

# Soils of Pohnpei

## Diversity and Fertility



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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 Pohnpei



# Plant Nutrition

Soil is the source of essential plant elements:

## Macronutrients

Nitrogen (N) – proteins and 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

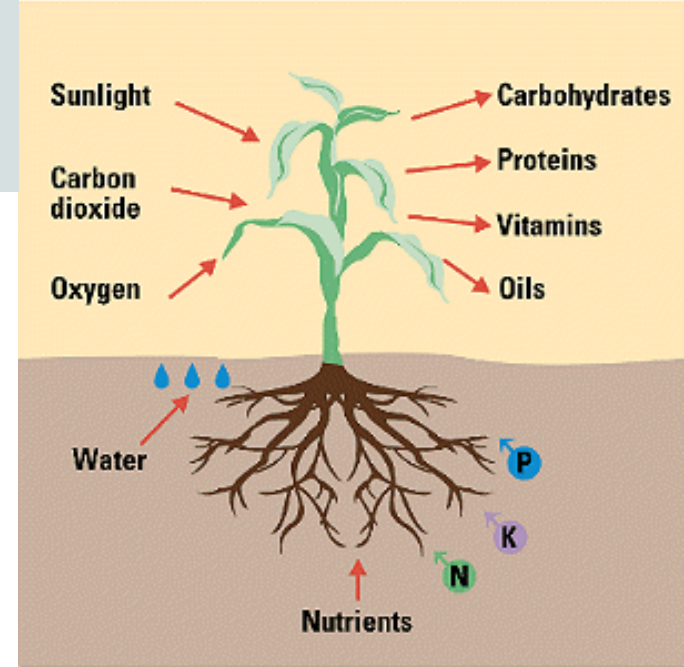
Boron (B)

Copper (Cu)

Iron (Fe)

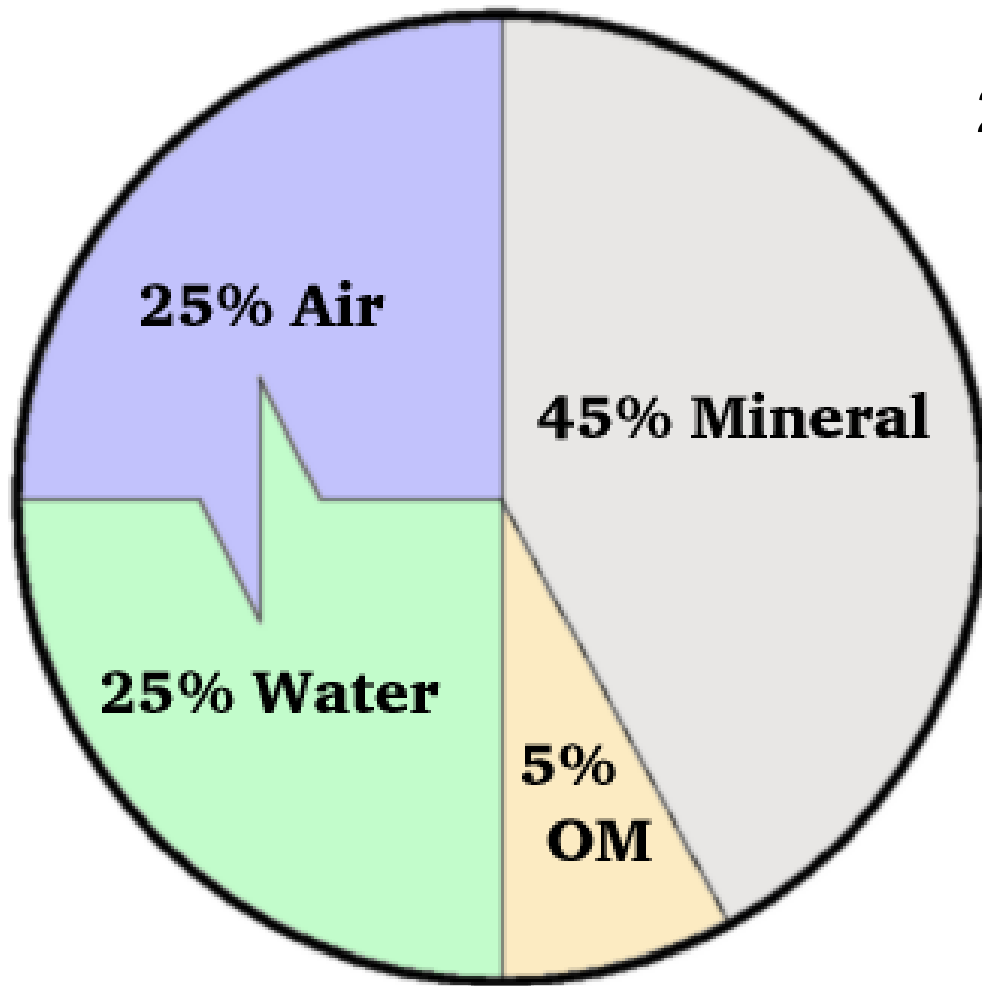
Manganese (Mn)

Zinc (Zn)



N deficiency in corn

# Soil Composition



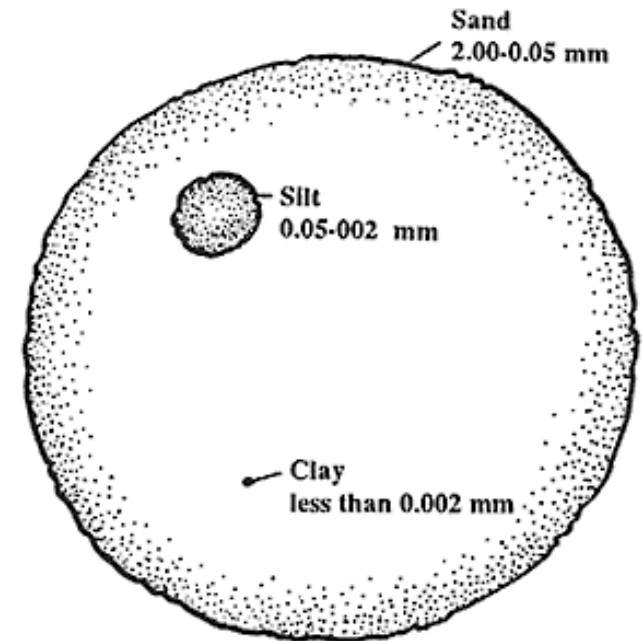
1. Mineral: sand, silt and clay
2. OM: organic matter



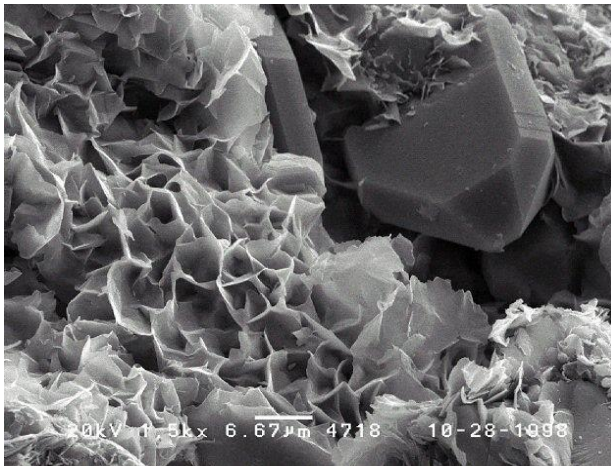


# Clay Properties

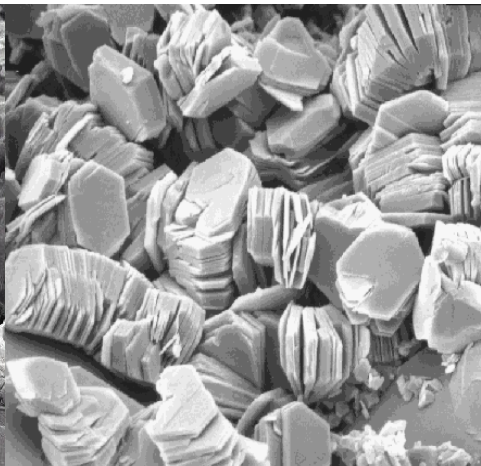
- Extremely high surface area
  - water retention
  - chemical reactions
  - biological activity
- Clay surfaces carry charge (-/+)
- Negative surface charge holds essential plant nutrients



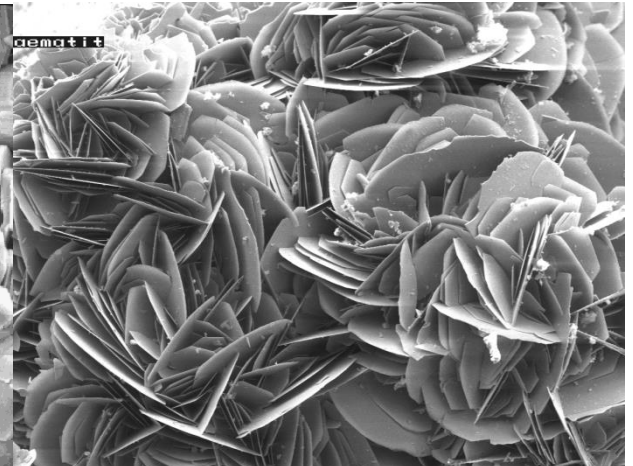
*montmorillonite*



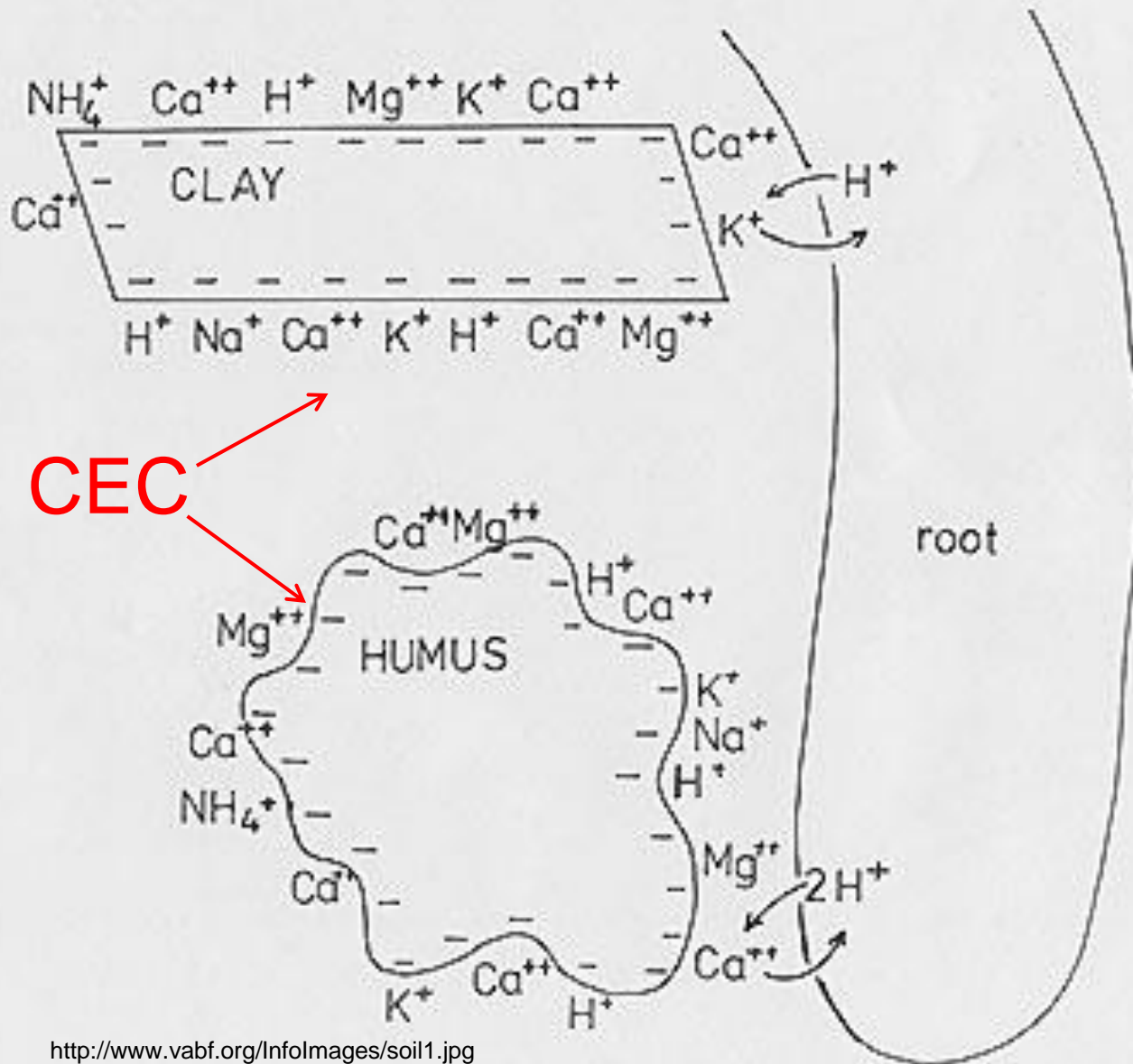
*kaolinite*



*hematite*

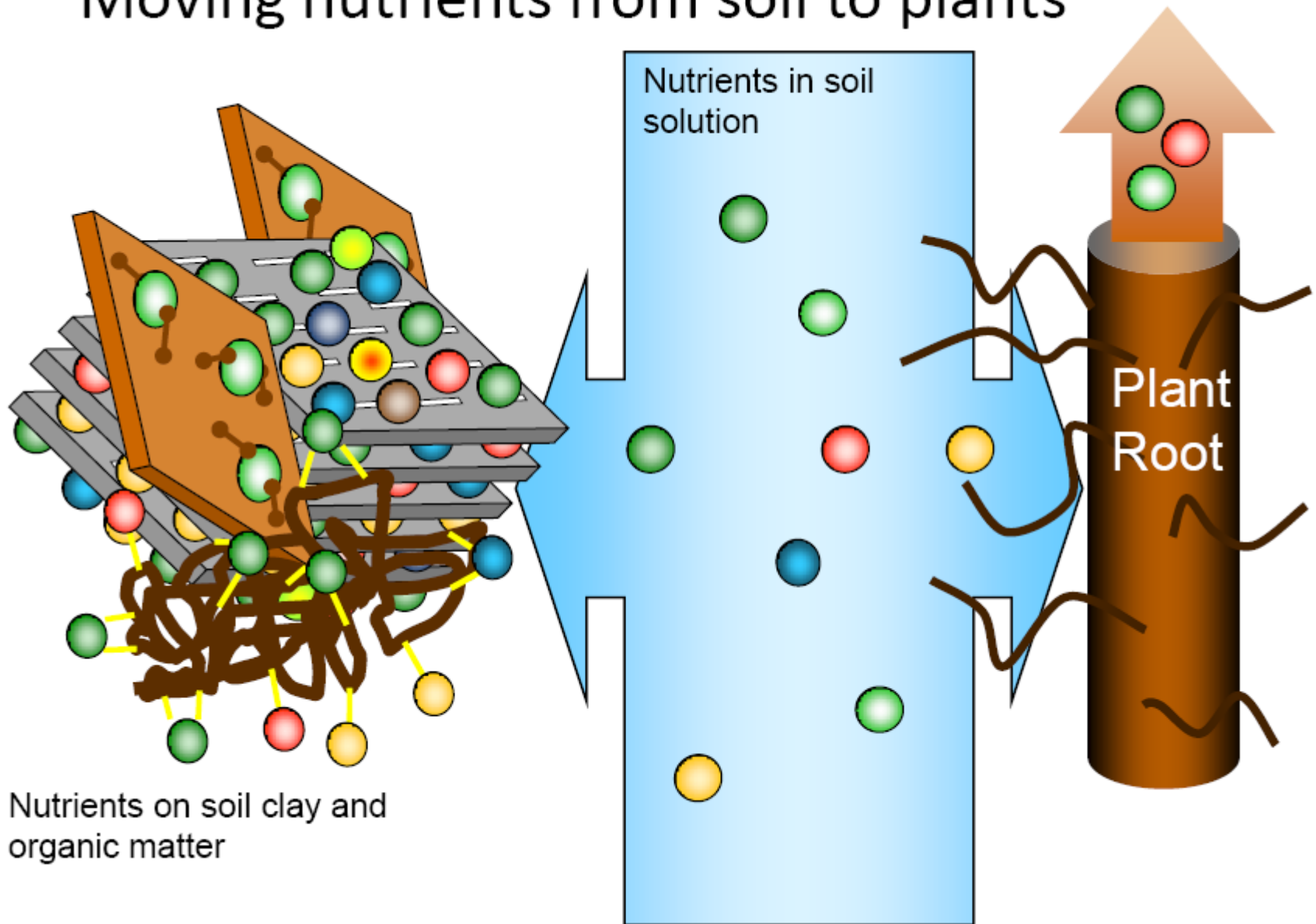


# Clay has Cation Exchange Capacity (CEC)



- 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

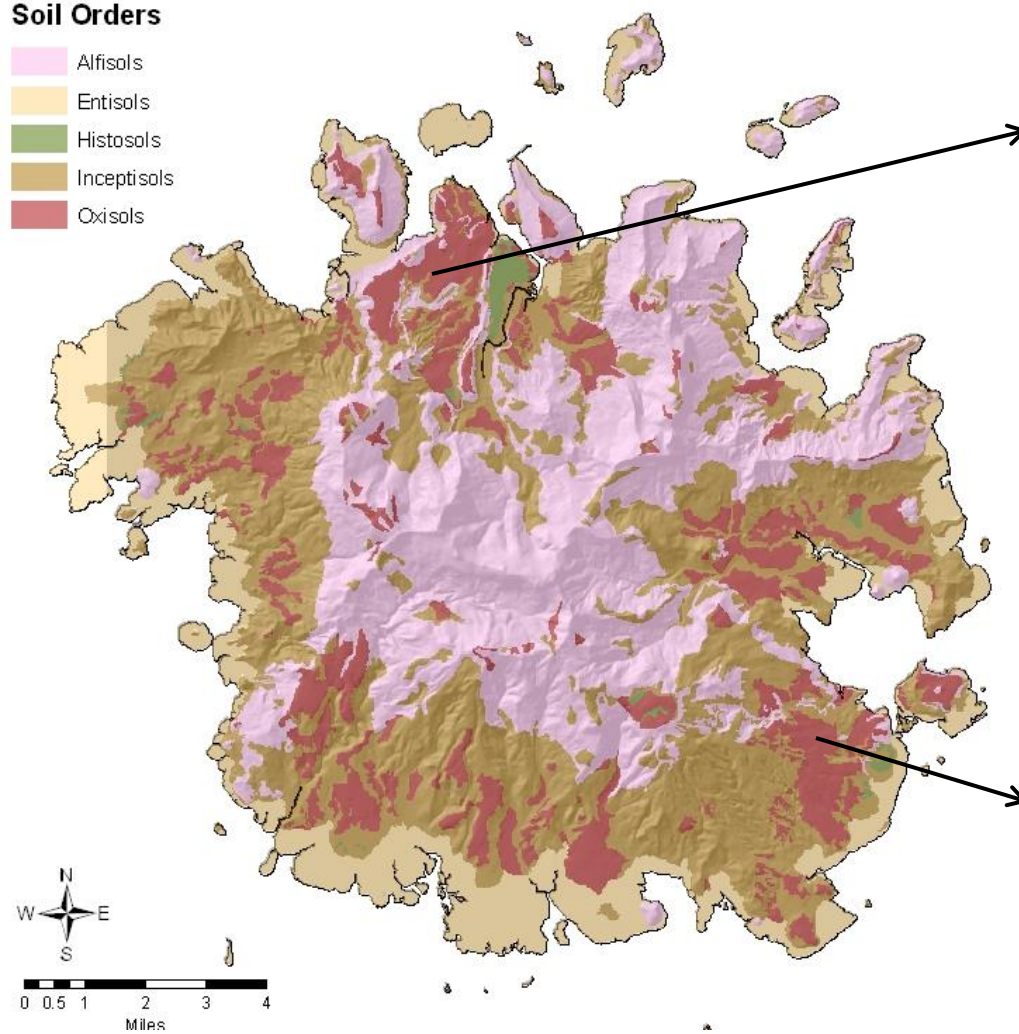
# Moving nutrients from soil to plants





## Soil Orders

- Alfisols
- Entisols
- Histosols
- Inceptisols
- Oxisols





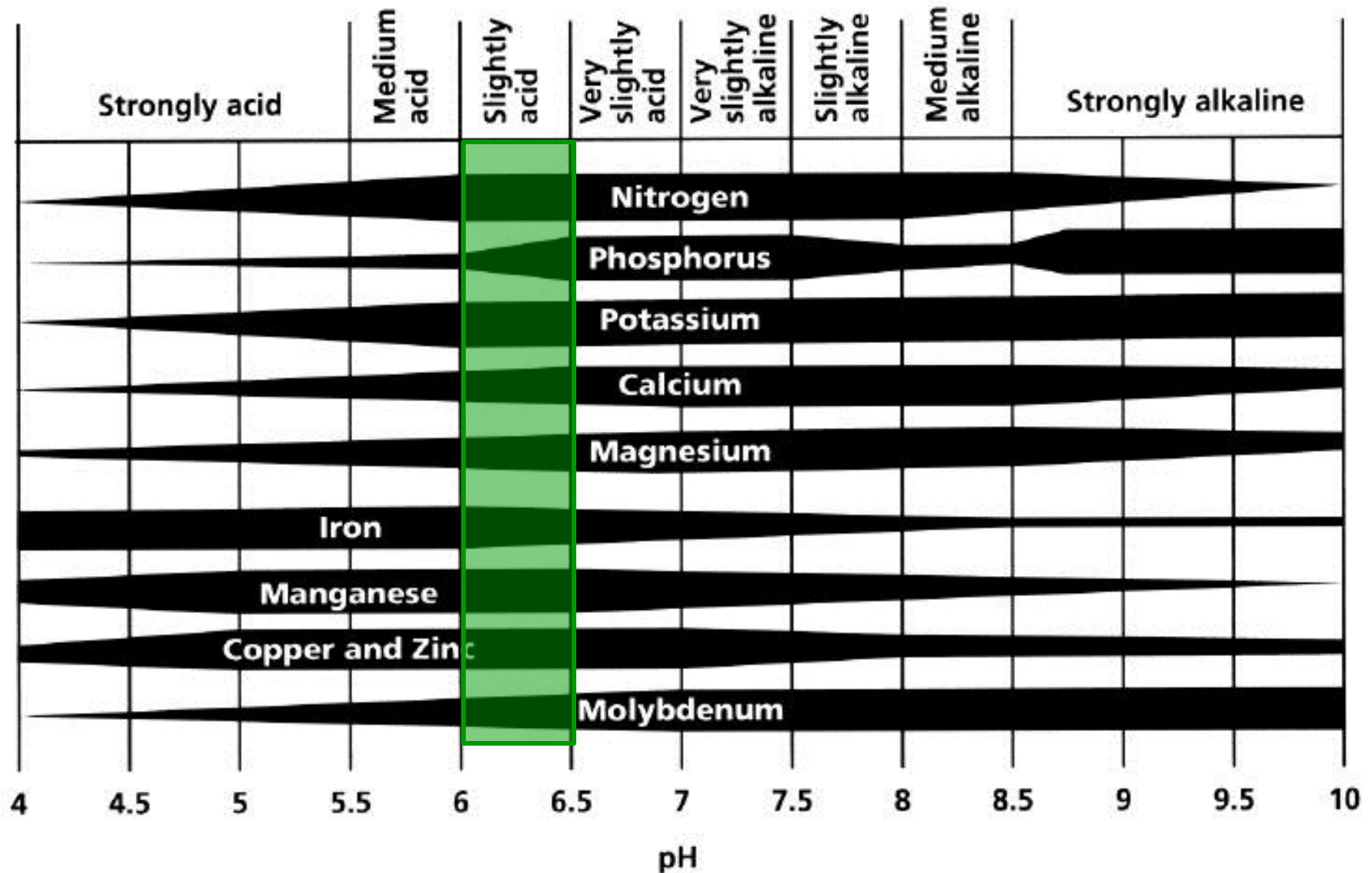
# Soil pH is an Expression of Acidity/Alkalinity

## The pH Scale



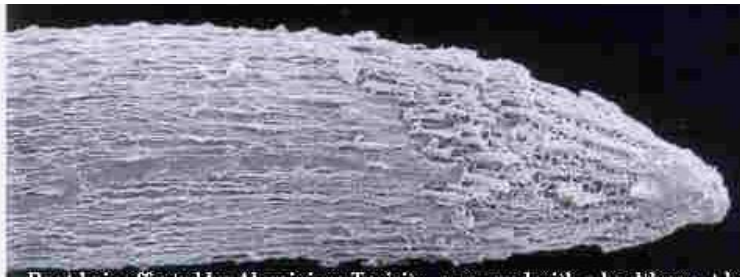
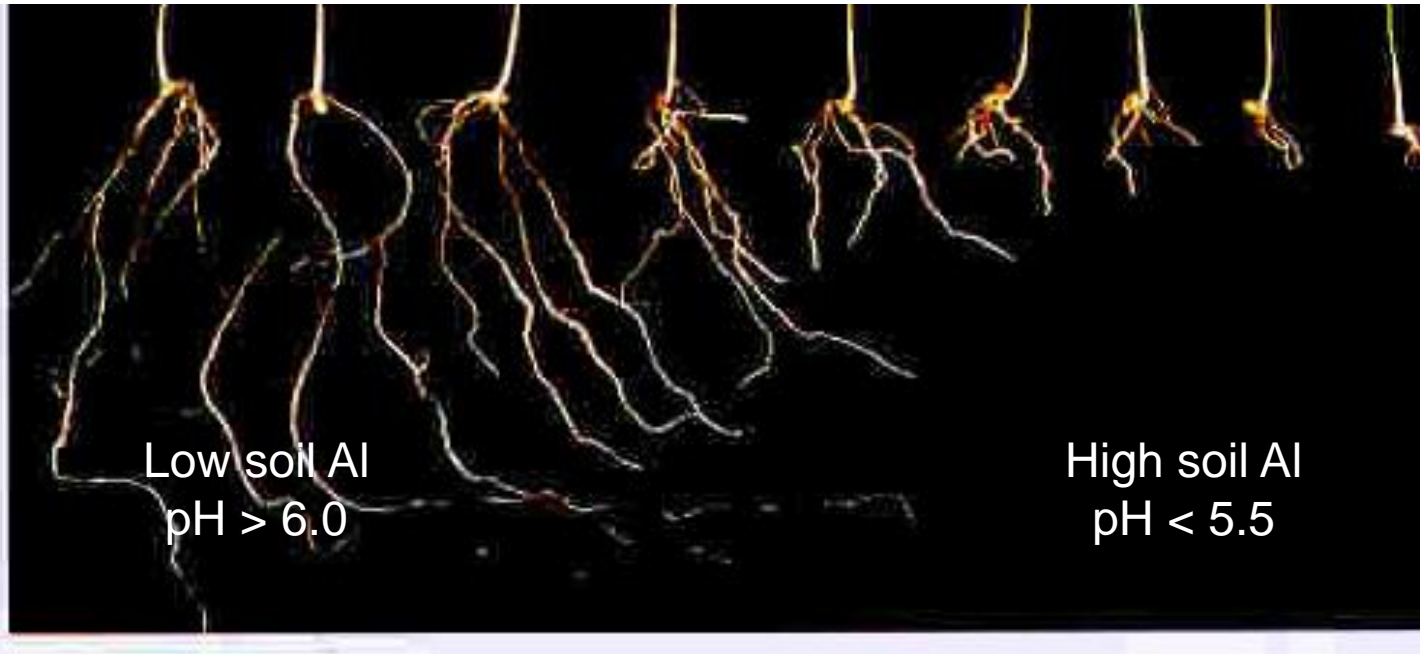
Typical pH range in soils

# Soil pH Affects Nutrient Availability





# High Soil Aluminum Causes Root Damage



Healthy root hair in soil with low Al

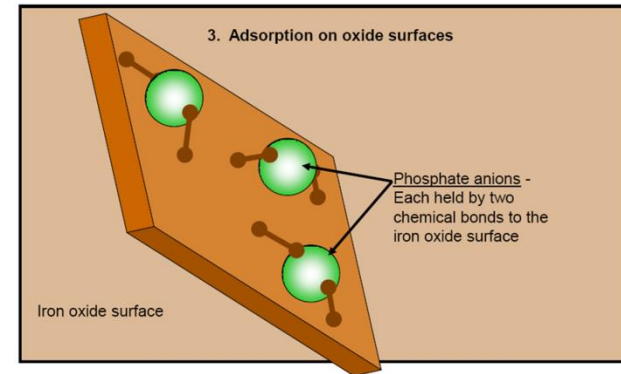
Deformed root hair in soil with high Al



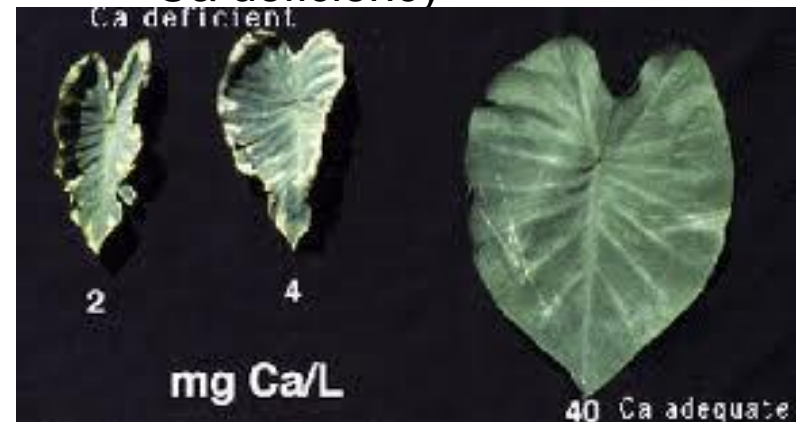
# Negative Effects of Soil Acidity



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

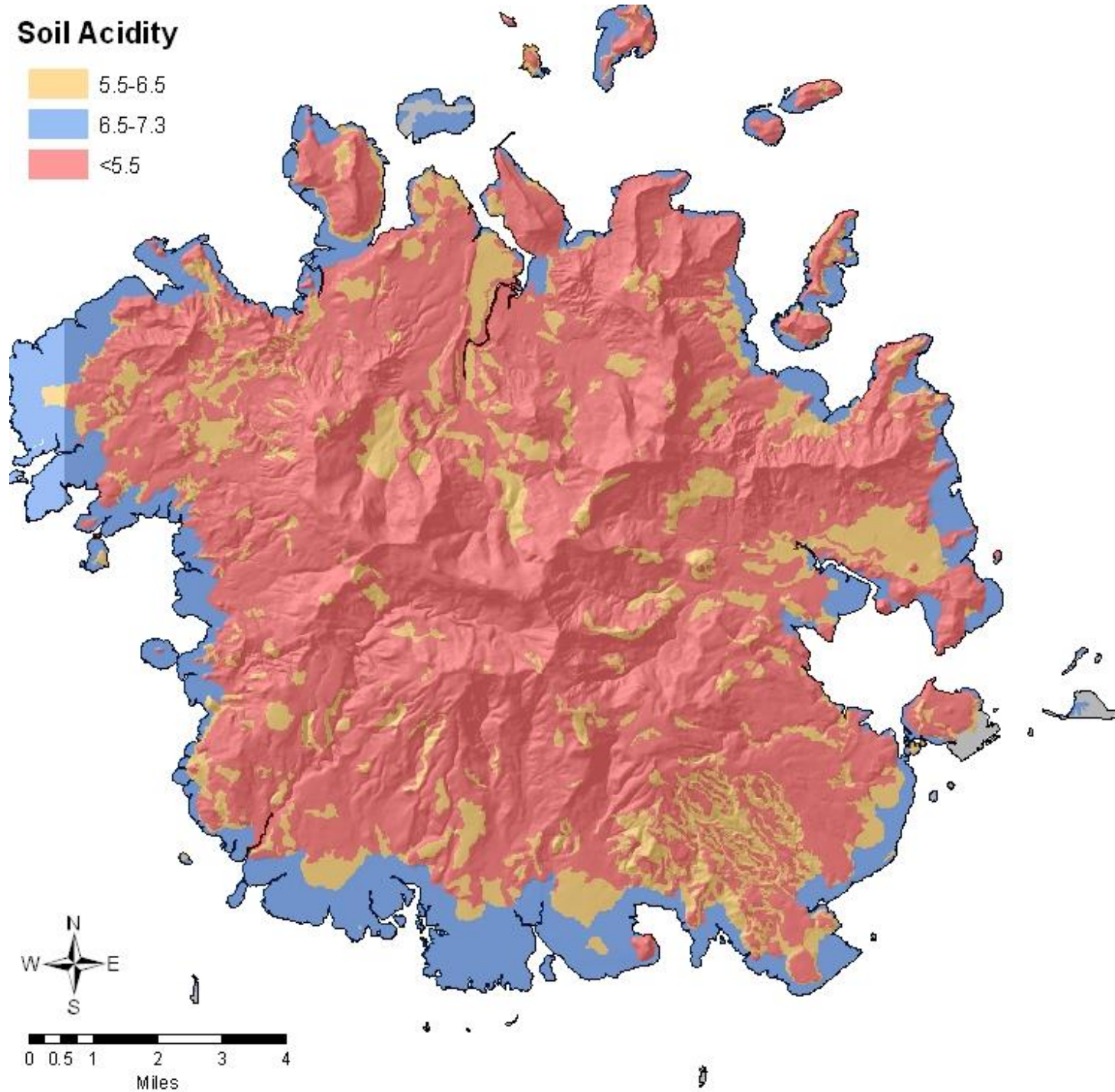
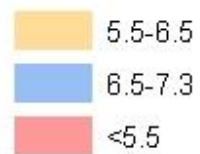


– Ca deficiency





## Soil Acidity





# 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 Organic Matter and Nitrogen

- SOM is one of the most important sources of plant N in natural landscapes.
- Decomposing plant and animal residues provide N for plant growth.
- Traditional agroforest systems rely on natural cycling of N through decomposition





# Soil Diversity



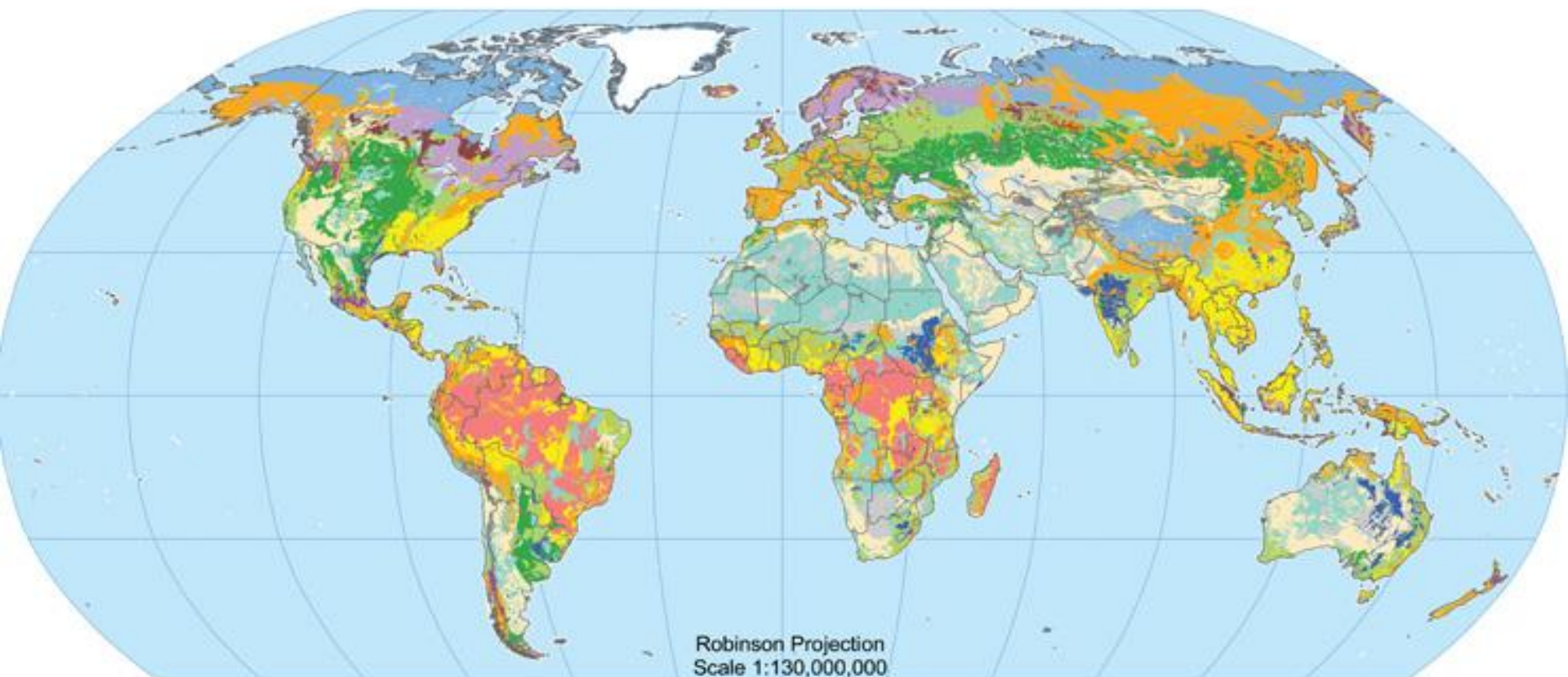
Organic matter rich  
Mangrove soils  
(Histosols)



Iron and aluminum rich  
forest soils (Oxisols)



# 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:

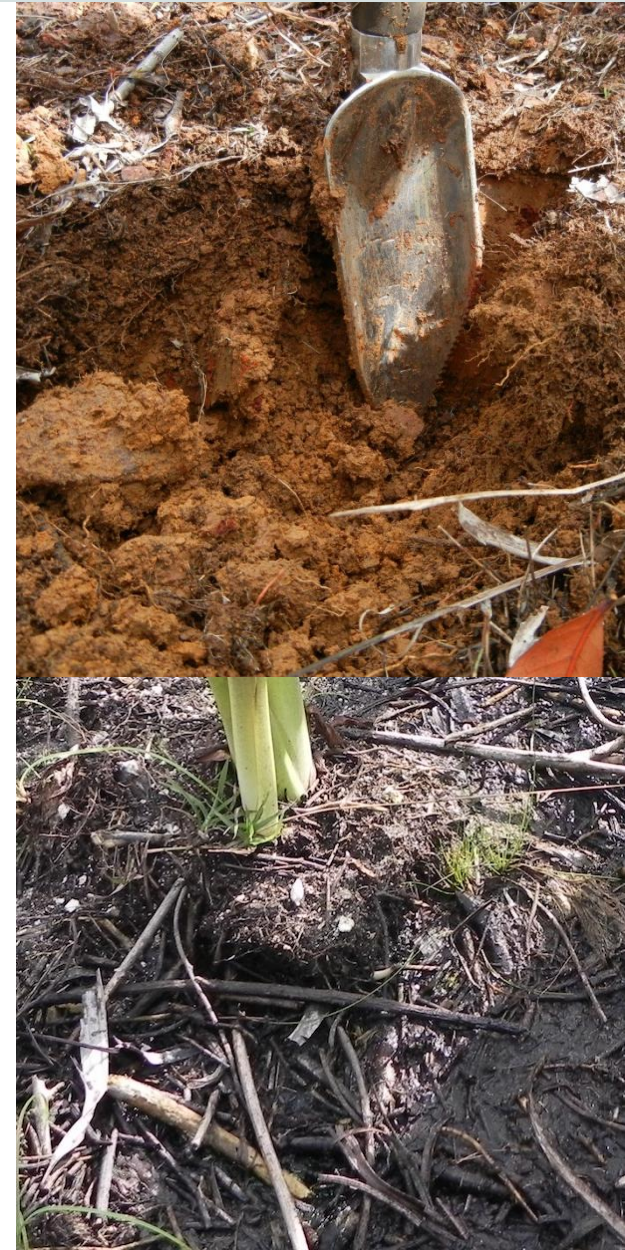
PM = parent material (rocks)

CI = climate (rainfall and  
temperature)

O = organisms (plants and animals)

R = relief (topography, drainage)

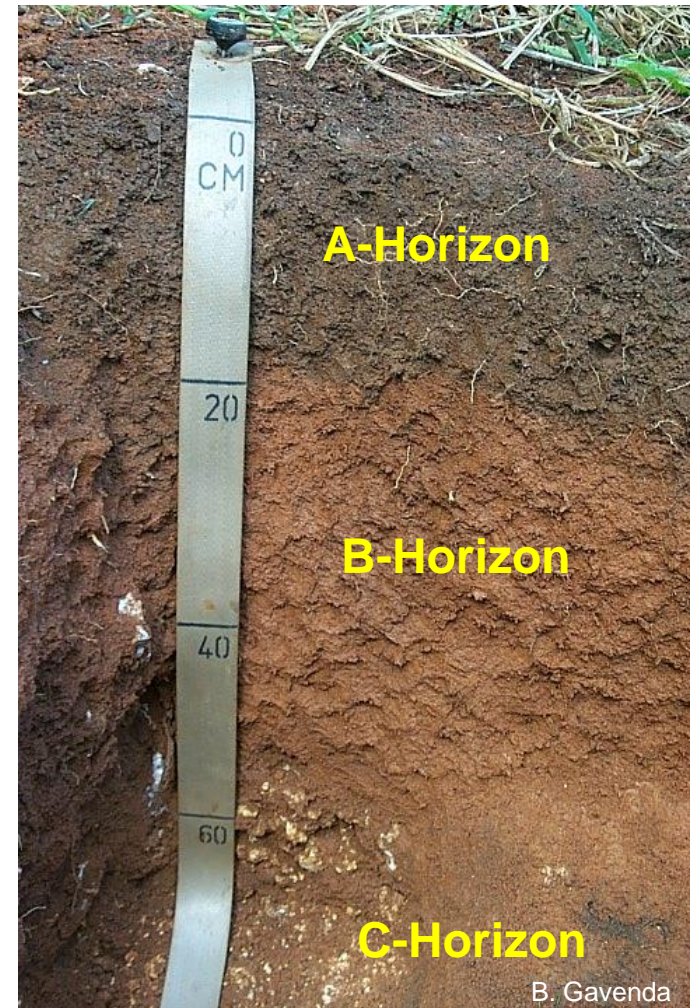
T = time



# Soil Formation

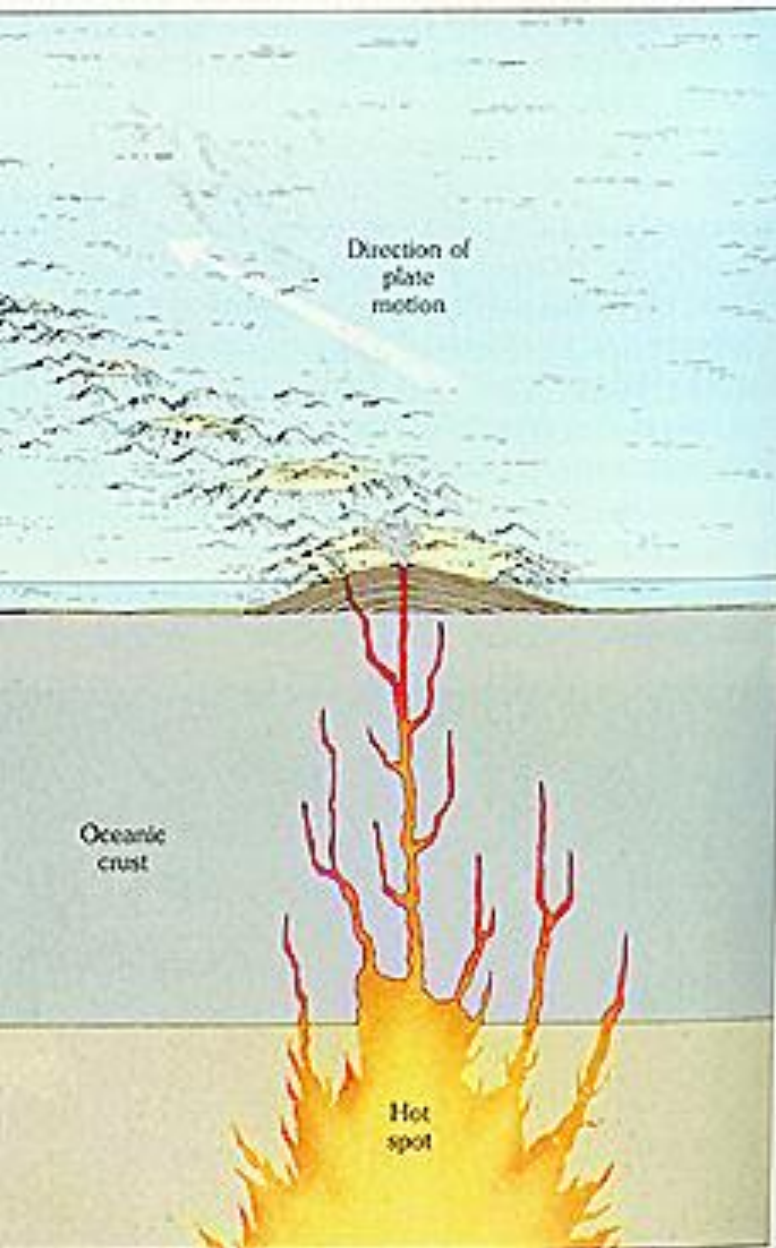
## Processes:

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



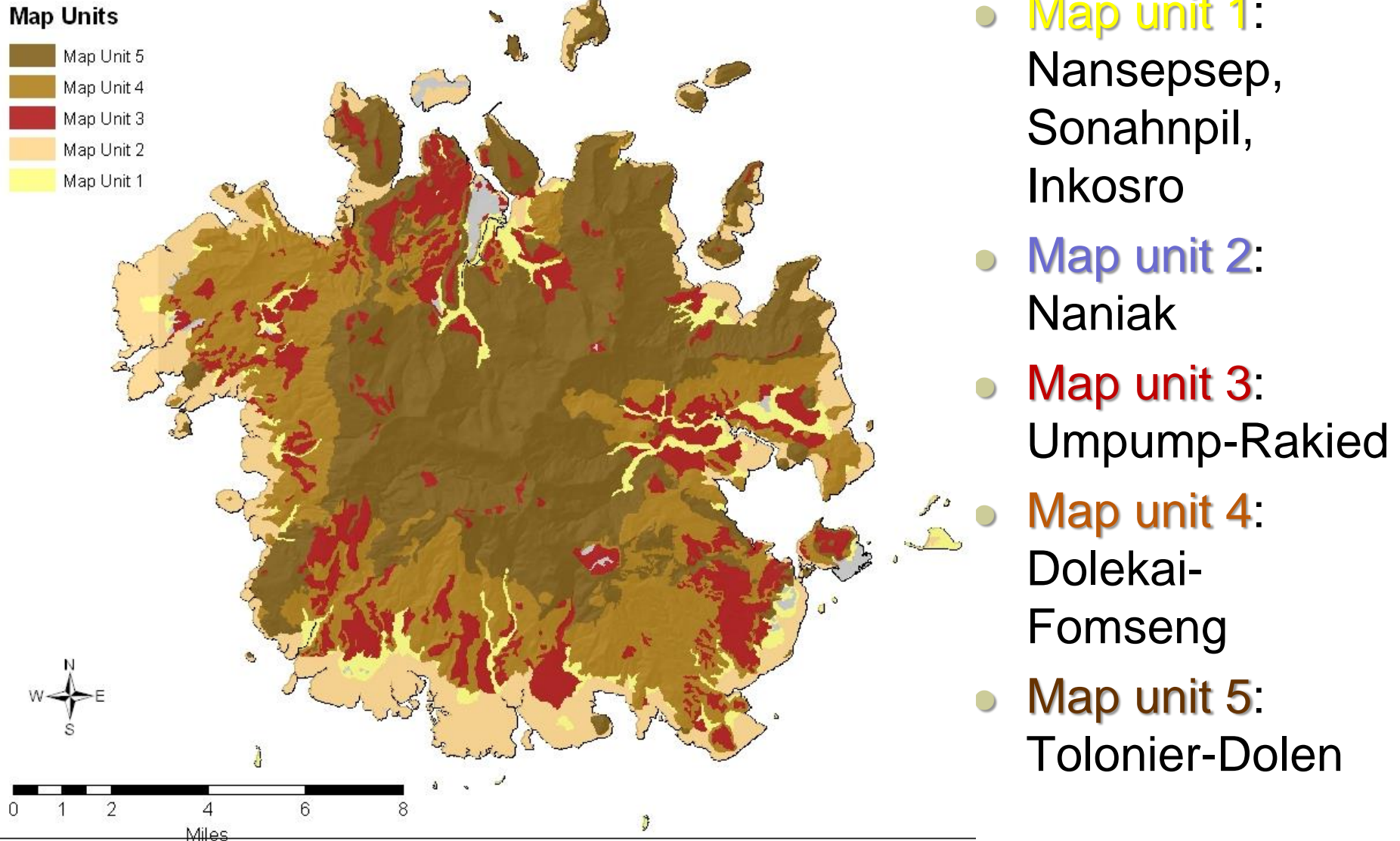


# Island Formation



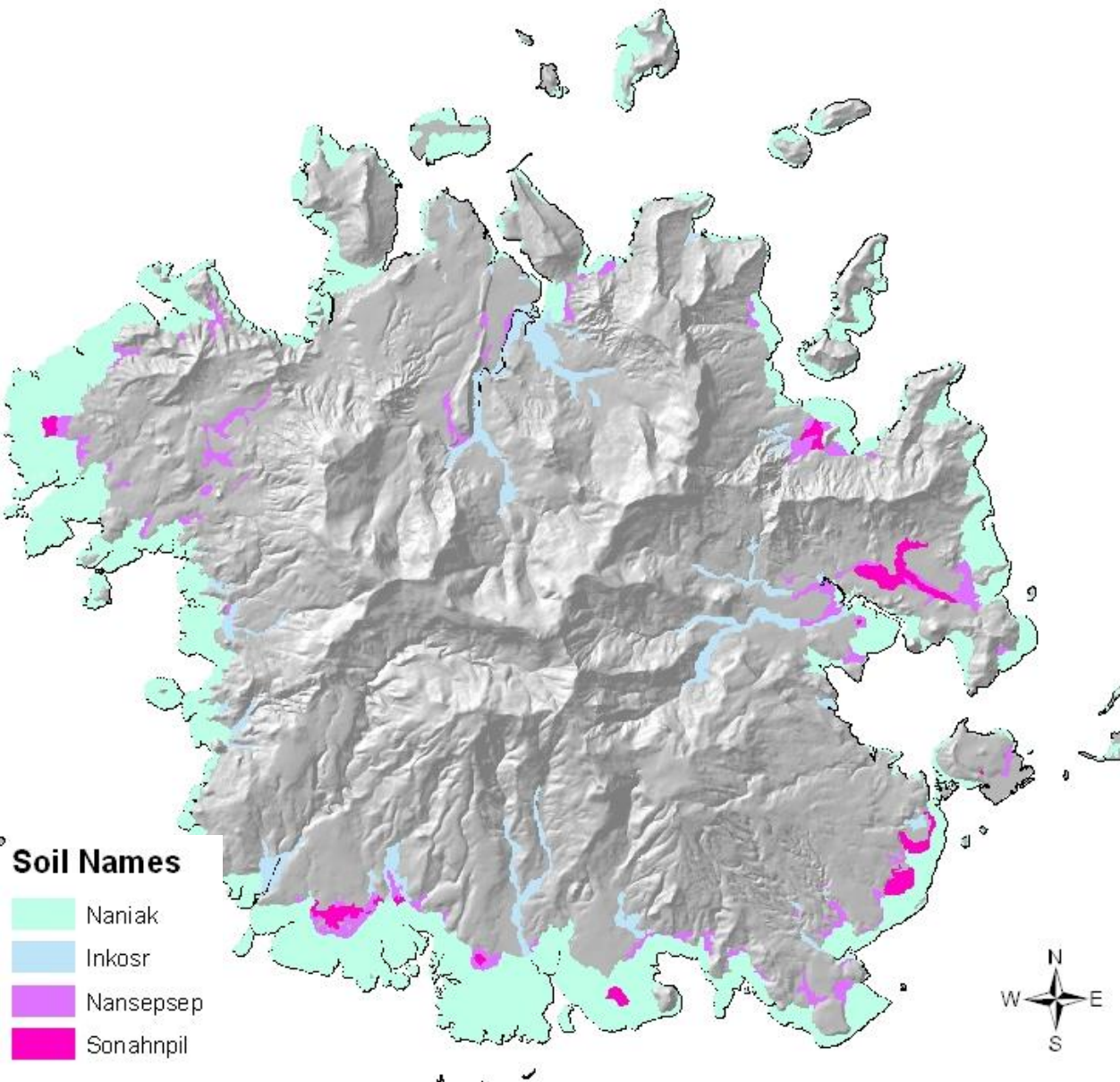
- Pohnpei formed from intermittent volcanic activity over last 8.5 million years
- In the interior, basalt is the parent material.
- Coral reef fringing the island is the parent material for low-lying mangrove swamps

# Soil Survey Map



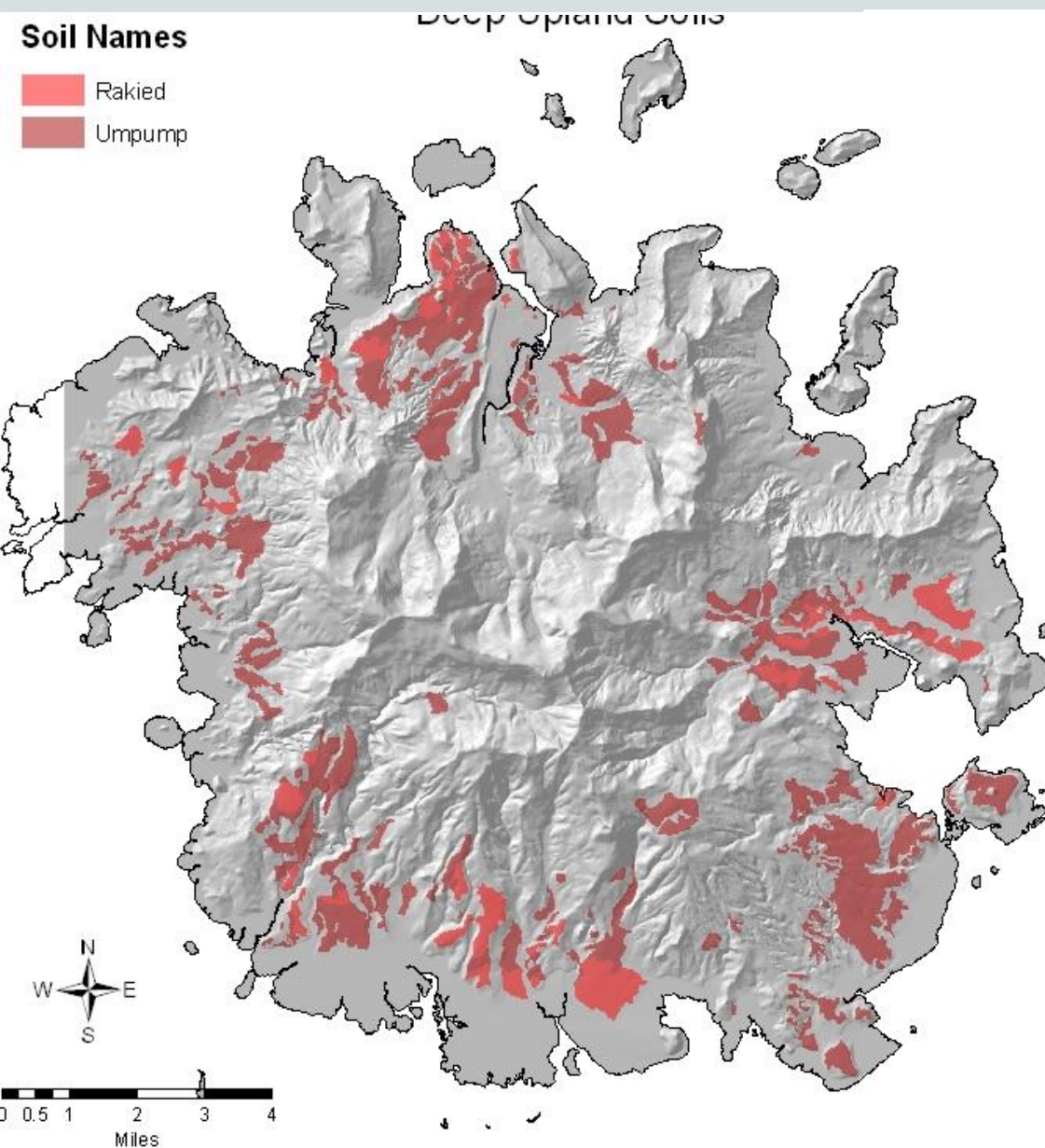


# Bottom Land Soils of Pohnpei



- *Naniak*: deep, neutral, poorly drained coastal marsh soils
- *Inkosr*: poorly drained soils
- *Sonahnpil*: acidic, well-drained soils
- *Nansepsep*: poorly drained, fertile soils

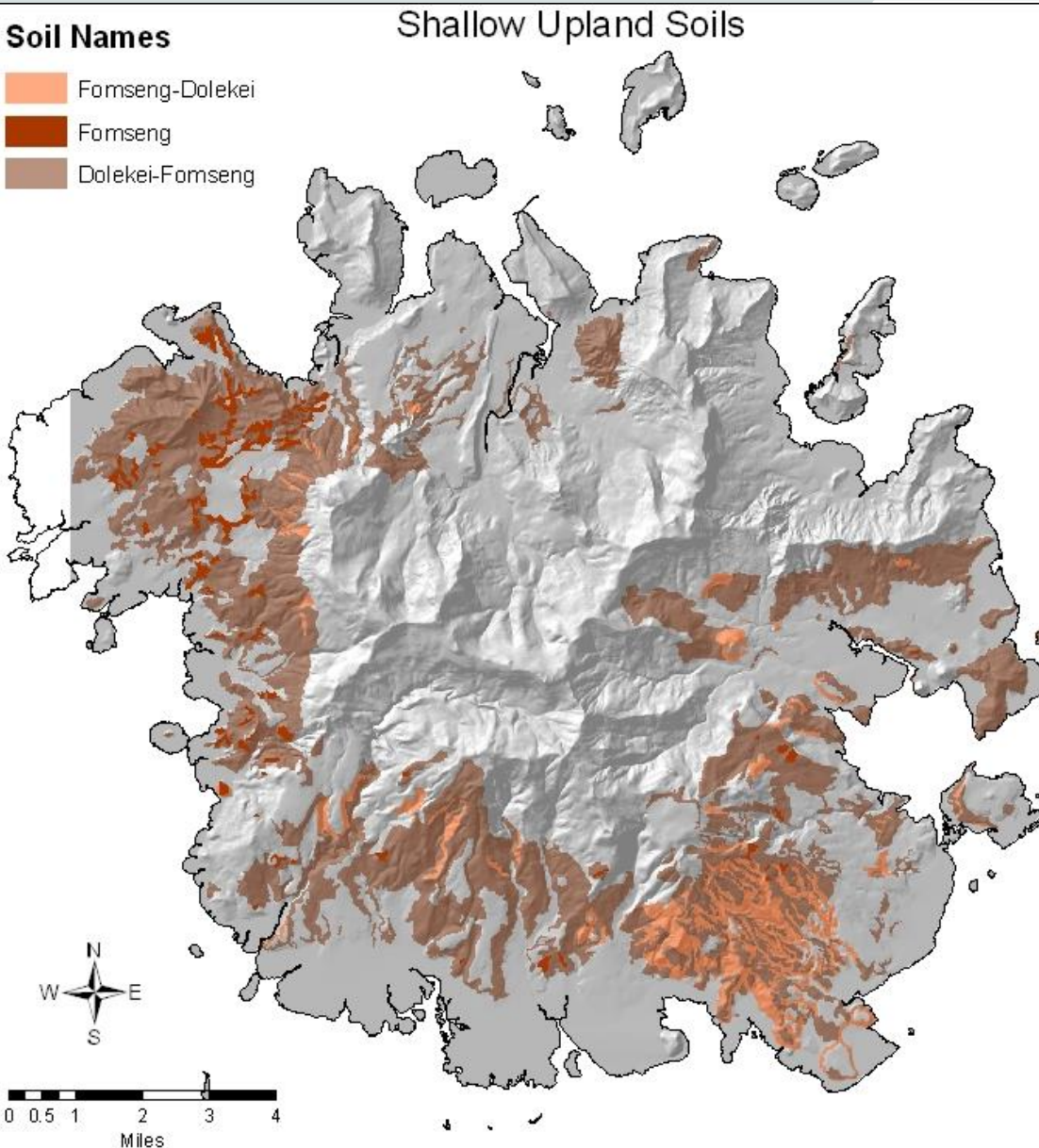
# Acid Soils on Upland Terraces



- *Umpump*: acidic, well-drained soils, fertility depends on organic matter, low P and Ca
- *Rakied*: similar to Umpump soils.



# Shallow Soils on Steep Land



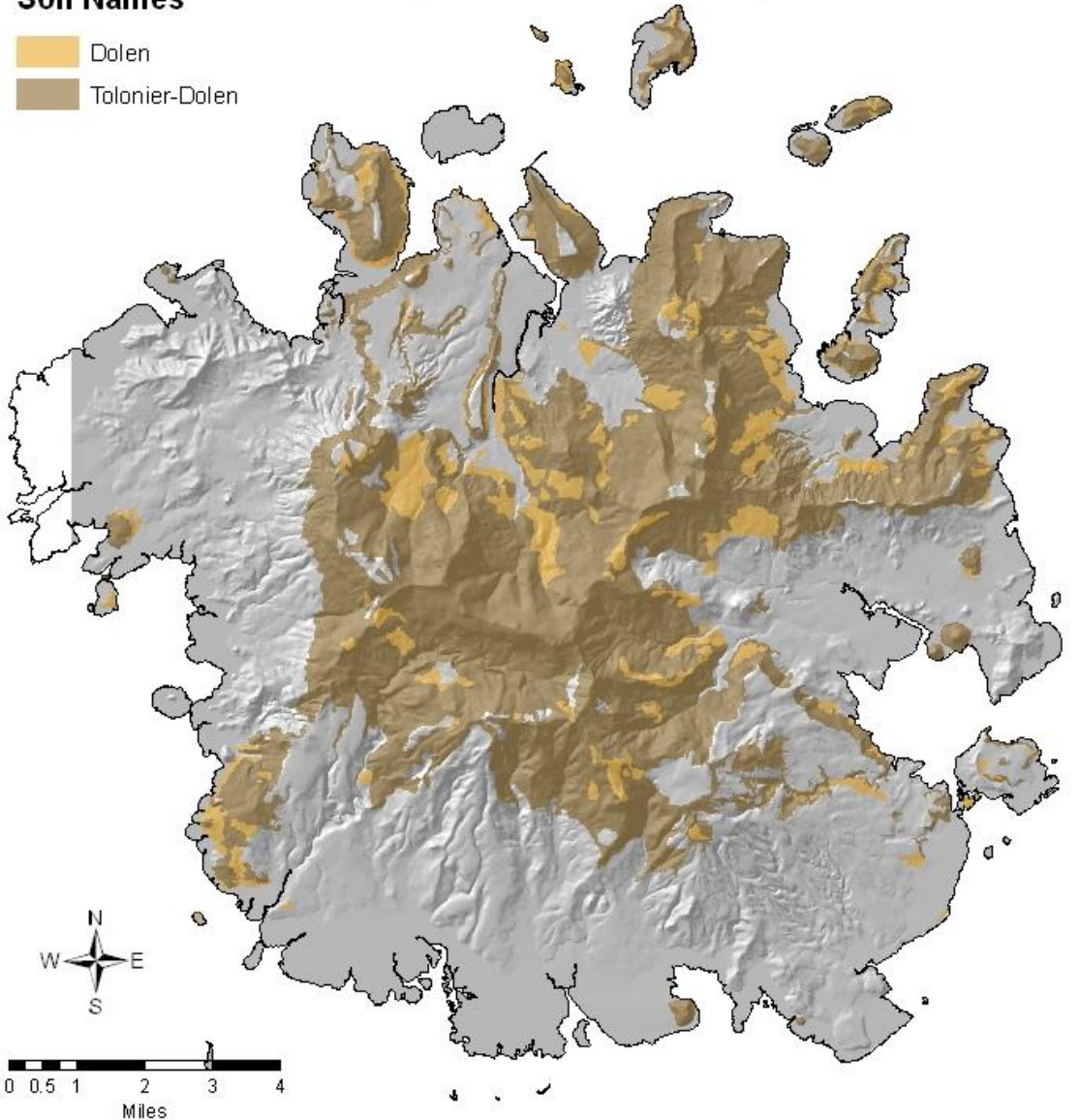
- *Fomseng-Dolekei*: shallow, slightly acid to acid, well-drained, fertility depends on organic matter, low P and Ca

# Deep Soils on Steep Slopes

## Soil Names

- Dolen
- Tolonier-Dolen

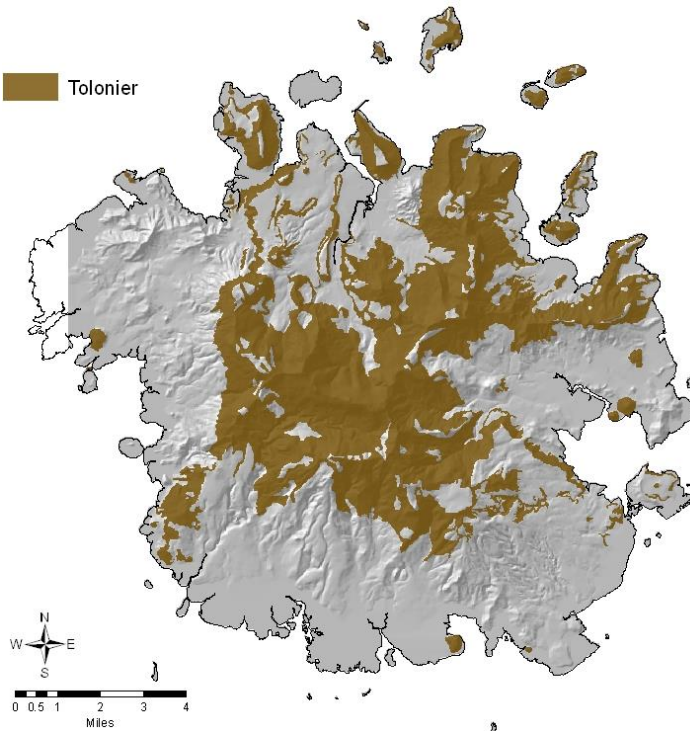
## Deep Soils on Steep Slopes



- *Dolen - Tolonier*:  
acidic, well-drained, deep soils where fertility depends on organic matter.



# Tolonier Soil (Forests)

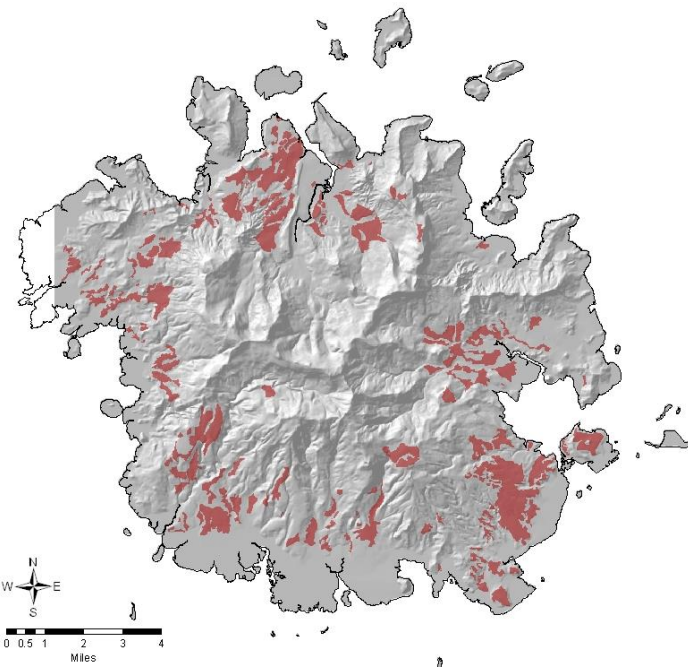


Select chemical properties of the Tolonier soil

Depth	pH	Org C	Ca	Mg	K	Al <sub>sat</sub>
cm		%	ppm			%
0-10	4.9	3.5	1040	660	117	22
10-20	5.5	0.8	660	444	78	46

- Fertility is in dependent on organic-rich surface horizon

# Umpump Soil



Select chemical properties of the Palau soil

Depth	pH	Org C	Ca	Mg	K	Al <sub>sat</sub>
cm		%		ppm		%
0-10	5.2	6.35	600	440	78	29
10-20	5.0	2.16	120	72	39	35

- The Umpump is an important agricultural soil



# Summary

- Plants require 15 essential nutrients, which they get primarily from the soil.
- Organic matter is a critical source of nutrients
- Soils vary on the landscape
- Pohnpei has 5 main soil types
- Most of the interior soils are acid.
- Traditional Agroforest systems rely on organic matter inputs

