Decoupling silicate weathering from primary productivity

- how ecosystems regulate nutrient uptake along a climate and vegetation gradient -

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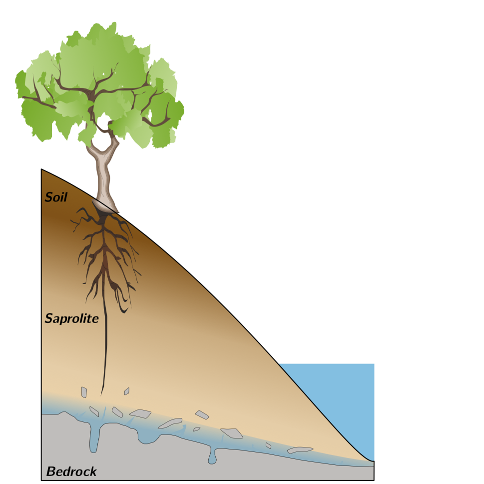
Element fluxes in the Critical Zone

plants

regolith



modified from Oeser and von Blanckenburg; submitted to BG (2020); doi:10.5194/bg-2020-69

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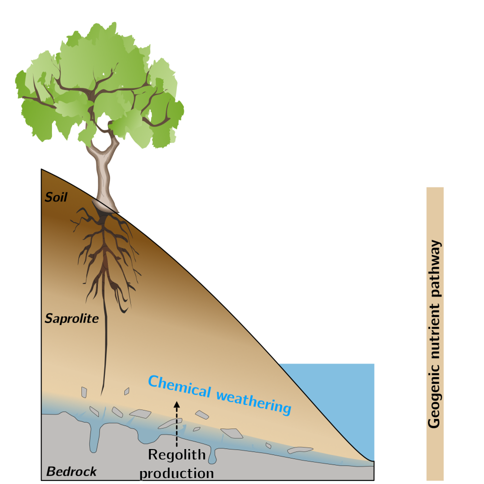

nutrient release through weathering

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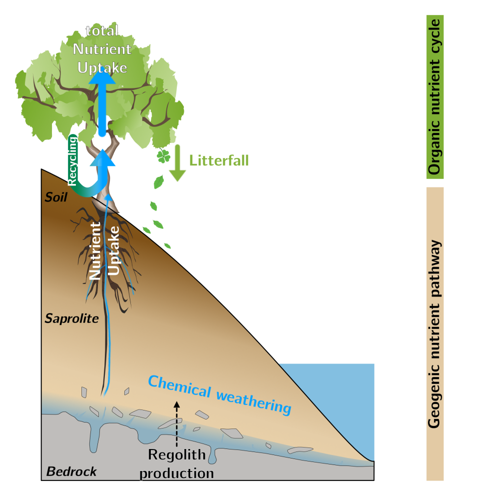

nutrient uptake from soil solution

nutrient return through litter fall

nutrient release through weathering

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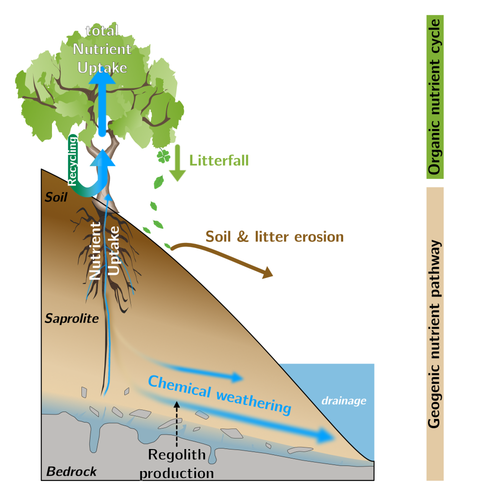

permanent nutrient loss !!!

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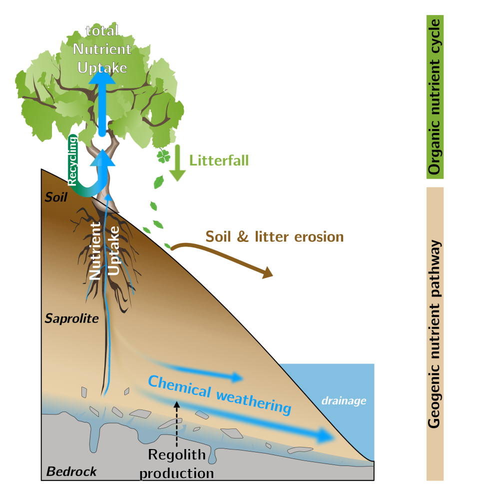

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How is nutrition sustained despite losses?

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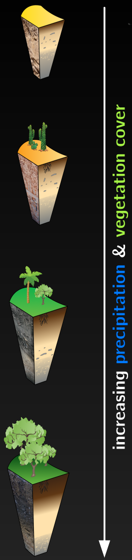

Exploring mineral nutrient supply along the EarthShape vegetation gradient

EarthShape
Earth Surface Shaping by Biota
A German-Chilean Research Initiative

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increasing precipitation & vegetation cover

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Exploring mineral nutrient supply along the EarthShape vegetation gradient

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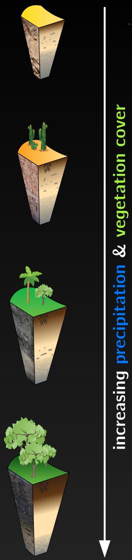
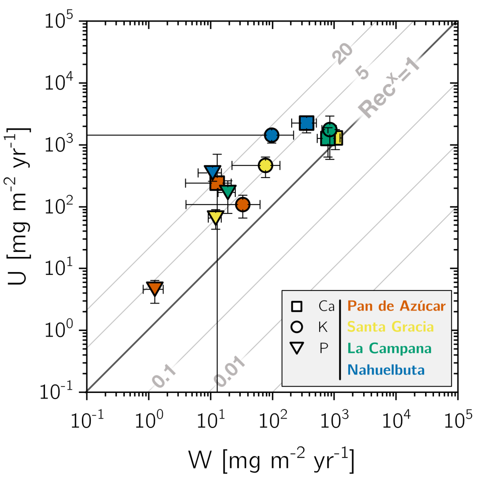
Ehlers et al., *EarthShape weather data collection* (2017)
Bernhard and Moskwa et al., *Catena, 170* (2018)
Oeser et al., *Catena, 170* (2018)
Werner et al., *Earth Surf. Dynam., 6* (2018)

Nutrient uptake exceeds release by weathering





$$U^X = \frac{NPP \times [X]_{plant}}{[C]_{plant}}$$

$$W^X = D \times [X]_{rock} \times (-\tau^X_{X_i})$$

$$Rec^X = \frac{U^X}{W^X}$$

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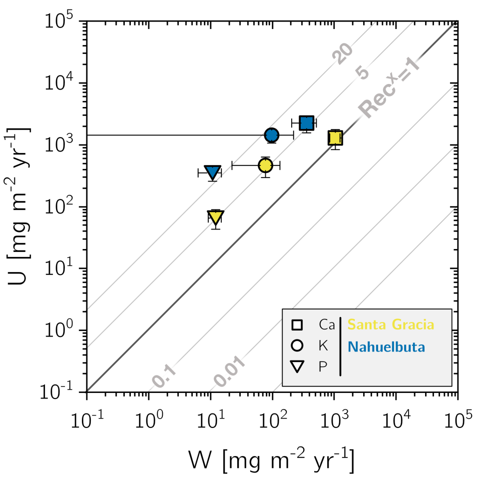

- Rather uniform W^X despite huge differences MAP, NPP & vegetation cover
- U^X exceed W^X
- U^X are higher in Nahuelbuta

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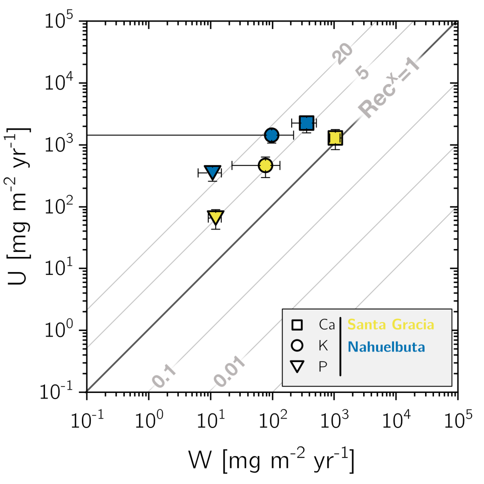

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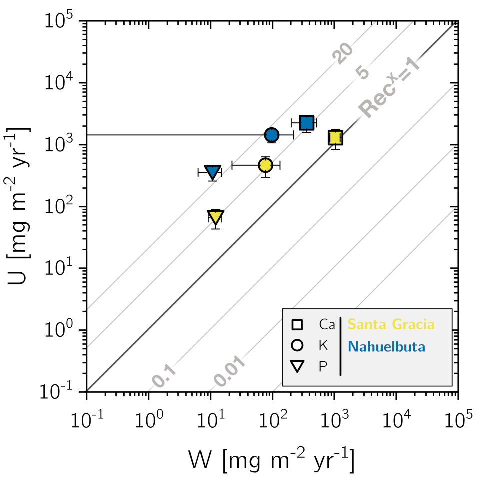

- Rather uniform W^X despite huge differences MAP, NPP & vegetation cover
- U^X exceed W^X
- U^X are higher in Nahuelbuta
- Rec^X are higher in Nahuelbuta, where NPP is high

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Why are W^X not high in humid Nahuelbuta?

Current paradigm: weathering flux is higher at sites with high MAP

- high runoff → high weathering flux for chemostatic elements

- high NPP → high W^X due to high demand

How biota accelerates weathering

(1) Deep plant roots can increase regolith thickness and provide larger nutrient inventory

(2) Land plants regulate the hydrological cycle and hence modulating runoff and total weathering fluxes

(3) Ectomycorrhizal fungi can actively extract nutrients such as P, K, Ca from minerals and plant litter

(4) Through the respiratory release of soil CO_2 and excretion of organic complexing agents plants, hyphae and their associated microbiota can increase the solubility limits of cations

How nutrient recycling decouples plant growth from weathering

- Ecosystems exert substantial control over weathering by both directly and indirectly modulating processes (enhance or increase W^X)
- Nutrient recycling rather than nutrient acquisition maintains plant's physiological demands in high NPP site
- **Because of nutrient buffering by recycling, higher plants today may not be a big driver in the global silicate-weathering cycle**