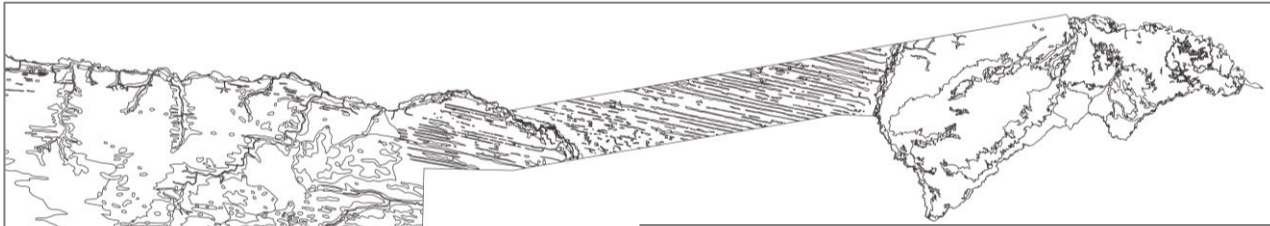
Soil Map of Namibia 2021

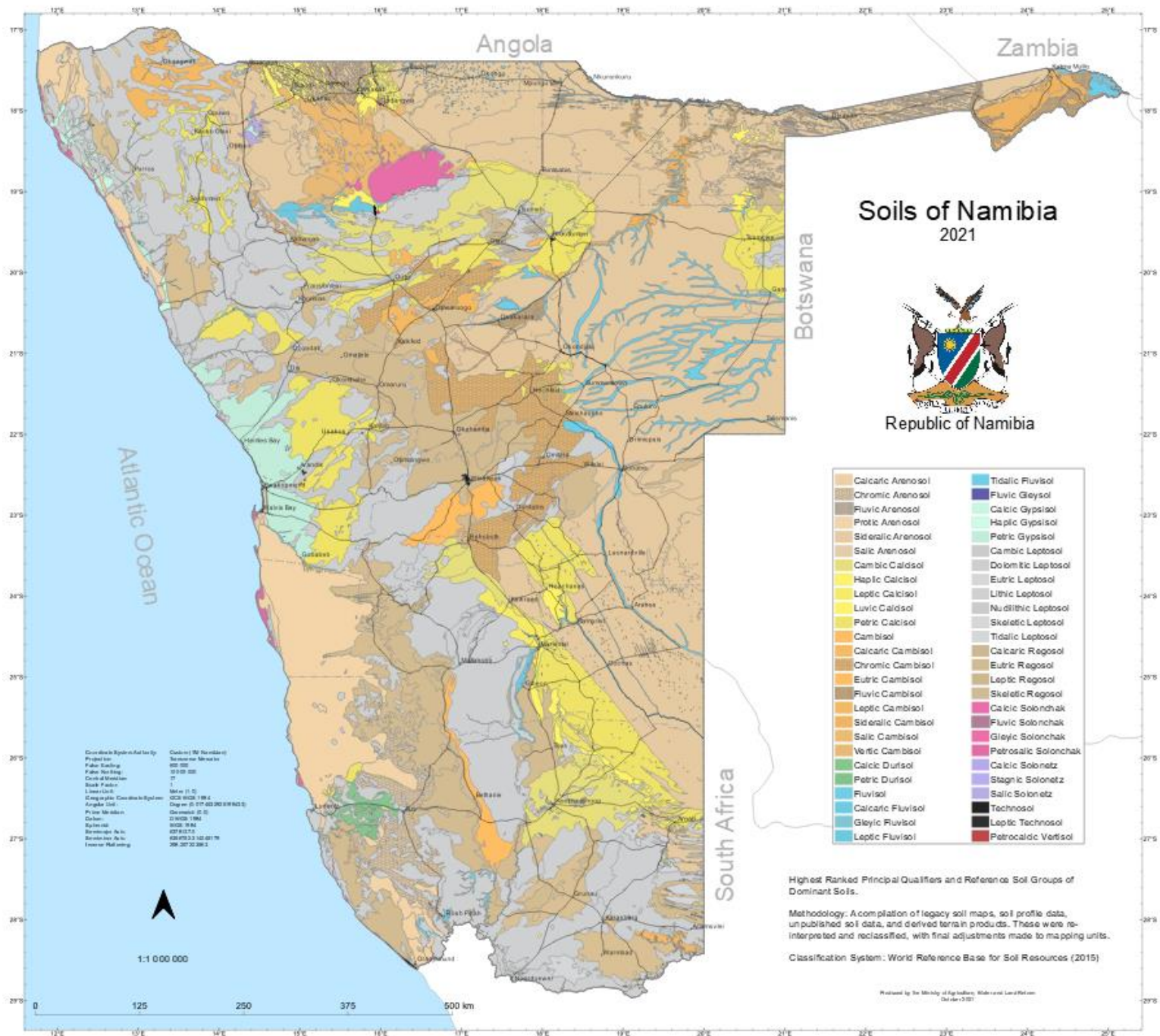


Soil Map of Namibia 2000



4,944 mapping units
456 combinations of
dominant ($\geq 50\%$),
associated (25–50 %)
& included (5–25 %)
soils





caAR ptCL
 cacrseAR haCLso ptCL
 caseAR caseCM haCL
 crAR ptCL
 crARqc ptCL sklerG liLP
 crseAR ptCL caLP haCL
 crseAR ptCL skRG
 crseAR ptCL
 crseAR caCM
 crseAR vrCM haVR ptCL
 crseAR caLP
 crseAR ccSN
 crseAR
 fIAR seAR
 fIAR caFLar liLP ptCL
 fIAR FLar seAR
 fIAR FLar FLgl
 fIAR FLar glFL
 fIAR ptCL
 flseAR
 flseARqc
 flsZnAR prARay
 flsZnAR tdjklP
 flsZnAR tdntLP prARay
 flsZnAR tdntLP tdjklP
 flsZnAR tdntLP
 flsZnAR haGY
 flsZnAR
 prARay ptCL ccDU
 prARay ptCL caFLar haGY
 prARay ptCL
 prARay CMarye liLPye
 prARay ccDU
 prARay ccGYye
 prARay ccptGY
 prARay ccptGYye
 prARay ptGY
 prARay ptGYye haGYye
 prARay liLP
 prARay liLPye haGYye
 prARay liLPye haGY
 prARay liLPye
 prARay euRG ptCL
 prARay ptCL
 prARay haGY
 prARay
 qgseAR seCMar haCL
 seAR fIAR FLar
 seAR seARqc haCL ptCL
 seAR seARqc seCMar ptCL

seAR haCL ptCL
 seAR haCLso
 seAR ptCL cmCL crCM
 seAR ptCL cmCL
 seAR ptCL haCLjc
 seAR ptCL euCM
 seAR ptCL caFL
 seAR ptCL FLar
 seAR ptCL
 seAR seCMar seARqc ptCL
 seAR seCMar
 seAR soCMar ccSN haCLso
 seAR sosZCMar haCL
 seAR FLar haCL ptCL
 seAR liLP
 seAR dyleRGar
 seAR
 seARqc caAR haCLlar ptCL
 seARqc FLar haCL ptCL

COMBINATIONS OF DOMINANT, ASSOCIATED & INCLUDED SOILS

cmlvCLso soCM
 gyptCL liLP
 gyptCL caleRG ccgyDU euLP
 gyptCL
 gyptCLfIye cagpFL euLP
 haCL ptCL crCM
 haCL ptCL caliLP seAR
 haCL soCM haLV
 haCL FLloqc ptCL
 haCL casklerG skLP
 haCL sklerG euLP
 haCLjc ptCL caAR
 haCLjc ptCL
 haCLjc eucaLPpar ptCL
 haCLlo euFLCMlo ptCL ccstSN
 haCLlofl ptCL FLar
 haCLso soCM
 haCLye ptCLye haGY
 leCL ptCL skLP
 leCL ptCL
 lvCL
 ptCL cacrAR
 ptCL crAR euRG

ptCL crseAR cosklerG
 ptCL euAR euRG euFLar
 ptCL euAR skRG haCL
 ptCL prARay
 ptCL seAR haCLjc
 ptCL seAR cosklerG

ptCL FLarqc
 ptCL haCL
 ptCL haCLjc caAR
 ptCL haCLjc seAR
 ptCL haCLjc leRG
 ptCL haCLjc
 ptCL haCLjcszn
 ptCL haCLlo
 ptCL skCLjc seAR
 ptCL cacrCM
 ptCL crCM haCL

ptCL euLP sklerG
 ptCL liLP euskRG crCM
 ptCL liLP leRGar
 ptCL liLP
 ptCL moLP caCM haCLjc
 ptCL moLP caCM
 ptCL moLP crleCM
 ptCL moLP FLar haCL
 ptCL moLP
 ptCL skliLP euskRG crCMar
 ptCL caRG
 ptCL cosklerG haCL liLP
 ptCL coskRG seAR haCL
 ptCL coskRG haCL
 ptCL doRG cmCL
 ptCL euRG euAR euFL
 ptCL leRG lecrCM crseAR
 ptCL sklerG cmCL crCM
 ptCL sklerG
 ptCL skRG euAR haCL
 ptCL skRG skliLP
 ptCL caAR
 ptCL

ptCLfl caFLar
 ptCLfIye haGY
 ptCLye euAR skRG haCLye
 ptCLye haCLjcye haGY
 ptCLye haCLjcye
 ptCLye haCLye euskRGye euLPye

ccrCM ptCL cmCL
 casoszCM caseAR ptCLjcsn
 casoszCM caseAR ptCLso
 casoszCM casosznAR ptCL
 casoszCM casosznAR ptCLjc
 casoszCM flsoSC ccSN
 casoszCM flsoSC
 CMar seCMar seAR FLar
 crCMar haCL
 crCMar ptCL cmCL
 crCMar ptCL liLP coskRG

crleCM haCL ptCL
 crleCM ptCL haCL
 crleCM ptCL
 crleCM liLP ptCL
 crleCM
 doleCM doLP
 euCM cosklerG skliLP
 euCMqcye caskRG skLP ptCL
 eucrCM haPH euRG ptCL
 eucrCM euRG haLV
 eucrCM euRG
 eucrleCM cmCL ptCL
 eucrleCM ptCL
 eucrleCM skliLP caFL ptCL
 eucrleCM euleRG
 euFLCMar ptCL leRG
 euFLCMar ptCL sklerG
 euFLCMar sklerG euskLP
 euFLCMar
 flCM seAR
 flCM eucaFL seARqc ptCL
 flCM glFL flGL flAR
 flCM glFL flGL

fICM glFL flGLce
 fICMar flAR FLar glFL
 fICMar flAR FLar
 fICMar fICMlo flAR FLar
 fICMar seCMar flAR FLar
 fICMar seCMar seAR FLar
 fICMar seCMar seAR
 fICMar seCMar FLar seAR
 fICMlo fICMar FLar glFL
 flseCMar flAR FLar
 seCMar seqgAR ptCL FLar
 seCMar qgseAR
 seCMar seAR flAR
 seCMar seAR
 seCMar fICMar flAR FLar
 seCMar fICMar flAR
 seCMar fICMar flseAR
 soCMlo ccSN haCLso
 sosZCM sosznAR ccSNce ccgysoVR
 vrCMar VRca
 ccDU pcDU liLP
 leccDU leccDU liLP
 leccDU liLP leccptDU
 pcptDU liLP
 pcptDU
 caFL caseAR haCL
 caFLar ptCL seARqc
 caFLar leRG ptCL
 caFLar leRG
 caFLar
 caFLhu ptCLar
 caleFL caRG liLP ptCL
 caleFL caRG liLP ptCLjc
 caleFLar ptCL sklerG
 caleFLar liLP liLP
 caleFLar caRG liLP ptCL
 caleFLar leRG ptCL haGY
 caleFLar leRG ptCL
 caleFLar sklerG ptCL
 FLar flAR haCL
 FLar flAR ptCL
 FLar flAR soCM
 FLar seARqc ptCL haLV
 FLar haCL ptCL
 FLar fICM glFLar glFLlo
 FLar fICMar glFL
 FLar fICMar glFLar glFLlo
 FLar FLlo haCLlo
 FLar FLloqc haCL ptCL
 FLar FLloqc haCL



QGIS *NamibiaSoilMap2021 Classification NamibianCRS — QGIS

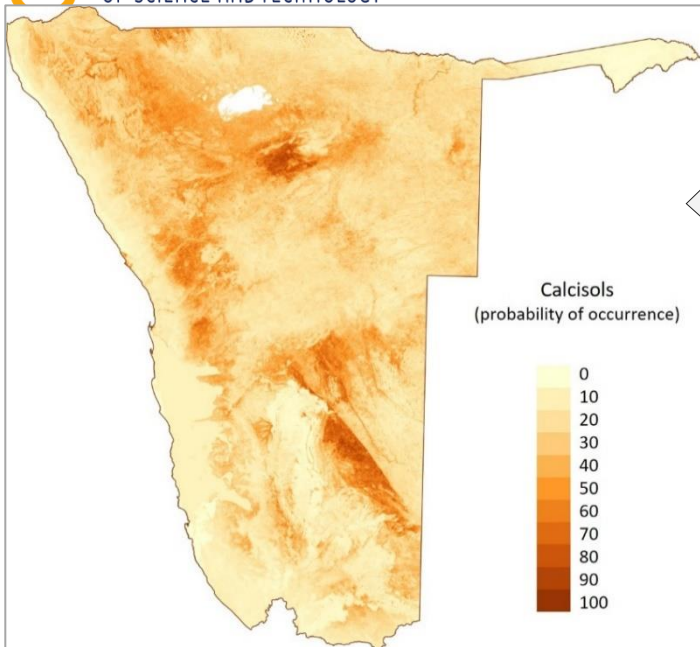
Project Edit View Layer Settings Plugins Vector Raster Database Mesh Processing Help

Layers

- mun town vil set*
- Town*
- Town*
- mun town vil set copy*
- towns_aez*
- Trunk Road*
- Main Road*
- National Boundary*
- Region*
- Other_countries*
 - Angola
 - Atlantic Ocean
 - Botswana
 - Namibia
 - South Africa
 - Zambia
 - Zimbabwe
 -
- District Road*
- degree squares*
- qds*
- DOMINANT SOIL copy**
- NamSoilMap2021 D_pQ hatching*
- DOMINANT SOIL - REFERENCE SOIL GROUP*
- DOMINANT SOIL**
- NamSoilMap2021 21Jul2021 with elev & slope_class*
- NamSoilMap2021 with scaled labels*
- NamSoilMap2021*
- NamSoilMap2021 outlines*
- Bing Aerial*
- OpenStreetMap*
- Google Satellite*
- National Boundary 1 light background*

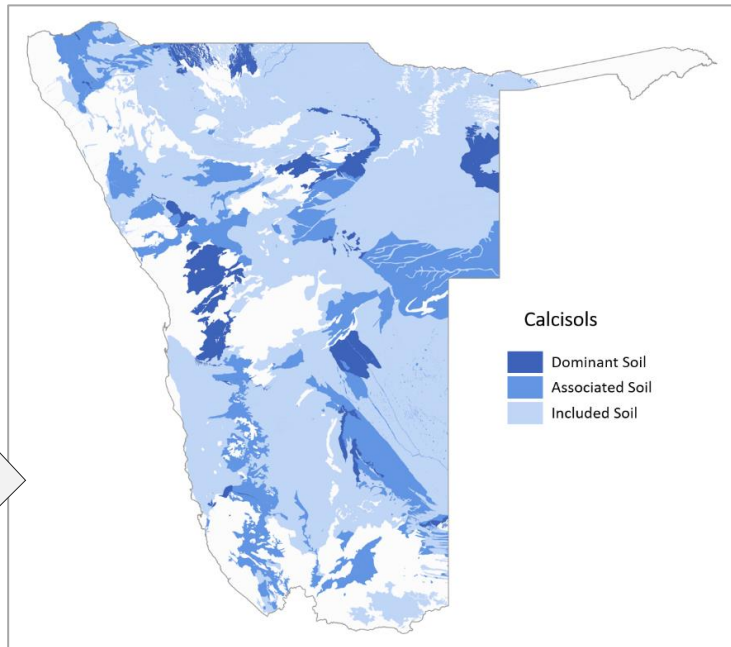


SOIL TYPE MAPS

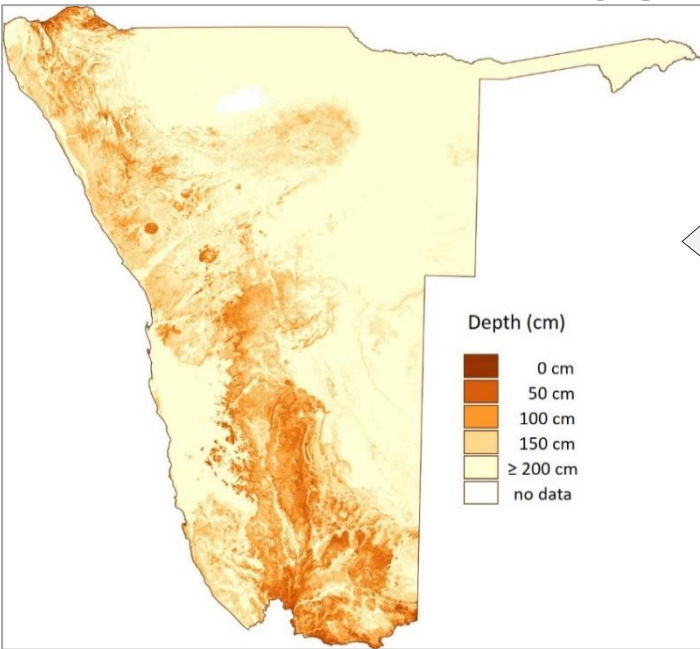


Probability of occurrence of a Reference Soil Group, per 250m grid cell
ISRIC SoilGrids250m

Occurrence of a Reference Soil Group as dominant, associated or included soil, per mapping unit
Coetzee, 2021

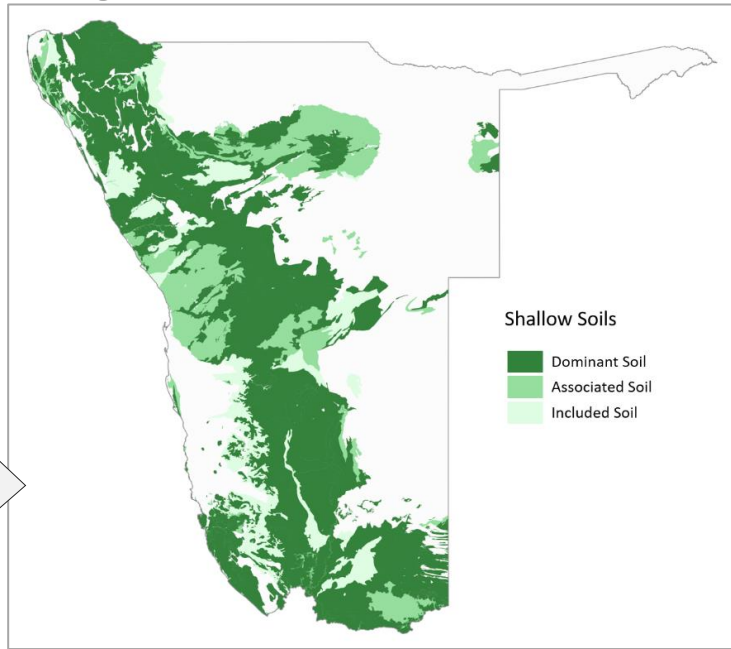


SOIL PROPERTY MAPS



Predicted soil property, per 250m grid cell
ISRIC SoilGrids250m

Soil property of dominant, associated or included soil, per mapping unit
Coetzee, 2021





DOCUMENTATION

Connotation,
climate/environment,
landscape position, parent
materials

CALCISOLS [CL]

(from Latin *calcaris*, lime-rich)

Reference
Soil
Group

Etymology
of RSG
name

Morphology
& genesis

Photos of
typical soil

Calcisols have a significant accumulation of calcium carbonate [lime, CaCO_3] within one metre of the soil surface. They are commonly found in arid and semi-arid environments with distinct dry seasons. They occur in level to gently sloping areas under sparse natural vegetation of shrubs, trees, ephemeral grasses and forbs that are adapted to arid conditions. Calcisols form in alluvial, colluvial and aeolian parent materials that are rich in bases, notably calcium and magnesium.

The accumulation of calcium carbonate [CaCO_3] from surface horizons to an accumulation layer at some depth is one of the widespread soil-forming processes in arid climates. The surface horizon is often completely or partially decalcified, as calcium carbonate is dissolved by rainwater, the calcium [Ca^{2+}] and bicarbonate [HCO_3^-] ions are leached from the upper part of the soil and precipitated as calcite (a form of calcium carbonate) further down where the percolation stops and water evaporates, or where the partial pressure of carbon dioxide in soil air drops.

Calcium carbonate accumulations appear as dispersed, fine calcite particles within pores of the soil, as discontinuous concentrations in the form of veins, pseudomycelia, coatings, soft and hard nodules. Calcification (by rain) and drying (by evaporation) of the soil tend to concentrate the calcium carbonate in a thin surface horizon. In time, calcic horizons can become indurated (cemented, petrified) by calcium carbonate and/or magnesium carbonate into nodular, lamellar or massive, extremely hard petrocalcic horizons (calcrete, *caliche*).

Calcisols typically have a thin, pale brown surface horizon, often with well-developed crumb or granular structure, or vesicular or biological crusts, bleaching and desert pavement. The calcic horizon is usually white, pinkish to reddish or grey and has low porosity, as soil pores are filled with lime. The sparse vegetation and high temperatures result in low organic matter content. Soil faunal activity is high in these soils.



Calcisols (JK/HM, MC)

Calcisols have neutral to high pH (≥ 7) that may reach 8 – 8.5 in the subsoil if free carbonates are present. They usually contain high amounts of bases [Ca, Mg, to a lesser extent K], but these are not necessarily accessible to plants, as excess calcium impedes the uptake of other bases. Uptake of phosphate and many trace elements are suppressed by the high pH and the predominance of calcium and magnesium on the exchange complex. Stone fruits, such as peaches, are very sensitive to iron [Fe] deficiencies on calcic soils. Boron [B] is also sensitive to high pH and may reach plant-toxic levels. Some Calcisols are also saline.

Value for
agriculture

Most Calcisols have fine to medium texture and good water retention. Internal drainage and root growth are impeded if the petrocalcic horizon is strongly and continuously cemented. However, a petrocalcic horizon, or a thick B horizon can be an asset in an arid climate with very sandy soils, as it allows water to be retained in the root zone for longer. Most Calcisols are susceptible to erosion. The surface is prone to slaking and crusting, thus hampering water infiltration.

Calcisols support good grazing with nutritious grasses. They can be used successfully for grapevines (grafted on rootstock tolerant of high soil pH) and fruit trees, if the petrocalcic horizon is broken up by deep ripping. They can be productive under irrigation with good management practices for fertilization and to prevent salinisation and erosion. Calcisols provide good, stable road surfacing material.

Calcisols are widespread throughout Namibia. Some are paleo-features, while others are actively forming in calcareous parent materials.

A soil keys out as a Calcisol in the World Reference Base (IUSS Working Group WRB, 2015) once it meets the following criteria:

Other soils having:

1. a petrocalcic horizon starting ≤ 100 cm from the soil surface; or
2. both of the following:
 - a. a calcic horizon starting ≤ 100 cm from the soil surface; and
 - b. no argic horizon above the calcic horizon unless the argic horizon is permeated throughout with secondary carbonate.

WRB
Key

A calcic horizon (Latin *calx* = lime) is a non-cemented surface or, more commonly, subsurface horizon within the top 100 cm of soil, in which secondary calcium carbonate (CaCO_3), also known as lime, has accumulated either as dispersed, fine calcite particles within the matrix, or as discontinuous concentrations in the form of pseudomycelia, coatings, soft and/or hard nodules. Some primary carbonates may be present. In the field, the presence of calcium carbonate in soil is confirmed by applying a few drops of 10% hydrochloric acid [HCl] solution. The degree of effervescence (audible only, visible as individual bubbles, or foam) is proportional to the amount of lime present. pH_{water} can be used to differentiate between soils dominated by calcium ($\text{pH } 8.0\text{--}8.7$) and sodium and/or magnesium ($\text{pH} > 8.7$). The diagnostic criteria for a calcic horizon, according to the World Reference Base (IUSS Working Group WRB, 2015), are as follows:

Diagnostic
materials or
horizons

A calcic horizon:

1. has a calcium carbonate equivalent in the fine earth fraction of $\geq 15\%$; and
2. has one or both of the following:
 - a. $\geq 5\%$ (by volume) secondary carbonates; or
 - b. a calcium carbonate equivalent in the fine earth fraction of $\geq 5\%$ higher (absolute) than that of an underlying layer and no lithic discontinuity between the two layers; and

WRB definition
of diagnostic
horizon

3. does not form part of a petrocalcic horizon; and
4. has a thickness of ≥ 15 cm.

When a calcic horizon becomes indurated by either calcium carbonate (CaCO_3) or magnesium carbonate (MgCO_3), a petrocalcic horizon (Gr. *petros* = rock; Latin *calx* = lime). The petrocalcic horizon is a lamellar calcic horizon (also known as *caliche*) that is indurated by carbonate cementation. A petrocalcic horizon is a calcic horizon that is indurated by carbonate cementation.

Diagnostic materials or horizons

WRB definition of diagnostic horizon

A petrocalcic horizon consists of mineral material and:

1. has very strong effervescence after adding a 1 M HCl solution; and
2. shows induration or cementation, at least partially by secondary carbonates, so that fragments do not slake in water; and
3. is continuous to the extent that vertical fractures, if present, have an average horizontal spacing of ≥ 10 cm and occupy $< 20\%$ (by volume); and
4. cannot be penetrated by roots except, if present, along the vertical fractures; and
5. has an extremely hard consistence when dry, so that it cannot be penetrated by spade or auger; and
6. has a thickness of ≥ 10 cm or ≥ 1 cm if it is laminar and rests directly on continuous rock.



Petrocalcic horizon at the surface (JK/HM) (MC)

In other classification systems, Calcisols are known as *Calcarosols* (Australia), *calcids* (US Soil Taxonomy) or fall under *Xerosols* or, to a lesser extent, *Yermosols* (FAO Soil Map of the World).

Names in other classification systems

The following Calcisols appear in the Soil Map of Namibia, either as dominant, associated or included soils:

Cambic Calcisols	Cambic Calcisols (Arenic, Endosalic, Sodlic)	cmCLarsznso
	Skeletal Cambic Calcisols	skcmCL
	Cambic Calcisols	cmCL
Haplic Calcisols	Haplic Calcisols (Arenic)	haCLar
	Haplic Calcisols (Hypercalcic)	haCLjc
	Haplic Calcisols (Hypercalcic, Endosalic)	haCLjcszn
	Haplic Calcisols (Hypercalcic, Yermic)	haCLjcye
	Haplic Calcisols (Loamic)	
	Haplic Calcisols (Loamic, Fluvic)	
	Haplic Calcisols (Sodic)	
Leptic Calcisols	Skeletal Leptic Calcisols	skieCL
	Skeletal Cambic Leptic Calcisols	skcmleCL
	Leptic Calcisols	leCL
Luvic Calcisols	Cambic Luvic Calcisols (Sodic)	cmLvCLso
	Luvic Calcisols	lvCL
Petric Calcisols	Petric Calcisols (Arenic)	ptCLar
	Petric Calcisols (Fluvic)	ptCLfi
	Petric Calcisols (Fluvic, Yermic)	ptCLfiye
	Gypsic Petric Calcisols	gyptCL
	Gypsic Petric Calcisols (Fluvic, Yermic)	gyptCLfiye
	Gypsic Petric Calcisols (Yermic)	gyptCLye
	Petric Calcisols (Sodic)	ptCLso
	Petric Calcisols (Yermic)	ptCLye
	Petric Calcisols	ptCL
	Skeletal Calcisols	Skeletal Calcisols (hypercalcic)

All types of specific RSG that appear on the 2021 Soil Map of Namibia

First principal qualifier and RSG

Full classification

Classification code

DESCRIPTION OF SOIL QUALIFIERS

Aeolic (ay)

Qualifier

(from Greek *aiolos*, wind)

Soils with a wind-deposited surface layer of at least 10 cm thickness and low organic carbon content (less than 0.6%). The dunes of the Namib are examples of Aeolic Arenosols.



Wind-deposited and -sculpted sand in the Namib (MC)

Albic (ab)

(from Latin *albus*, white)

Soils with a layer of *albic* material, at least 1 cm thick and starting within 100 cm from the surface. Albic material is light-coloured (low chroma), with most organic material and/or free iron oxides removed so that the actual sand and silt grain colour is visible without any coatings on these particles. They are usually associated with strongly expressed relocation of clay materials and usually overlie horizons with accumulations of clay. They are also frequently associated with *stagnic* properties.

The fine, white, powdery layer on top of rounded columns in Solonetz, is albic material.



Albic material in Solonetz (EM; ISRIC)

Etymology of
qualifier

Anthric (ak)

(from Greek *anthropos*, man)

Cultivated soils with *mollic* or *umbric* horizons, signs of human disturbance (plough layer, lumps of applied lime, high phosphorus content, etc.) and very few signs of biological activity (animal pores, coprolites, other traces of soil faunal activity).

Some intensely cultivated Namibian crop fields show *anthric* properties, but Namibia does not have true Anthrosols. Anthrosols are 'man-made' agricultural soils that have been modified profoundly by *centuries-long* agricultural use and recurrent, mono-management measures to improve soil fertility and productivity, such as long-continued addition of organic or mineral materials, irrigation with sediment-rich water, or wet cultivation. The diagnostic surface horizons must be at least 50 cm thick.

Arenic (ar)

(from Latin *arena*, sand)

Soils with a sandy or loamy sand texture and thickness of at least 30 cm, within 100 cm from the soil surface.

Aridic (ad)

(from Latin *aridus*, dry)

Soils with surface layers typical of arid conditions. Aridic properties refer to a number of characteristics of surface horizons of arid zone soils, such as low soil organic carbon, evidence of aeolian activity, high base saturation ($\geq 75\%$) and relatively dark and strong colour, especially when moist. Aeolian activity is demonstrated by rounded to subangular sand particles with a matt surface, ventifacts (wind-shaped rocks), aeroturbation (e.g. cross-bedding) or other signs of wind erosion or deposition.



Ventifacts, wind-sculpted rocks and stones – signs of wind erosion (MC)

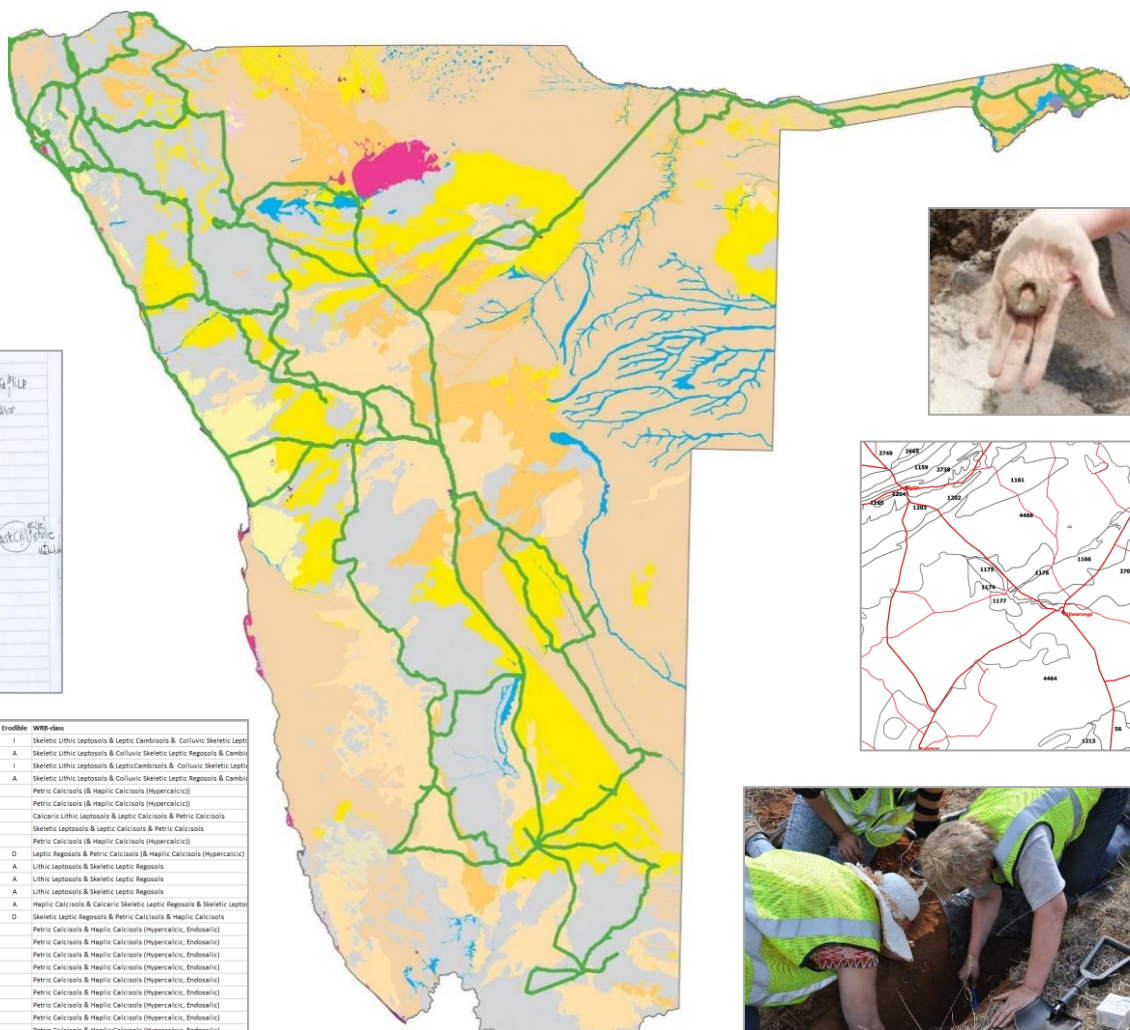
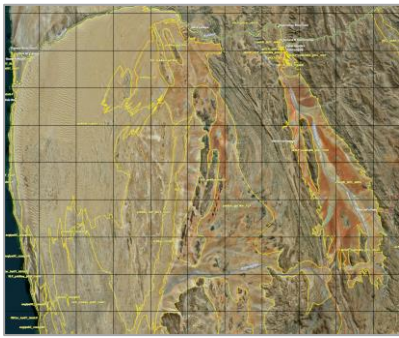
Description
of the
qualifier

Photos illustrating
or clarifying the
qualifier

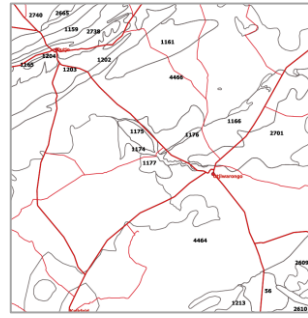
Brunic (br)

(from Low German *brun*, brown)

Soils with a layer of at least 15 cm thick and starting within 50 cm from the soil surface, that does not consist of albic material and meets the criteria for a cambic horizon, except criterion 1 (having a texture class of sandy loam or finer, or very fine sand or loamy very fine sand).



MapUnit	FullCode	Shallow	V_shallow	Bare_rock	Calcareous	Calcrete	Sandy	Surf_stony	Stony	Wet_log	Erodible
✓	103		D						D		I
✓	104		D						D		A
✓	106		D						D		A
✓	108		D						D		A
✓	113		D						D		D
✓	114		D						D		D
✓	115		D						D		D
✓	116		D						D		D
✓	117		D						D		D
✓	111		A		A	A					D
✓	112		D								A
✓	113		D								A
✓	114		D								A
✓	115		D								D
✓	116		D								D
✓	117		D								D
✓	118		A		A	A					D
✓	119		D								D
✓	120		D								D
✓	121		D								D
✓	122		D								D
✓	123		D								D
✓	124		D								D
✓	125		D								D
✓	126		D								D
✓	127		D								D
✓	128		D								D
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✓	130		D								D
✓	131		D								D
✓	132		D								D
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✓	135		D								D
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✓	173		D								D
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✓	177		D								D
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✓	180		D								D
✓	181		D								D
✓	182		D								D
✓	183		D								D
✓	184		D								D
✓	185		D								D
✓	186		D								D
✓	187		D								D
✓	188		D								D
✓	189		D								D
✓	190		D								D
✓	191		D								D
✓	192		D								D
✓	193		D								D
✓	194		D								D
✓	195		D								D
✓	196		D								D
✓	197		D								D
✓	198		D								D
✓	199		D								D
✓	200		D								D
✓	201		D								D



MapUnit	FullCode	Shallow	V_shallow	Bare_rock	Calcareous	Calcrete	Sandy	Surf_stony	Stony	Wet_log	Erodible	WRB-class
103	skilp_hcm_cookshg		D						D		I	Skeletal Lithic Lepsoils & Leptic Cambisols & Colluvic Skeletic Lepts
104	skilp_hcm_cookshg		D						D		A	Skeletal Lithic Lepsoils & Colluvic Skeletic Leptic Regosols & Cambisols
106	skilp_hcm_cookshg		D						D		I	Skeletal Lithic Lepsoils & Leptic Cambisols & Colluvic Skeletic Lepts
109	skilp_cookshg_cmlc_gstc		D		I	I			D		A	Skeletal Lithic Lepsoils & Colluvic Skeletic Leptic Regosols & Cambisols
113	hcl_hclic		D									Petric Calcisols (Haplic Calcisols (Hypercalcic))
114	hcl_hclic		D									Petric Calcisols (Haplic Calcisols (Hypercalcic))
115	hcl_hclic		D									Calcic Lithic Lepsoils & Leptic Calcisols & Petric Calcisols
116	hcl_hclic		D									Skeletal Lepsoils & Leptic Calcisols & Petric Calcisols
117	hcl_hclic		D									Petric Calcisols (Haplic Calcisols (Hypercalcic))
121	hclp_gstc_hclic		A		A	A					D	Leptic Regosols & Petric Calcisols (Haplic Calcisols (Hypercalcic))
122	hclp_shng		D								A	Lithic Lepsoils & Skeletic Leptic Regosols
123	hclp_shng		D								A	Lithic Lepsoils & Skeletic Leptic Regosols
124	hclp_shng		D								A	Lithic Lepsoils & Skeletic Leptic Regosols
125	hcl_cookshg_hclp		I		D						A	Haplic Calcisols & Calcic Skeletic Leptic Regosols & Skeletic Lepsoils
150	skilp_gstc_hcl		A		A	A					D	Skeletal Leptic Regosols & Petric Calcisols & Haplic Calcisols
184	hcl_hclic		D								D	Petric Calcisols & Haplic Calcisols (Hypercalcic, Endosalic)
190	hcl_hclic		D								D	Petric Calcisols & Haplic Calcisols (Hypercalcic, Endosalic)
195	hcl_hclic		D								D	Petric Calcisols & Haplic Calcisols (Hypercalcic, Endosalic)
196	hcl_hclic		D								D	Petric Calcisols & Haplic Calcisols (Hypercalcic, Endosalic)
204	hcl_hclic		D								D	Petric Calcisols & Haplic Calcisols (Hypercalcic, Endosalic)
374	hcl_hclic		D								D	Petric Calcisols & Haplic Calcisols (Hypercalcic, Endosalic)
375	hcl_hclic		D								D	Petric Calcisols & Haplic Calcisols (Hypercalcic, Endosalic)
376	hcl_hclic		D								D	Petric Calcisols & Haplic Calcisols (Hypercalcic, Endosalic)
377	hcl_hclic		D								D	Petric Calcisols & Haplic Calcisols (Hypercalcic, Endosalic)
773	hclp_cookshg		D								A	Lithic Lepsoils & Colluvic Skeletic Leptic Regosols
788	cookshg_hclp_cmlc		A								D	Colluvic Skeletic Regosols & Lithic Lepsoils & Chromic Leptic Cambisols
900	skilp_hcl_cookshg		D								I	Skeletal Lithic Lepsoils & Nudolithic Lepsoils & Colluvic Skeletic Lepts
901	skilp_hcl_cookshg		D								I	Skeletal Lithic Lepsoils & Nudolithic Lepsoils & Colluvic Skeletic Lepts

VALIDATION





- Bibliography of literature sources on Namibian soils
- Most articles in digital format (pdf)
- Uploaded to two online repositories (NUST Library Special Collections; EIS)

Appendix A: Sources of Namibian Legacy Soil Data

Source	P	D
Anonymous. (1965). South West Africa. A five year plan for the development of the native areas. 196 p. Department of Bantu Administration and Development, Pretoria, South Africa.	Y	
Anonymous. (1999). Coastal profile of the Erongo Region. Unpublished document prepared for the Ministry of Environment and Tourism and Erongo Regional Council, Walvis Bay.	Y	Y
AOAD/BADEA. (1999). Technical and economic feasibility study of the Tandjeskoppe irrigation project. Preliminary report. AOAD (Arab Organization for Agricultural Development – consultant), BADEA (Arab Bank for Economic Development in Africa – donor), for the Ministry of Agriculture, Water and Rural Development, Windhoek, Namibia.	Y	
Agabawi, K.A., El Tom, O.A., Gamei, M.N., El Shafei, Y.Z., Dingle, M.A. Main Report. El Tom, O.A. Annex 1 – Reconnaissance soil survey. Vol. 1. Survey report. El Tom, O.A. Annex 1 – Reconnaissance soil survey. Vol. 2. Profile description, laboratory analyses and maps.		
AOC Technical Services (Pty) Ltd. (1966). Report on the preliminary reconnaissance soil survey of the Kunene River Irrigation Project. Report for the South West Africa Administration, Water Affairs Branch.	Y	
AOC Technical Services (Pty) Ltd. (1967a). A preliminary survey of the natural environment and the agricultural resources of Okavangoland. Report for the Department of Bantu Administration and Development. Pretoria, South Africa.	X	
AOC Technical Services (Pty) Ltd. (1967b). A proposal for an irrigation research scheme in the vicinity of the canal route in the region east of the oshana Olusandja – Owamboland. Report for the South West Africa Administration, Water Affairs Branch.	X	
AOC Technical Services (Pty) Ltd. (1967c). Report on a reconnaissance soil survey of Okavangoland with particular reference to the riparian land. Report for the South West Africa Administration, Water Affairs Branch.	X	Y
Bertram, S. (2003). Late Quaternary sand ramps in south-western Namibia. Nature, origin and palaeoclimatological significance. PhD dissertation. Bayerischen Julius-Maximilians-Universität, Würzburg, Germany.	Y	Y
Bertram, S., Broman, C.M. (1999). Assessment of soils and geomorphology in central Namibia. Minor Field Studies 71. Swedish University of Agricultural Sciences, Uppsala, Sweden.	Y	Y
Bertram, S. & J. Kempf. (2003). Soils of the Neudamm Highlands, Namibia – New approaches to soil classification in semi-arid regions. <i>Würzburger Geographische Arbeiten</i> 97: 33-58.	Y	
Beugler-Bell, H. (1991). Untersuchungen zur Bodenerosion im Etosha Nationalpark, Namibia – unter besonderer Berücksichtigung der Erodierbarkeit der Böden. Diplomarbeit. Universität Regensburg.	Y	
Beugler-Bell, H., Buch, M.W. (1997). Soils and soil erosion in the Etosha National Park, northern Namibia. <i>Madoqua</i> 20(1): 91-104.	Y	Y
Beugler-Bell, H., Buch, M.W. & Trippner, C. (1993a). An extended soil classification system for the Etosha National Park and adjacent areas in central northern Namibia. Based on the Revised FAO Legend of the Soil Map of the World. Field Paper No. 1 Unpublished project report: Deutsche	Y	

Forschungsgemeinschaft (DFG)/Gesellschaft für Technische Zusammenarbeit (GTZ) Research Cooperation Project 'Environmental Change in the Etosha National Park/Northern Namibia' (Az. Bu 659/4-1)		
Beugler-Bell, H., Buch, M.W. & Trippner, C. (1993b). A guide for soil classification in the Etosha National Park and adjacent areas in central northern Namibia. Based on the FAO/UNESCO Legend of the Soil Map of the World and including a methodology for a basic eco-pedological hazard assessment. Field Document No. 1.2 Project report: DFG/GTZ Research Cooperation Project 'Environmental Change in the Etosha National Park/Northern Namibia' (Az. Bu 659/4-1). Part III. Regensburg, Germany and Okaukuejo, Namibia.	Y	
Blümel, W.D. (1982). Calcretes in Namibia and SE-Spain – Relations to substratum, soil formation and geomorphic factors. <i>Catena Suppl.</i> 1:67-82. Braunschweig.	Y	
Buch, M.W. (1990). Soils, soil erosion and vegetation in the Etosha National Park/northern Namibia. Field and laboratory results of the year 1989; part I (field results). 36 pp & appendix; part II (laboratory results). University of Regensburg (unpublished).	Y	Y
Buch, M.W. (1993). Känozoischer Klima- und Umweltwandel in Etoscha/Nord-Namibia – Untersuchungen zur Klimasensibilität und Geomorphodynamik eines semi-ariden Landschaftsraumes im Südlichen Afrika. Habilitationsschrift. Universität Regensburg. Regensburg, Germany.	Y	Y
Buch, M.W. (1997). Etosha Pan – the third largest lake in the world? <i>Madoqua</i> , 20(1):49-64.	Y	Y
Buch, M.W., Beugler-Bell H. & Trippner, C. (1997). Atlas of the project areas – northern Grootberg farms (Kunene Region) and Uuvudhiya Constituency (Oshana Region). A project funded by the German for Technical Cooperation (GTZ).	X	
Buch, M.W., Lindeque, M., Beugler-Bell, H., Du Plessis, W. & Trippner, C. (Eds.) (1993/94). Environmental change in the Etosha National Park/Northern Namibia. Aims, activities and first results. Unpublished report submitted to the 'Deutsche Forschungsgemeinschaft' (DFG) and the 'Gesellschaft Für Technische Zusammenarbeit' (GTZ). Part I. Regensburg and Okaukuejo.	X	
Buch, M.W., & Trippner, C. (1997). Overview of the geological and geomorphological evolution of the Etosha region, northern Namibia. <i>Madoqua</i> 20(1):65-74.	Y	Y
Burke, A. (2002a). Properties of soil pockets on arid Nama Karoo Inselbergs – the effect of geology and derived landforms. <i>Journal of Arid Environments</i> 50:219-234.	Y	Y
Burke, A. (2002b). Present vegetation in the Kavango Region. <i>Journal of the Namibia Scientific Society.</i> 50:133-145.	Y	Y
Coetzee, M.E. (2001). NAMSOTER – A SOTER database for Namibia. Report. Agro-Ecological Zoning (AEZ) Programme, Ministry of Agriculture, Water and Rural Development, Windhoek, Namibia.	Y	Y
Coetzee, M.E. (2009). Chemical characterisation of the soils of east-central Namibia. M.Sc. thesis. Stellenbosch University. Available from http://scholar.sun.ac.za/handle/10019.1/4068 .	Y	Y
Coetzee, M.E., Beernaert, F. and Calitz, A.J. (1999). Soil survey of Uitkomst Research Station. <i>Agricola</i> 10:17-25.	Y	Y
Correia, R.I.De S. (1977). A brief survey on Caprivi soil / vegetation correlation for agricultural purposes.	Y	
Correia, R.I.De S., Bredenkamp, G.J. (1987?). A reconnaissance survey of the vegetation of the Kavango, South West Africa. <i>SWA Scientific Society Journal XL/XLU</i> 1985/86,1986/87.	Y	



Thank You.

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