Biogeochemical Cycling in Conifer Forests of the Pacific Northwest, USA: Long-term Interactions of Soil Nitrogen, Mineralogy, and Logging Disturbance

Kaveh G. Siah, Steven S. Perakis, Julie C. Pett-Ridge, Gregory van der Heijden, Douglas A. Maguire

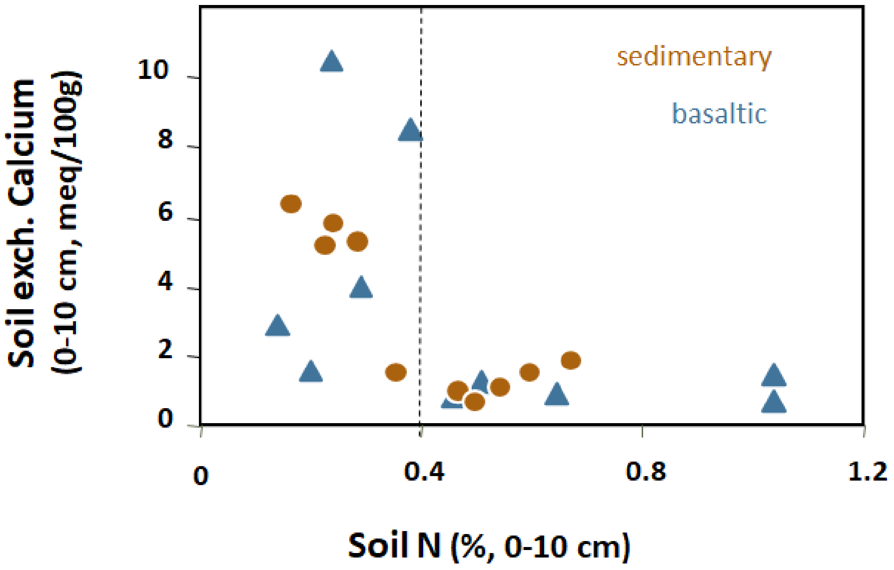
Background

- Focused on the Oregon Coast Range (OCR)
  - Douglas-fir forests
  - Nutrient depletion and effects on yield

- 3 interacting factors
  - Soil N
  - Soil mineralogy (parent material/bedrock type)
  - Logging disturbance

Soil N

- OCR soils have high soil N
  - High soil N can drive nutrient limitation
  - Nitrification promotes coupled nitrate-Ca leaching



Perakis et al., 2006

Parent Material

- Basaltic and Sedimentary bedrock
  - Basalt: high nutrient content
  - Sedimentary: lower nutrient content

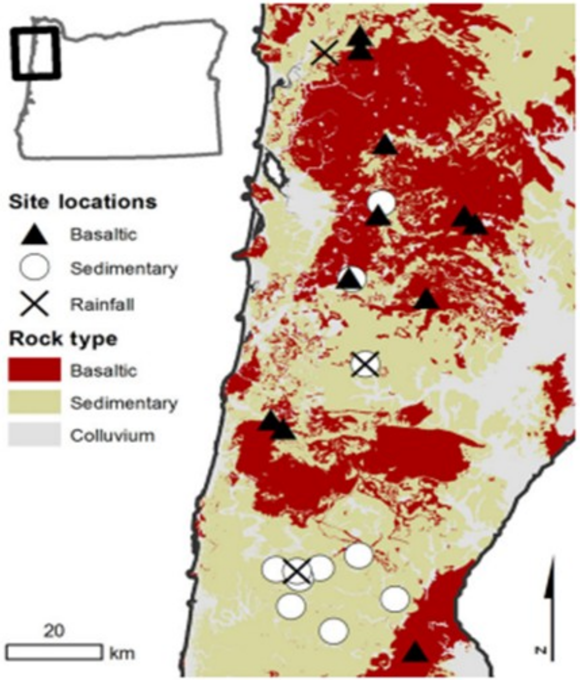


Fig. 1 Simplified geologic map and sampling locations in the Oregon Coast Range, USA.

Hynicka et al., 2016

Logging Disturbance

- Highly productive Douglas-fir forests are grown and harvested along these gradients
- They are managed along different harvest types (BO, WTH) and rotation lengths (40, 80 years).
- Forest management affects the nature and rate of nutrient depletion (which nutrient is being depleted)

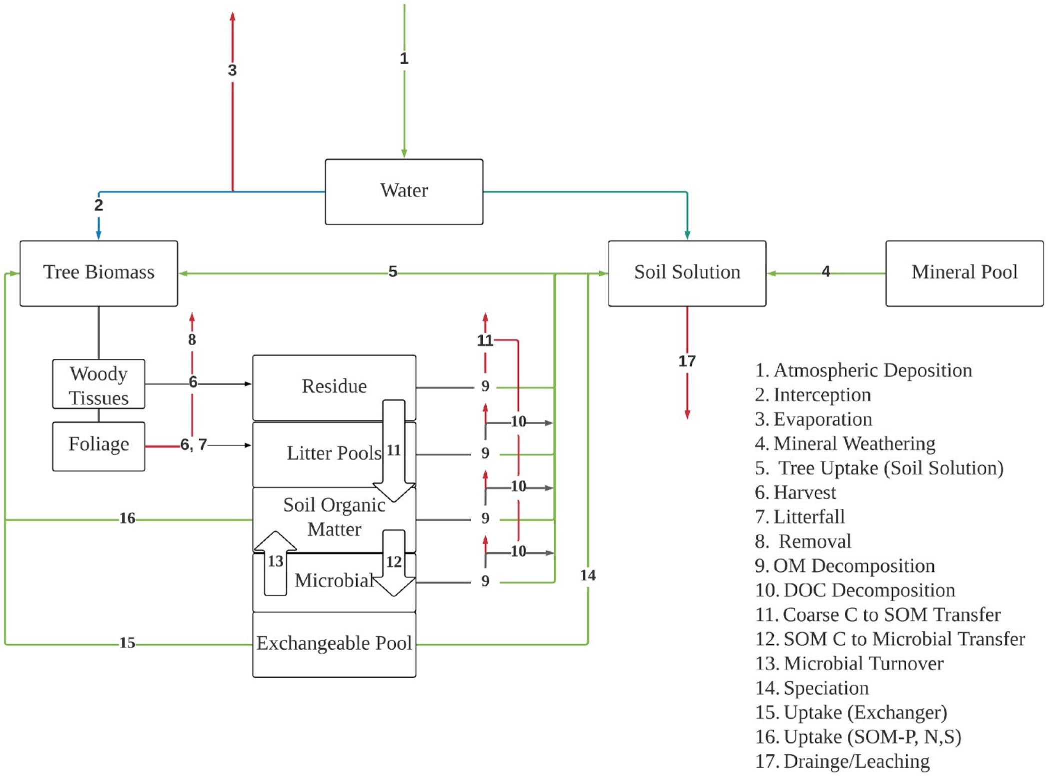
Harvest Type Influences Longterm Yield

- **What is the effect of harvest on longterm yield?**

- What nutrients are limiting over the course of the simulations?

The NutsFor Model

- Nutrient Cycling in Forest Ecosystems
- Simulates biogeochemistry, mineral weathering, hydrology, and tree growth
- Originates from soil-chemical models designed to study soil acidity
- Lead developer: Gregory van der Heijden (INRAE)



Ca, Mg, K, Na, NO_3, NH_4, SO_4, Cl, P, DOC, DON*, DOP*, H, pH, Al, R, HR, Si

Experimental Design: Nitrogen x Rock x Harvest

Table 2	Harvest Scenarios			
Site Conditions	***40-year, WTH***	***40-year, BO***	***80-year, WTH***	***80-year, BO***
Low N, Sedimentary				
High N, Sedimentary				
Low N, Basaltic				
High N, Basaltic				

Experimental Design: Nitrogen x Rock x Harvest

Table 2	Harvest Scenarios			
Site Conditions	***40-year, WTH***	***40-year, BO***	***80-year, WTH***	***80-year, BO***
Low N, Sedimentary				
High N, Sedimentary				
Low N, Basaltic				
High N, Basaltic				

Experimental Design: Nitrogen x Rock x Harvest

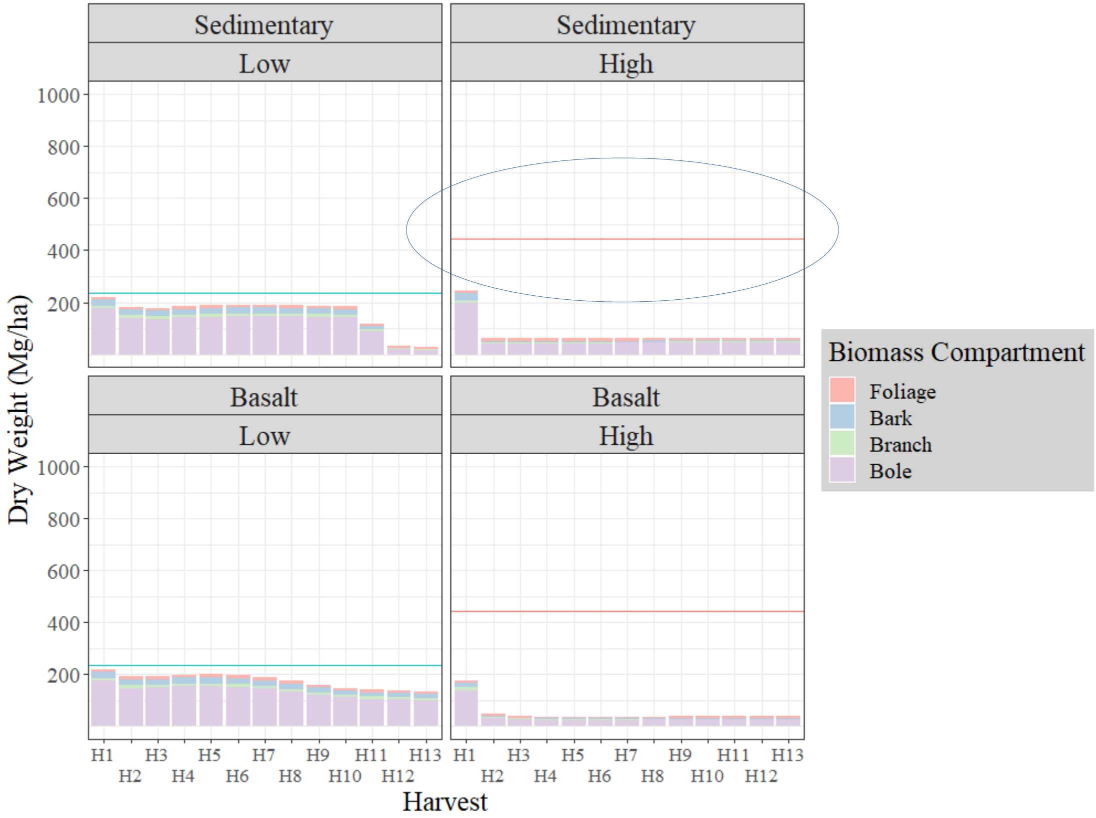
Table 2	Harvest Scenarios			
Site Conditions	*40-year, WTH*	*40-year, BO*	*80-year, WTH*	*80-year, BO*
Low N, Sedimentary	*40-year, WTH, Low N, Sed*	*40-year, BO, Low N, Sed*	*80-year, WTH, Low N, Sed*	*80-year, BO, Low N, Sed*
High N, Sedimentary	*40-year, WTH, High N, Sed*	*40-year, BO, High N, Sed*	*80-year, WTH, High N, Sed*	*80-year, BO, High N, Sed*
Low N, Basaltic	*40-year, WTH, Low N, Basalt*	*40-year, BO, Low N, Basalt*	*80-year, WTH, Low N, Basalt*	*80-year, BO, Low N, Basalt*
High N, Basaltic	*40-year, WTH, High N, Basalt*	*40-year, BO, High N, Basalt*	*80-year, WTH, High N, Basalt*	*80-year, BO, High N, Basalt*

Results

- **Compare biomass accrual**
  - Over time and cumulatively

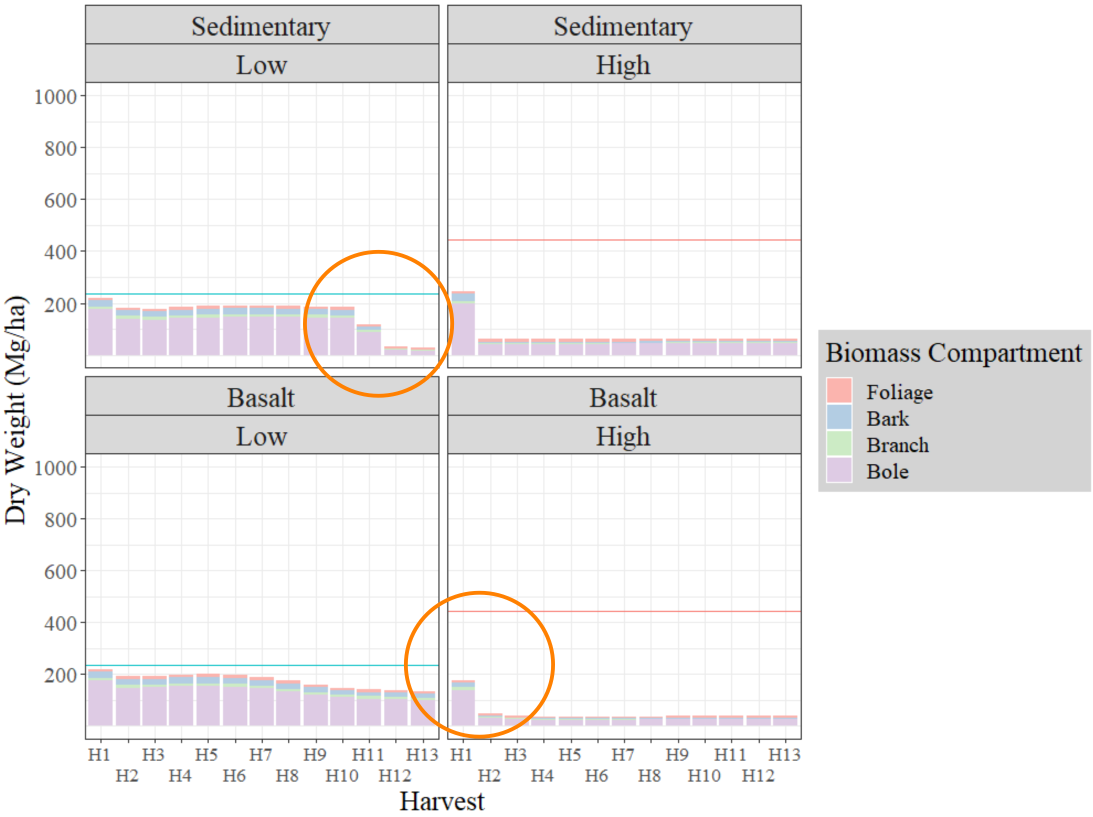
- Track nutrient uptake and limitation

40 BO



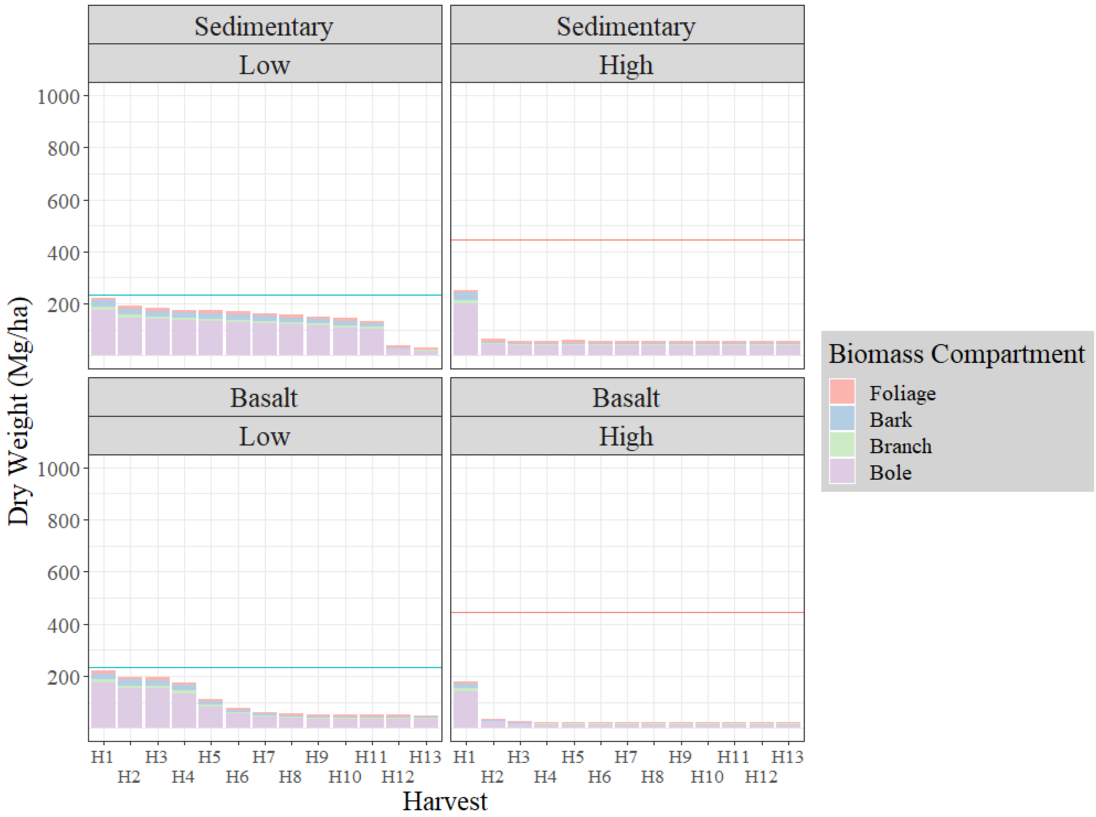
Sedimentary
Low
Sedimentary
High
Basalt
Low
Basalt
High
Dry Weight (Mg/ha)
1000
800
600
400
200
H1 H2 H3 H4 H5 H6 H7 H8 H9 H10 H11 H12 H13
Harvest
Biomass Compartment
Foliage
Bark
Branch
Bole

40 BO



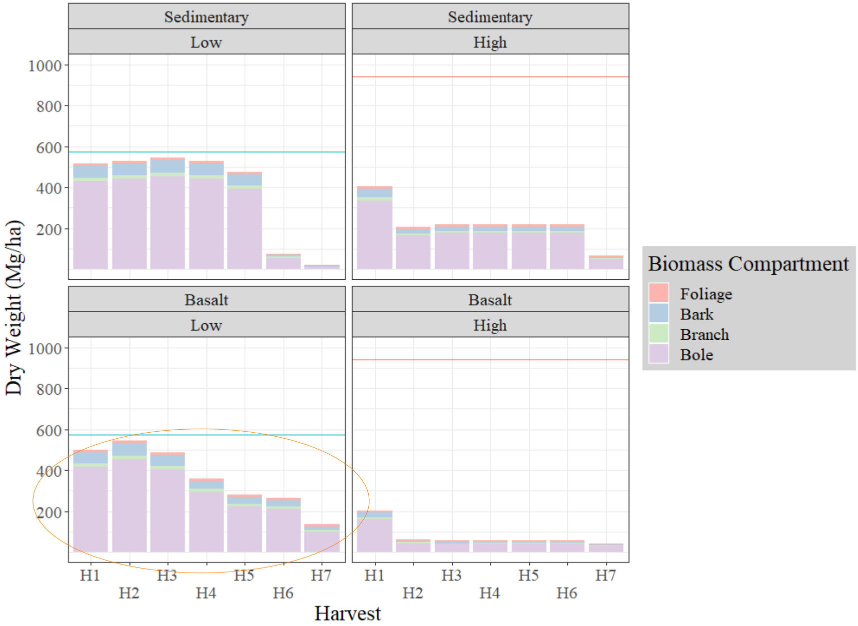
Sedimentary
Low
Sedimentary
High
Basalt
Low
Basalt
High
Dry Weight (Mg/ha)
1000
800
600
400
200
H1 H2 H3 H4 H5 H6 H7 H8 H9 H10 H11 H12 H13
Harvest
Biomass Compartment
Foliage
Bark
Branch
Bole

40 WTH



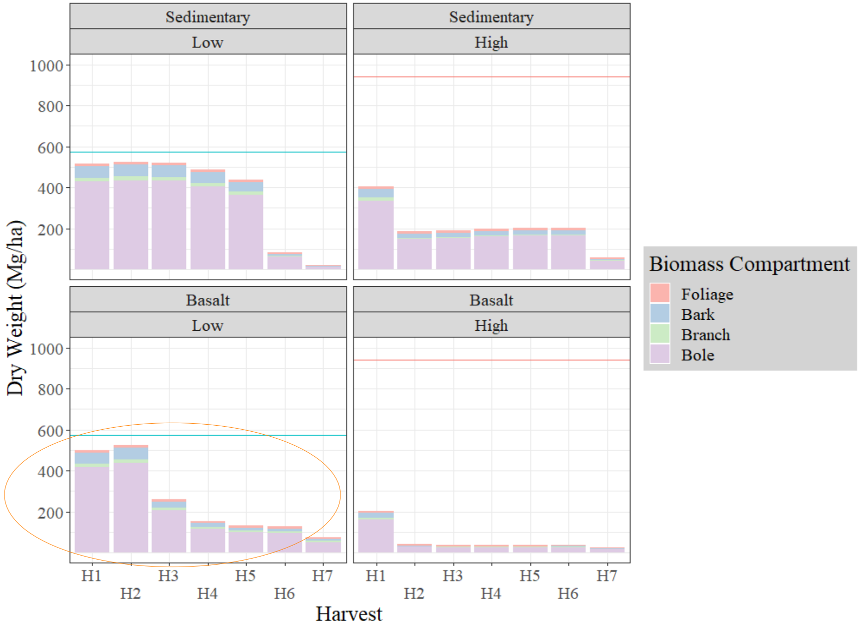
Sedimentary
Low
Sedimentary
High
Basalt
Low
Basalt
High
1000
800
600
400
200
Dry Weight (Mg/ha)
H1 H2 H3 H4 H5 H6 H7 H8 H9 H10 H11 H12 H13
Harvest
Biomass Compartment
Foliage
Bark
Branch
Bole

80 BO



Sedimentary
Low
Sedimentary
High
Basalt
Low
Basalt
High
1000
800
600
400
200
Dry Weight (Mg/ha)
H1
H2
H3
H4
H5
H6
H7
Harvest
Biomass Compartment
Foliage
Bark
Branch
Bole

80 WTH



Sedimentary
Low
Sedimentary
High
Basalt
Low
Basalt
High
1000
800
600
400
200
Dry Weight (Mg/ha)
H1
H2
H3
H4
H5
H6
H7
Harvest
Biomass Compartment
Foliage
Bark
Branch
Bole

Harvest Type Influences Longterm Yield

- What nutrients are limiting over the course of the simulations?
  - High N Sites: Ca and K
  - Low N Sites: N
    - Low N Basalt: K (less certain)
    - Low N Sedimentary: P

- What is the effect of harvest on nutrient depletion?

Management Implications

- High N sites experience base cation limitation
  - Biomass “crashes” after first harvest event
  - Harvest type and rotation length not enough
  - Amendments

Conclusion

- Long term N saturation determines the potential for growth limitation
- Logging intensity can alleviate some nutrient limitation
    - Not by much, growth limitation still occurs at high N sites

Thanks For Listening!

List of Collaborators and Contact Info:

Kaveh G. Siah: kavehsiah@gmail.com

Steven S. Perakis: sperakis@usgs.gov

Julie C. Pett-Ridge: julie.pett-ridge@oregonstate.edu

Gregory van der Heijden: gregory.van-der-heijden@inrae.fr

Douglas A. Maguire: doug.maguire@oregonstate.edu