



# Soils of Palau

## Diversity and Fertility

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Palau Livestock  
Management Workshop  
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# Outline

- Plant nutrition
- Soil fertility
  - Soil composition
  - Texture and clay minerals
  - Soil organic matter
- Soil diversity and formation
- Soil distribution on Babeldoab



# Plant Nutrition

Soil is the source of essential plant elements:

## Macronutrients

Nitrogen (N) – proteins, enzymes, photosynthesis

Phosphorus (P) – energy compounds, fruiting  
flowering

Potassium (K) – fruit quality and water balance

Calcium (Ca) – cell walls, root and leaf development

Magnesium (Mg) – chlorophyll

Sulfur (S) – proteins, chlorophyll, seed production

## Micronutrients

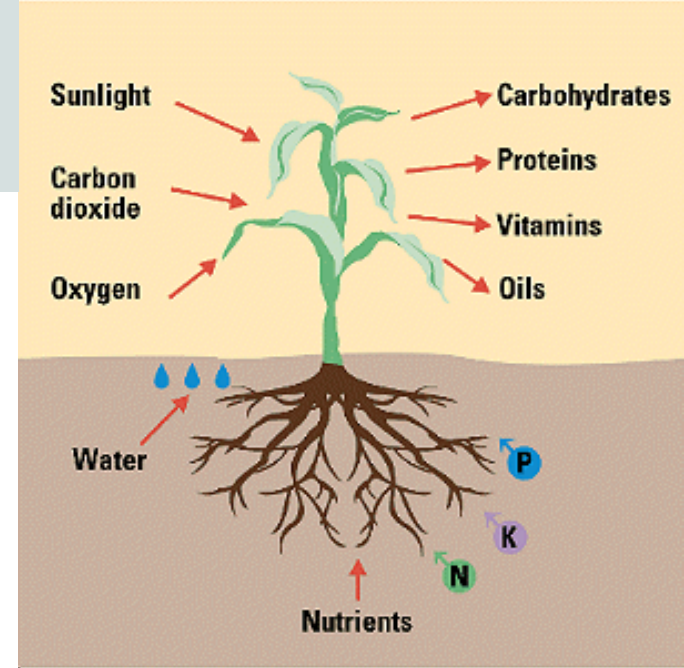
Boron (B)

Copper (Cu)

Iron (Fe)

Manganese (Mn)

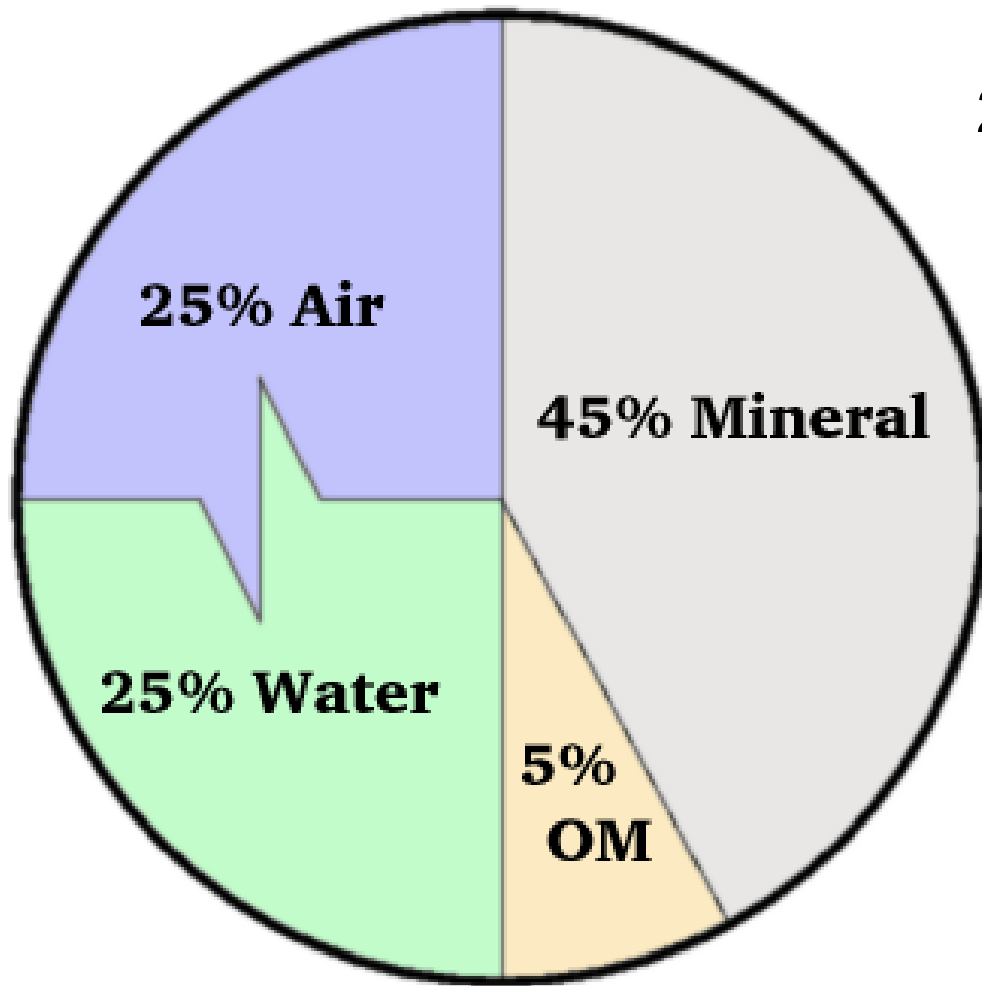
Zinc (Zn)



N deficiency in corn



# Soil Composition

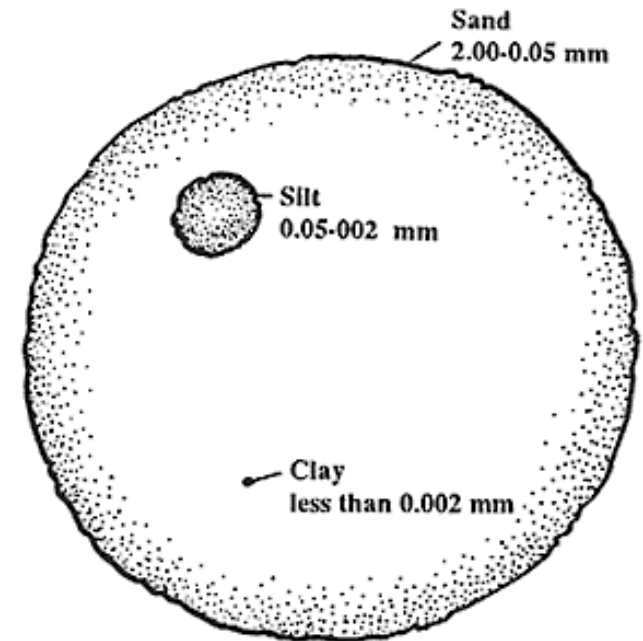


1. Mineral: sand, silt and clay
2. OM: organic matter



# Clay Properties

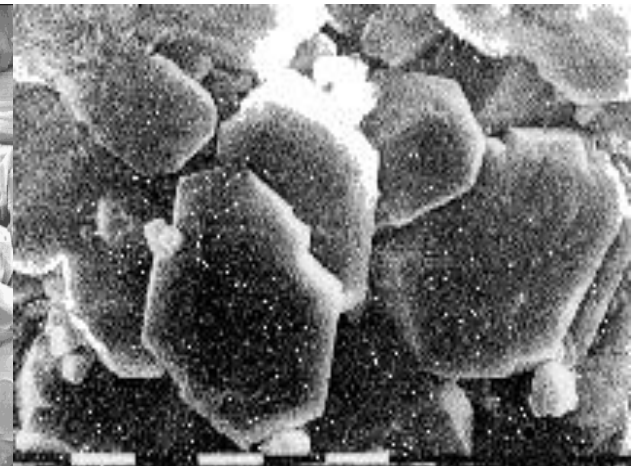
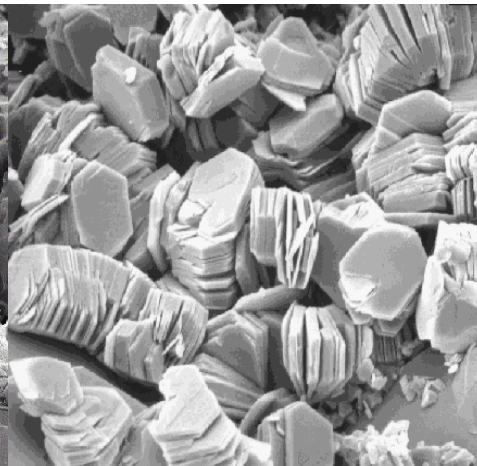
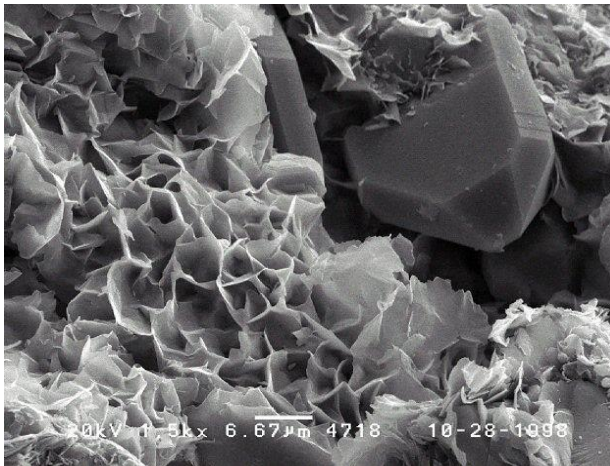
- Extremely high surface area
  - water retention
  - chemical reactions
  - biological activity
- Clay surfaces carry charge (-/+)
- Negative surface charge holds essential plant nutrients



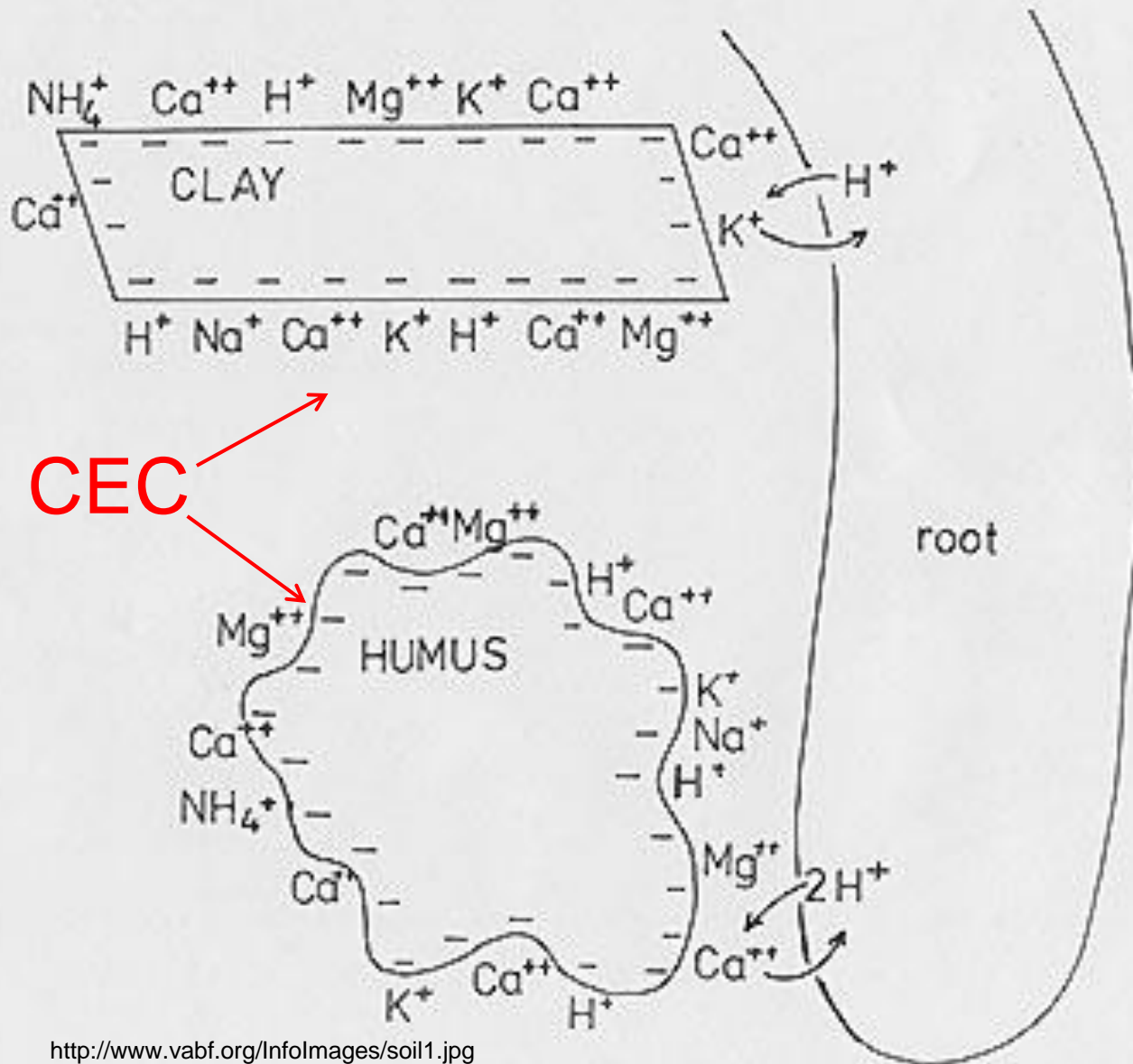
*montmorillonite*

*kaolinite*

*Gibbsite and hematite*



# Clay has Cation Exchange Capacity (CEC)



- Negative surface charge attracts and holds nutrients ( $Ca^{2+}$ ,  $Mg^{2+}$ ,  $K^+$ )
- However, clays in acid soils have low CEC
- Organic matter has a very high CEC



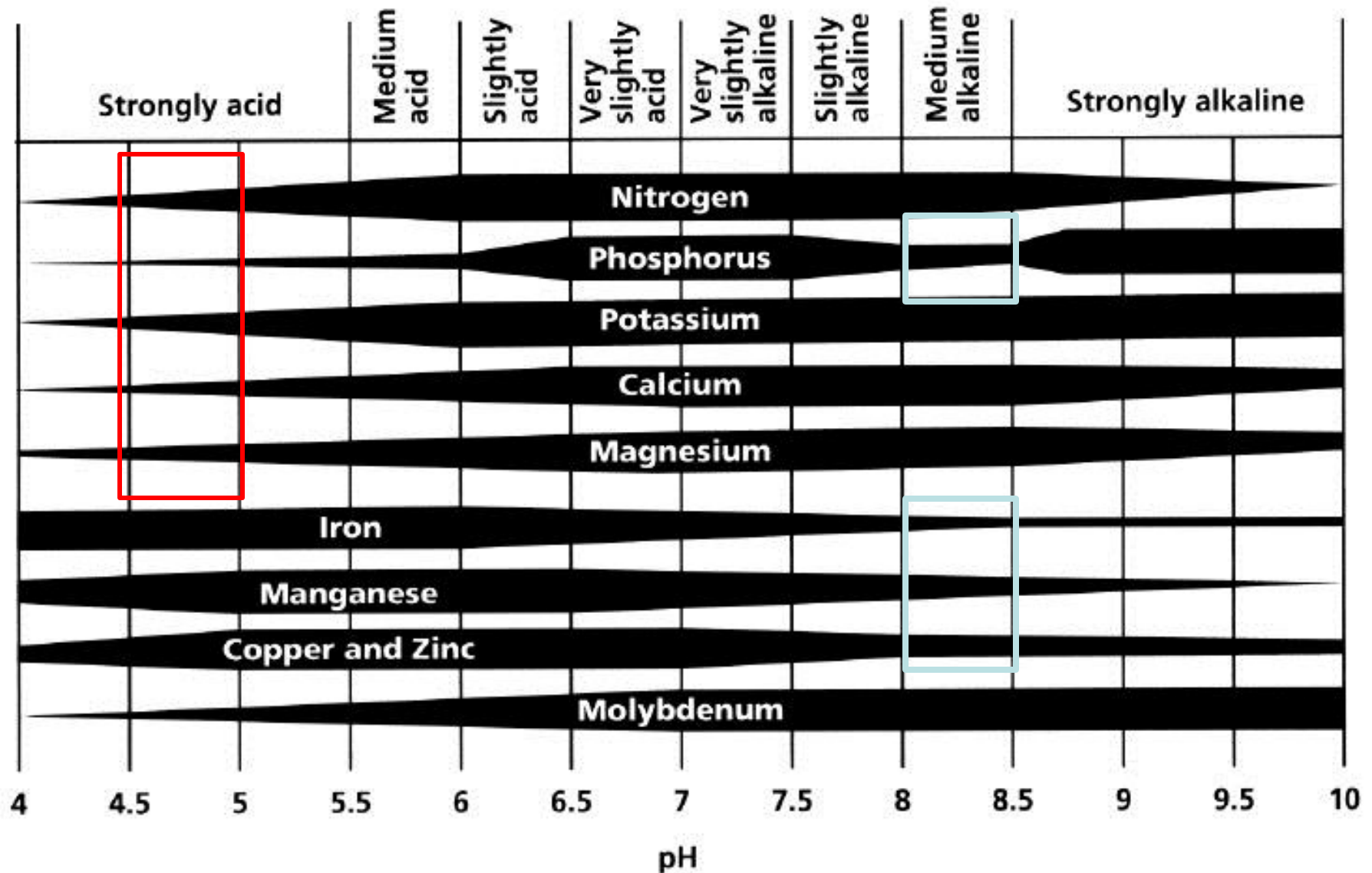
# Soil pH is an Expression of Acidity/Alkalinity



False staghorn fern (*Dicranopteris linearis*)  
an indicator of very acidic soils



# Soil pH Affects Nutrient Availability

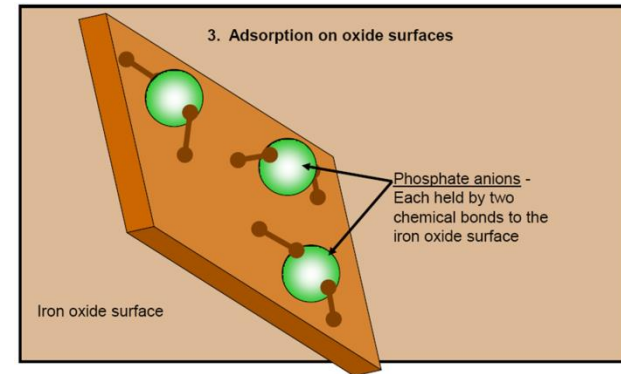




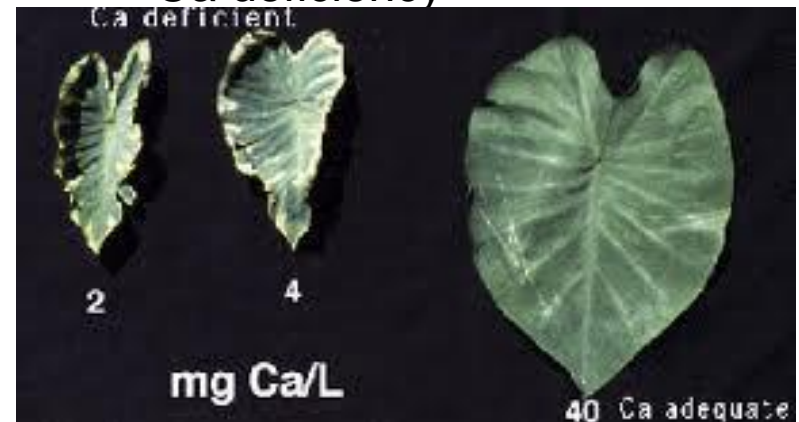
# Negative Effects of Soil Acidity



- Low nutrient retention (CEC)
- Nutrient deficiencies
  - P deficiency

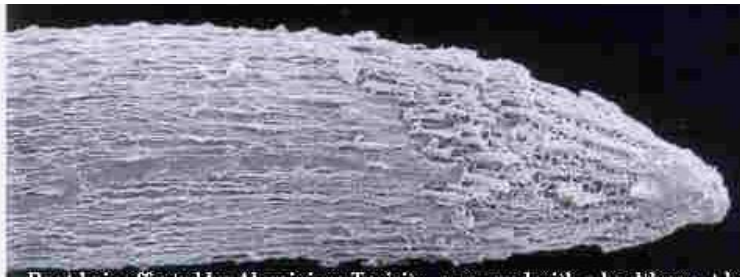
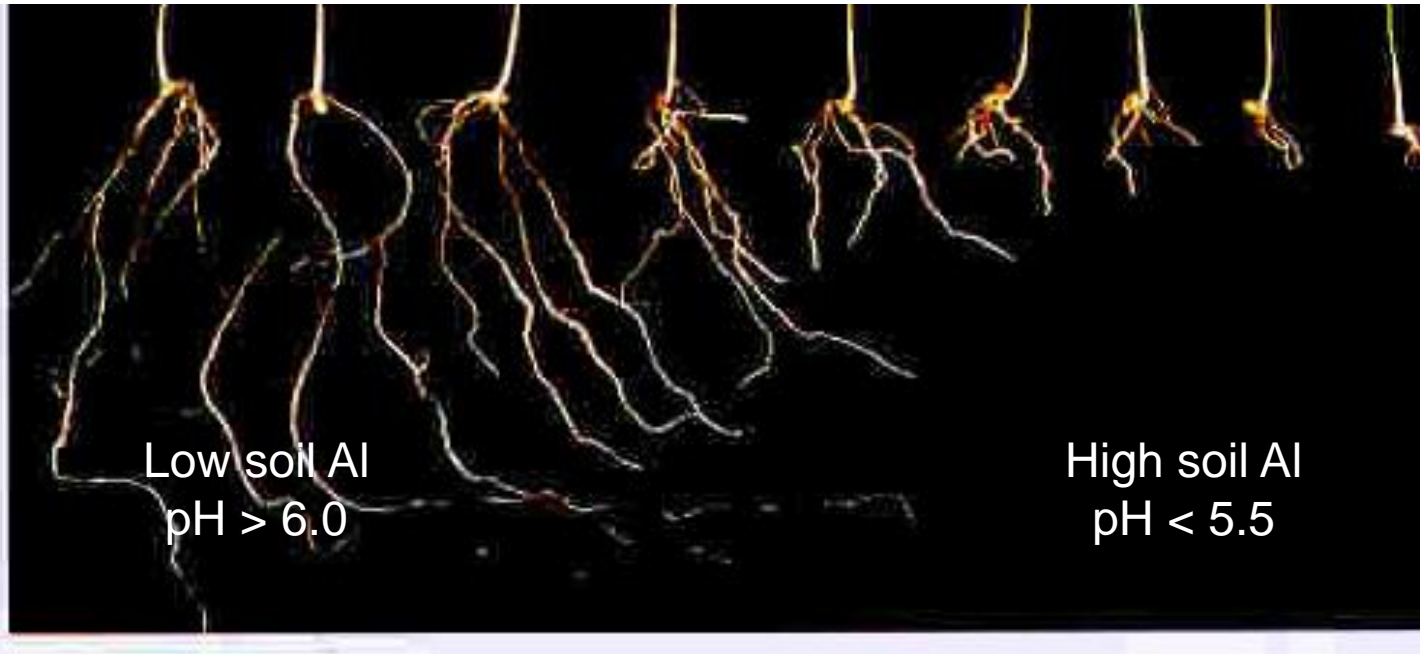


– Ca deficiency





# High Soil Aluminum Causes Root Damage



Healthy root hair in soil with low Al

Deformed root hair in soil with high Al





# Soil Organic Matter is Responsible for Crop Productivity in Tropical Island Soils





# Organic Matter Improves Soil Physical Properties

- OM decreases soil bulk density
- OM increases soil porosity
- OM promotes H<sub>2</sub>O infiltration and aeration
- OM increases water retention



# Organic Matter Improves Soil Chemical Properties

- OM increases nutrient availability (N cycling, P and micronutrient solubility)
- OM increases nutrient retention (CEC)
- OM detoxifies Al





# Organic Matter Improves Soil Biology

- OM is the food for soil organisms
- OM increases microbial diversity
- Microbial diversity ensures nutrient cycling
- Microbial diversity promotes pathogen suppression through competition

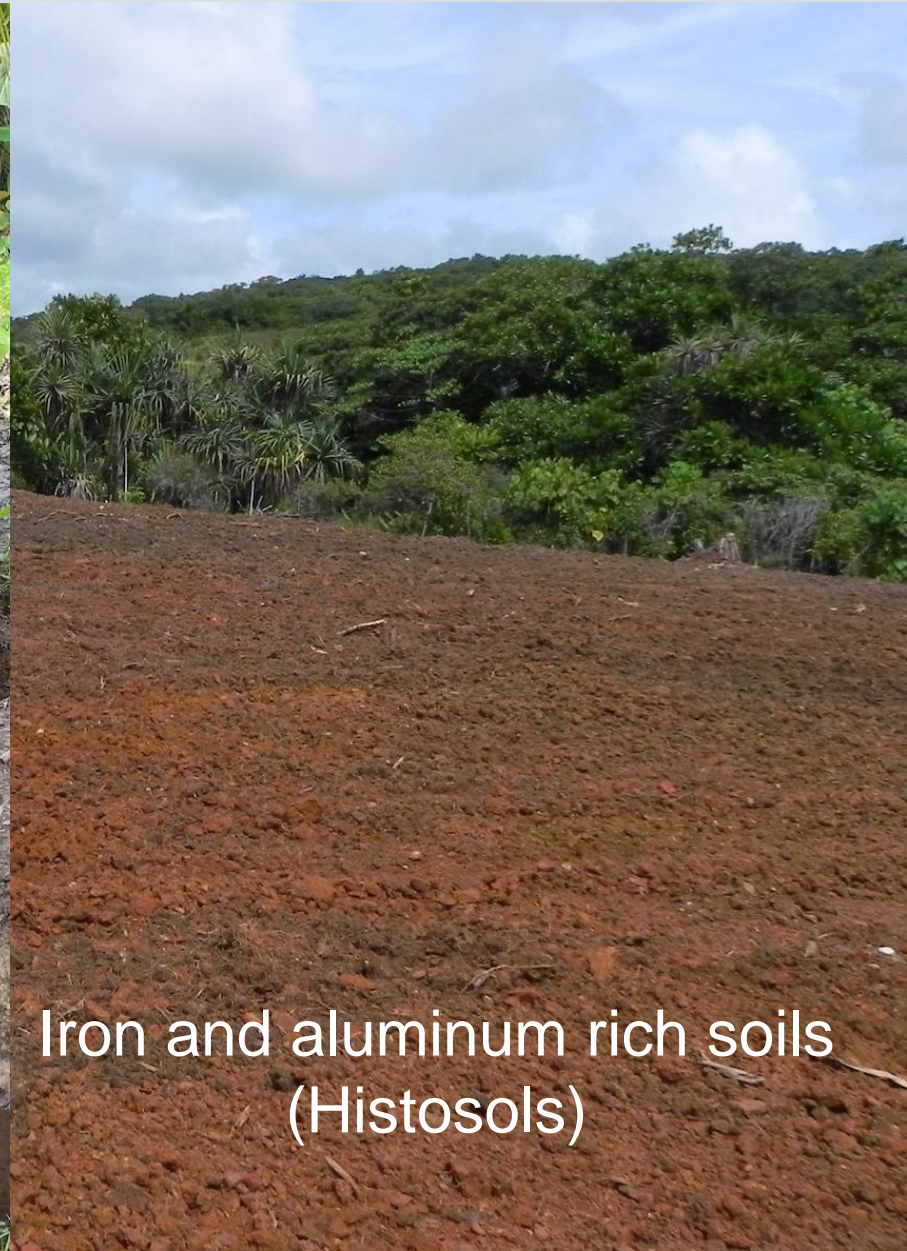




# Soil Diversity



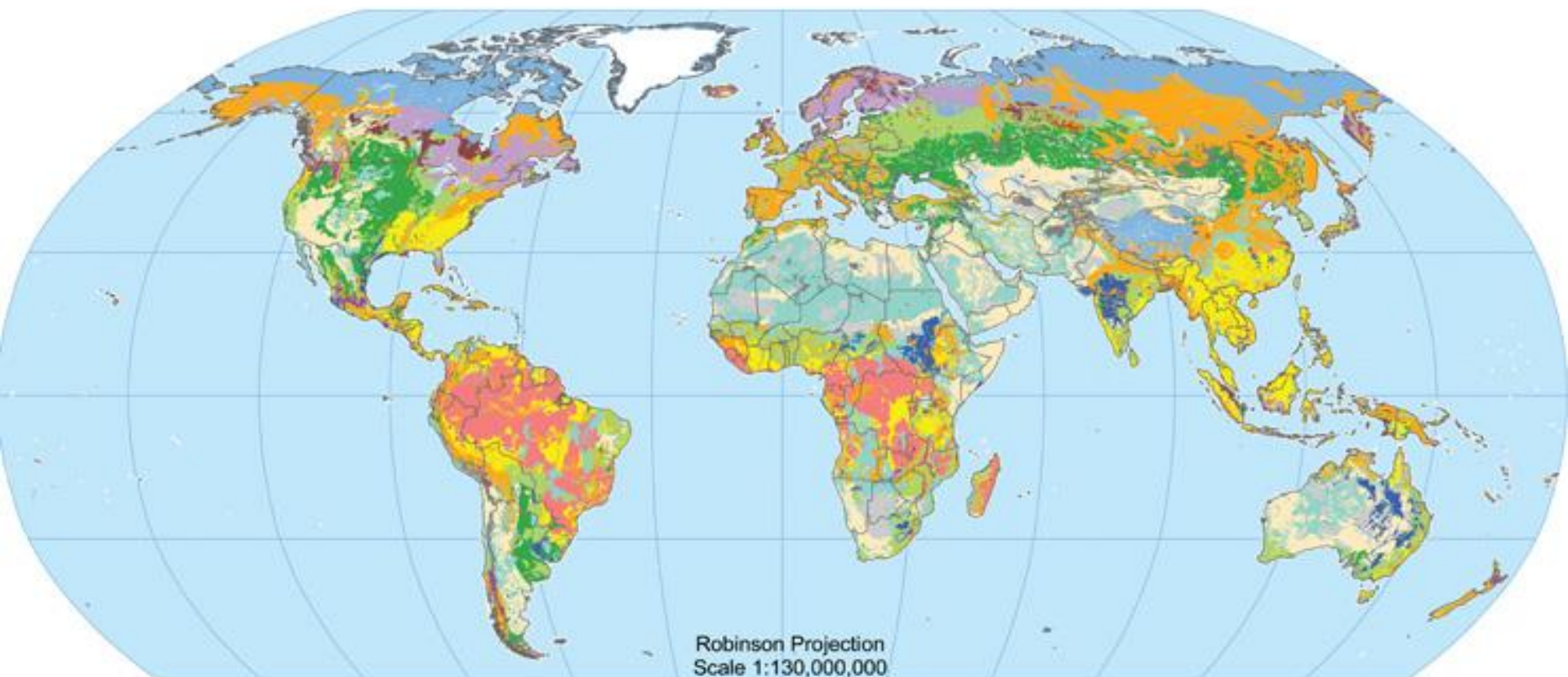
Organic matter rich soils  
(Histosols)



Iron and aluminum rich soils  
(Histosols)



# Global Soil Regions



## Soil Orders

Alfisols	Entisols	Inceptisols	Spodosols	Rocky Land
Andisols	Gelisols	Mollisols	Ultisols	Shifting Sand
Aridisols	Histosols	Oxisols	Vertisols	Ice/Glacier

# Soil Formation

$$\text{Soil} = f(\text{PM}, \text{CI}, \text{O}, \text{R}, \text{T})$$

## Factors:

PM = parent material (rocks)

CI = climate (precipitation and temperature)

O = organisms (plants and animals)

R = relief (topography, drainage)

T = time

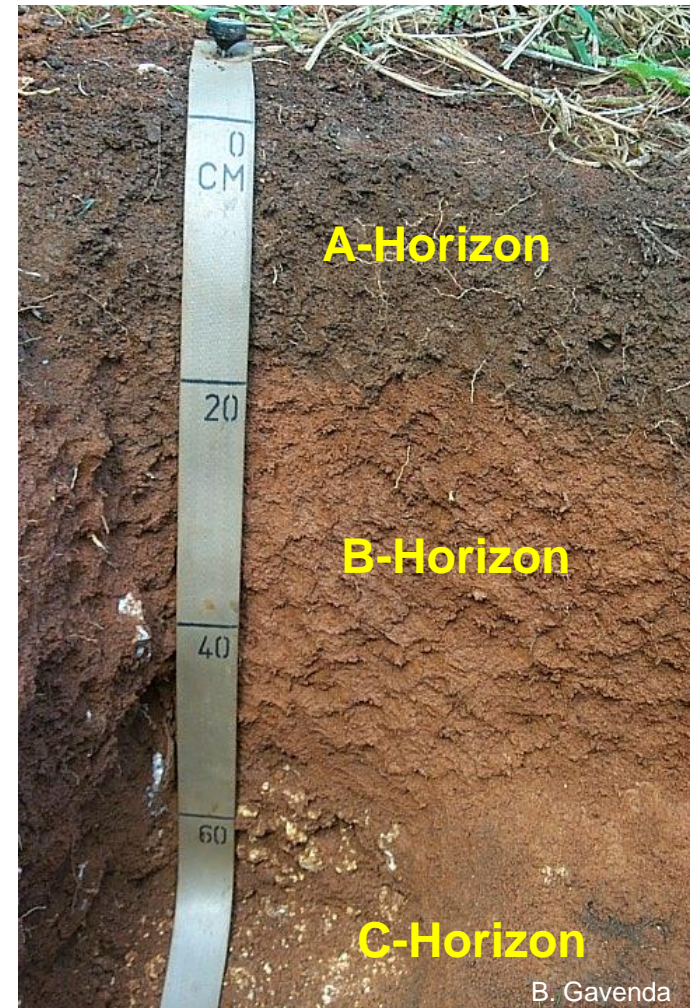




# Soil Formation

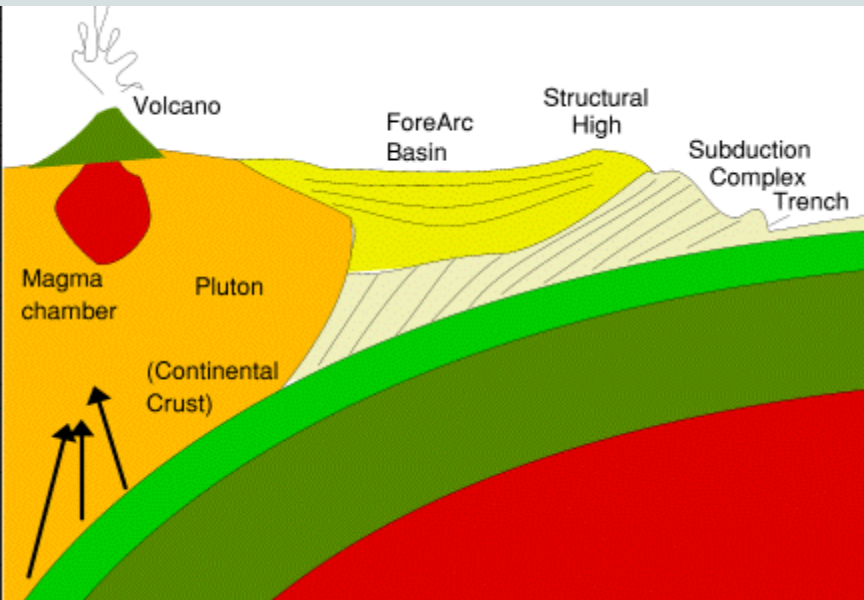
## Processes:

1. Additions
  - Water, organic matter, sediment
2. Losses
  - soluble compounds, erosion
3. Transformations
  - Organic matter to humus
  - Primary minerals to clay minerals
4. Translocations
  - Soluble compounds
  - Clays





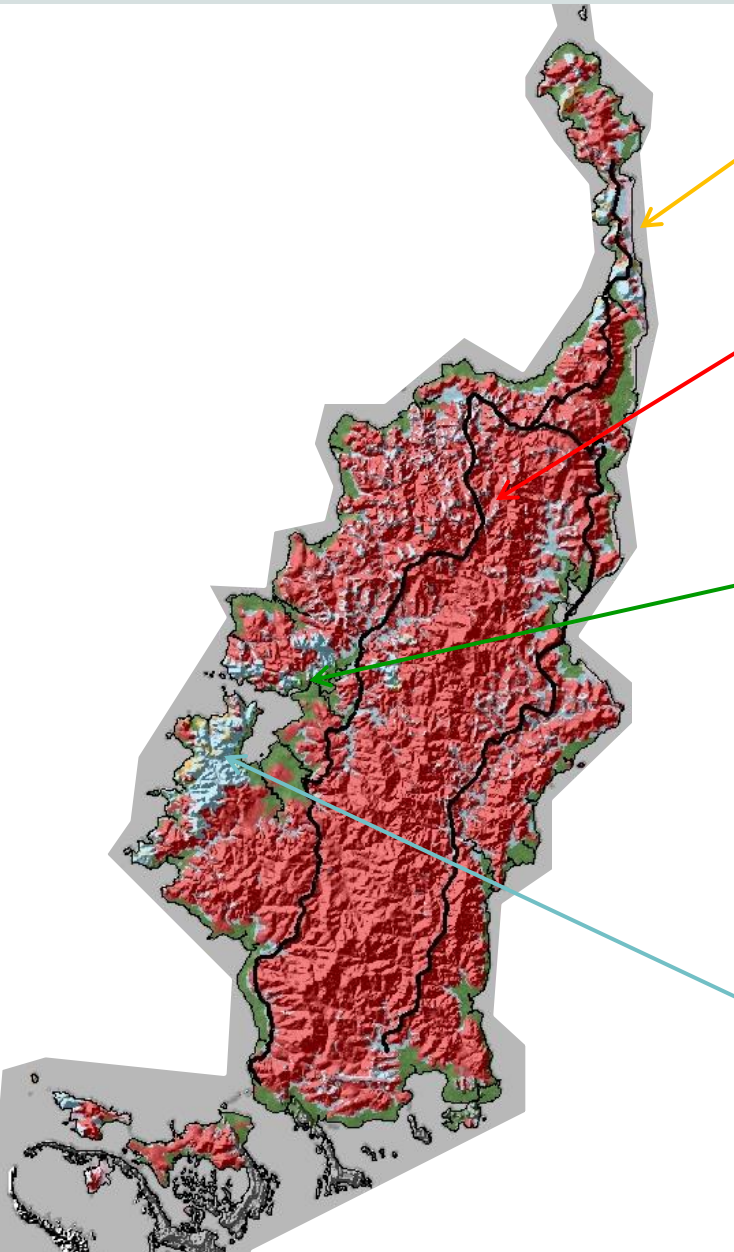
# Island Formation



- Babaldaob & Koror formed by volcanic activity between 40 – 20 Ma.
- Parent material is basalt
- The combination of coal limestone deposition and tectonic uplift created limestone islands
- Parent material is coral limestone

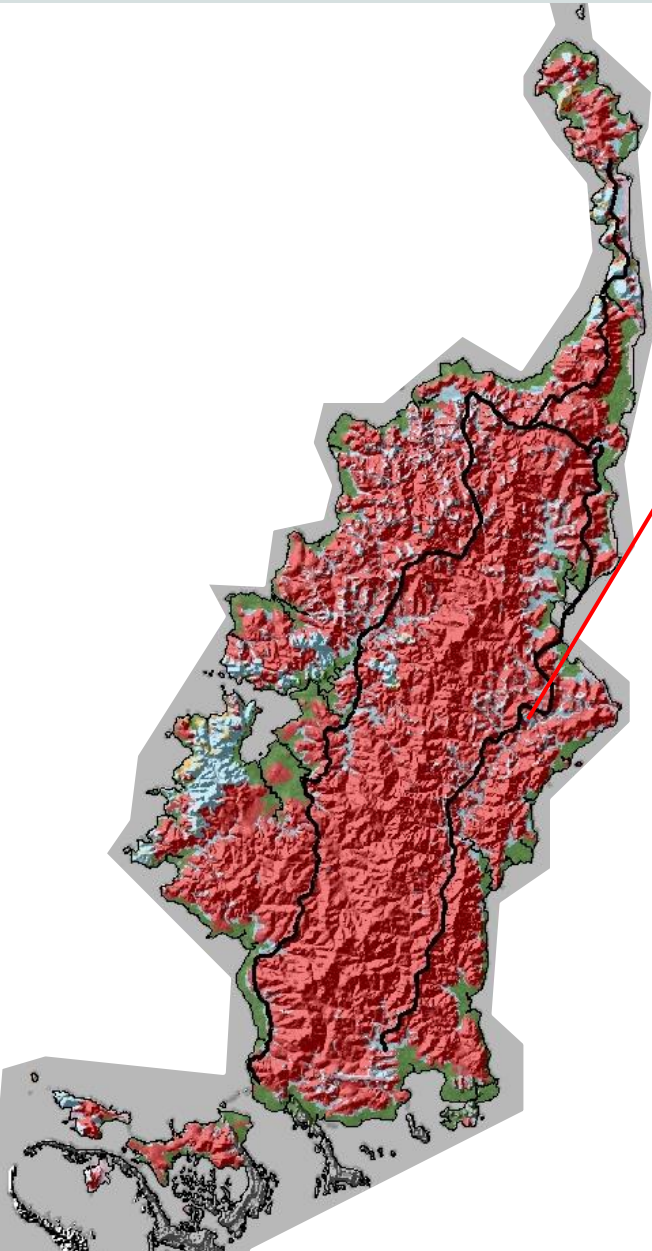


# Primary Soils of Palau



- Sandy **Entisols** are found in low-lying coastal areas
- Very acidic, red iron and aluminum rich **Oxisols** are the dominant soil type
- Organic matter rich soils (**Histosols**) of the poorly drained lowlands are important taro producing lands
- Mixture of **Inceptisols** and **Ultisols**

# Aimeliik Soil (Forests)



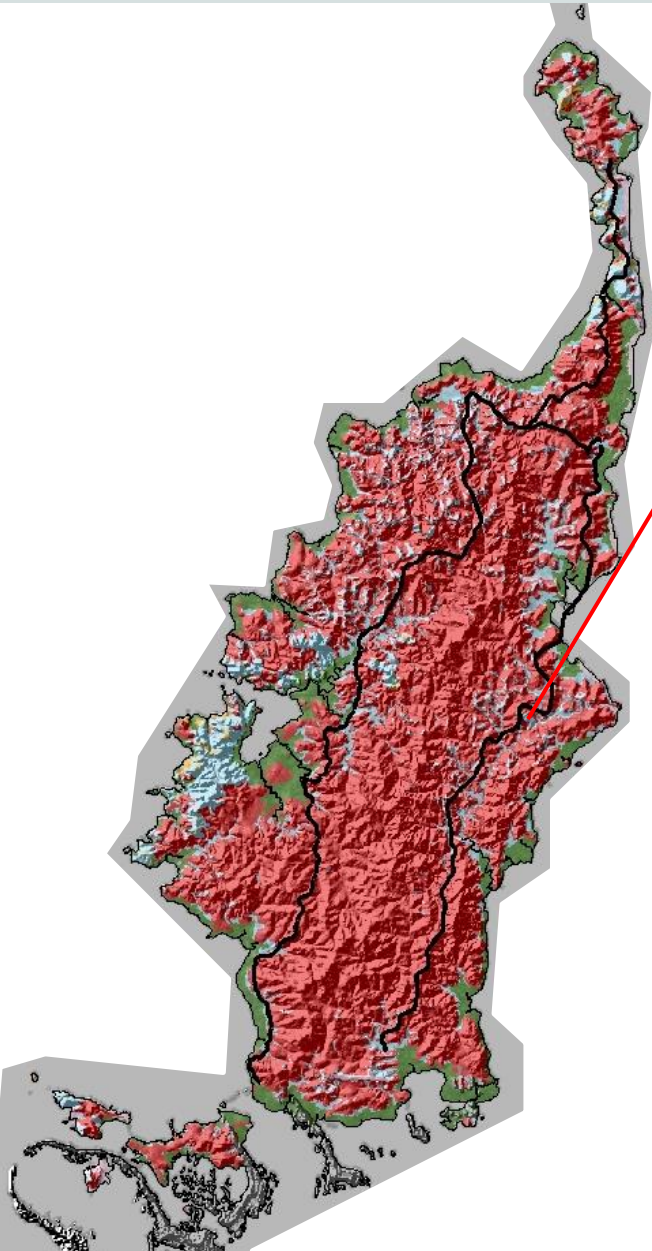
Select chemical properties of the Aimeliik soil

Depth	pH	Org C	Ca	Mg	K	Al <sub>sat</sub>
cm		%	ppm			%
0-10	5.3	9.6	1540	684	390	1
10-20	4.9	1.45	60	84	78	75

- Fertility is in dependent on organic-rich surface horizon



# Palau Soil (Grasslands)



Select chemical properties of the Palau soil

Depth	pH	Org C	Ca	Mg	K	Al <sub>sat</sub>
cm		%		ppm		%
0-10	4.9	5.35	160	48	78	81
10-20	5.0	1.40	60	0	39	92

- Once organic matter is depleted, soil loses fertility



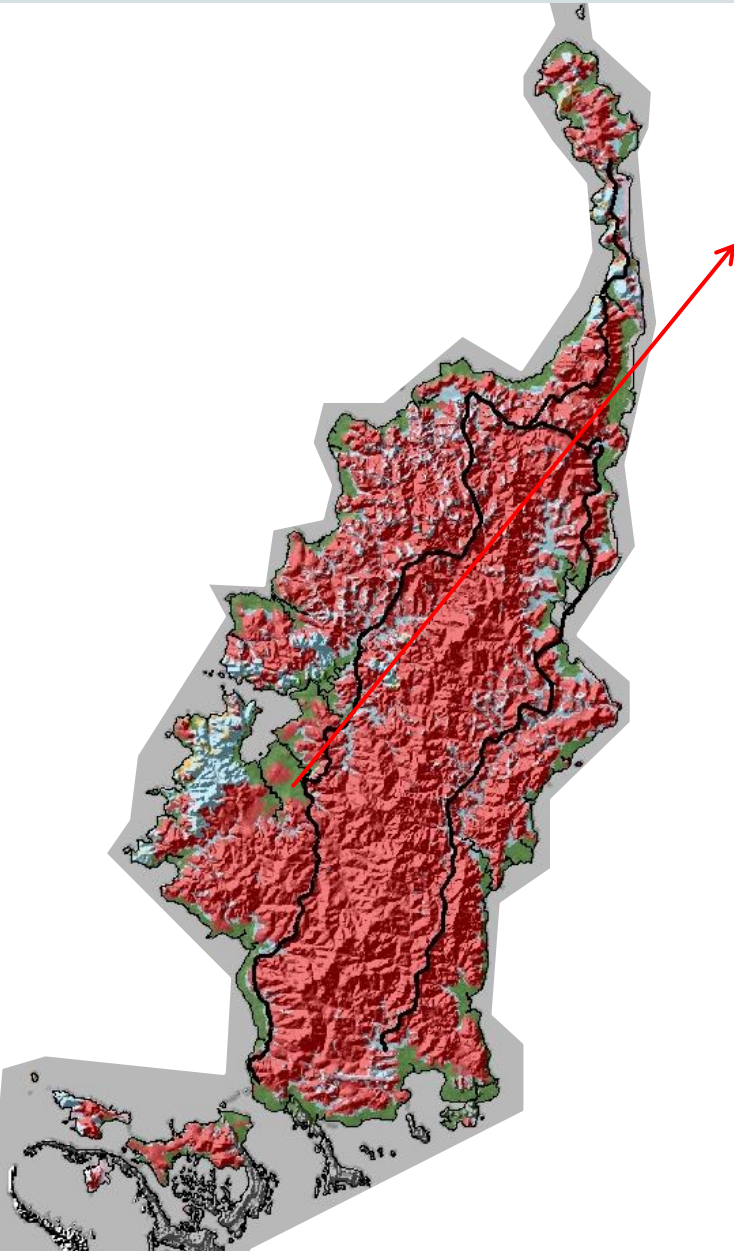


## Oxisols:

- Fertility depends on organic matter
- Subsoil is nutrient depleted and Al toxic



# Ngerungor (Taro Soils)



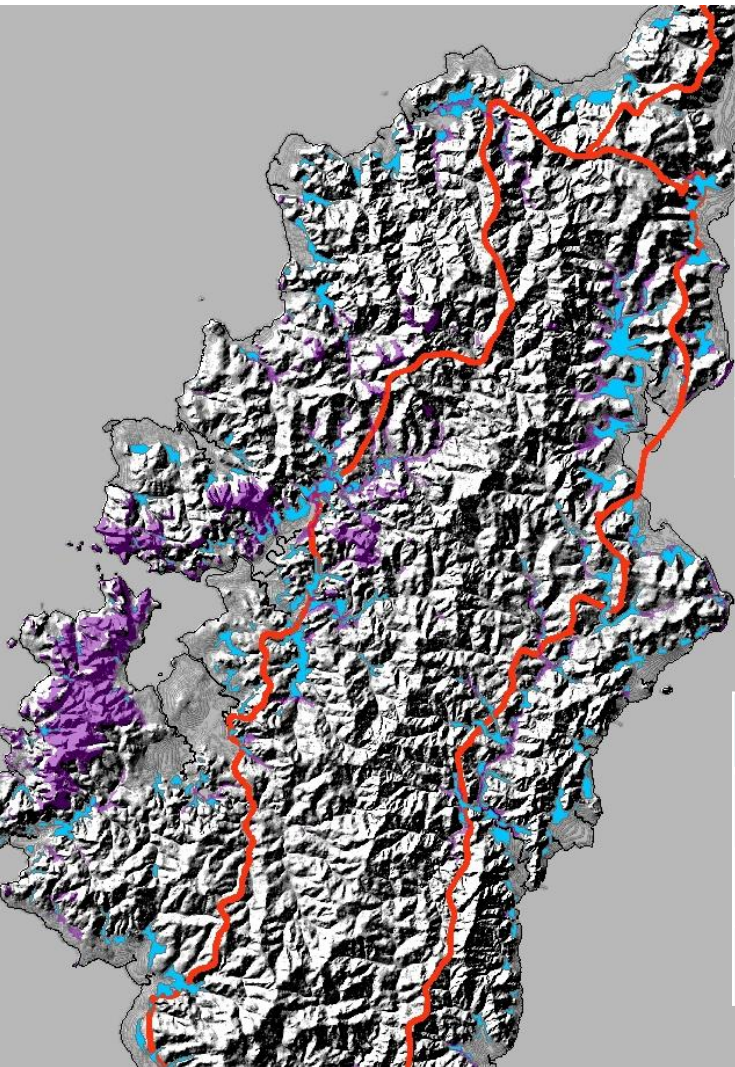
Select chemical properties of the Mesei soil

Depth	pH	Org C	Ca	Mg	K	Al <sub>sat</sub>
cm		%		ppm		%
0-10	6.9	49.5	VH	372	NA	0
10-20	7.2	46.1	VH	732	273	0

- Organic matter is a source of nutrients and it detoxifies Al



# Inceptisols



Select chemical properties of the **Dechel** soil

Depth	pH	Org C	Ca	Mg	K	Al <sub>sat</sub>
cm		%	ppm			%
0-10	6.9	5.84	5660	936	78	0
10-20	6.9	1.95	5300	900	156	0

Select chemical properties of the **Ollei** soil

Depth	pH	Org C	Ca	Mg	K	Al <sub>sat</sub>
cm		%	ppm			%
0-10	5.2	10.6	2760	744	312	3
10-20	5.1	5.7	1400	468	156	26

# Summary

- Plants require 15 essential nutrients, which they get primarily from the soil.
- Soils vary on the landscape
- Palau has 6 main soil types
- Babeldoab is composed primarily of infertile, acid Oxisols in the uplands and fertile Histosols and Inceptisols in the lowlands

