CHRONIC NITROGEN DEPOSITION EFFECTS UNDER CLIMATE CHANGE IN AN AUSTRIAN KARST CATCHMENT

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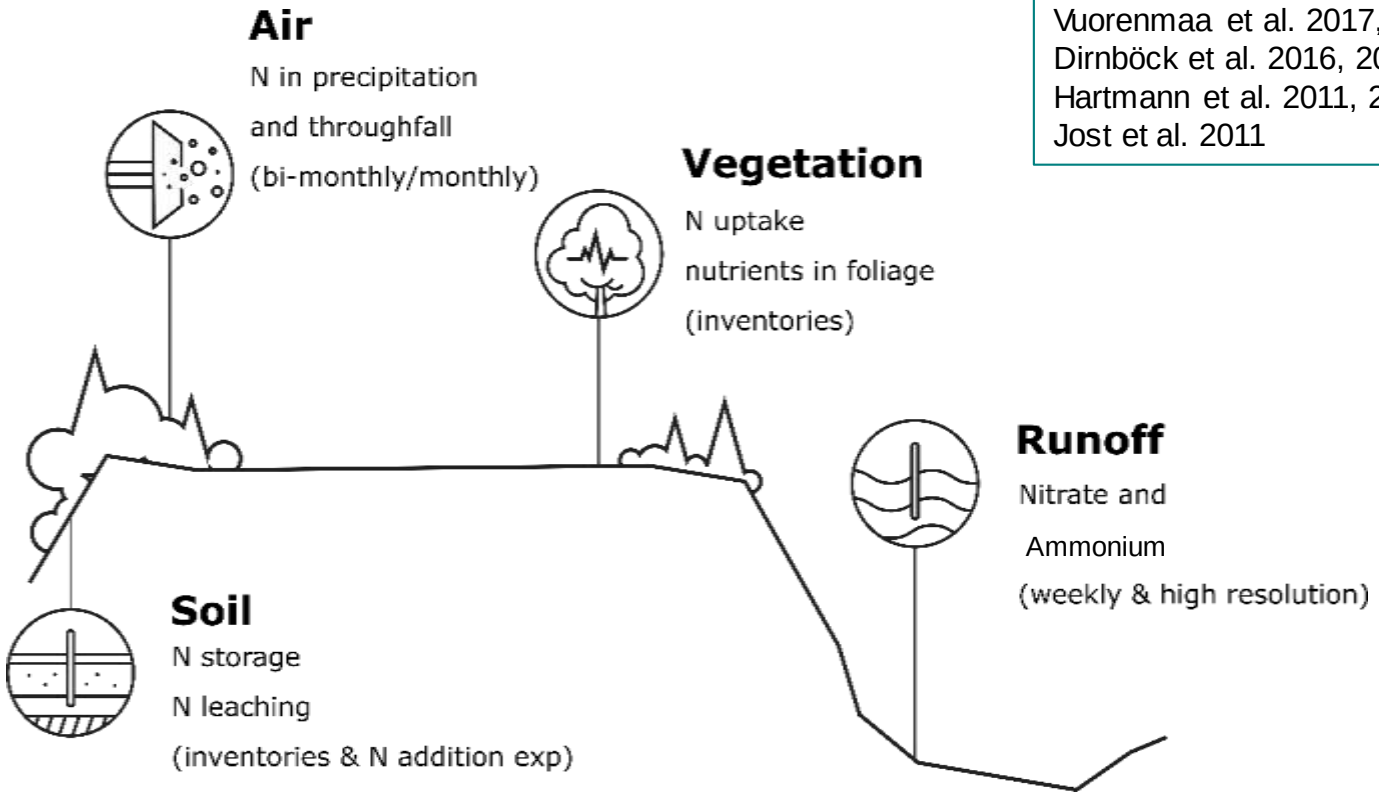
LONG-TERM ECOSYSTEM MONITORING ZÖBELBODEN

Input
energy, matter, water

Output
energy, matter, water

Long-term N cycle data

Hood-Nowotny et al. 2021
Leitner et al. 2020
Vuorenmaa et al. 2017, 2018
Dirnböck et al. 2016, 2017a, 2017b
Hartmann et al. 2011, 2016
Jost et al. 2011



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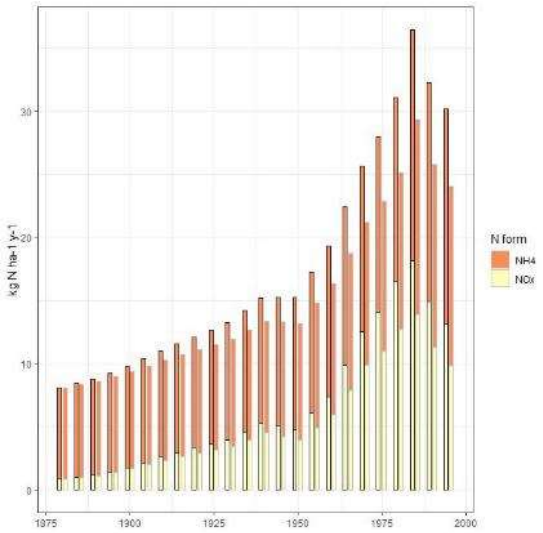
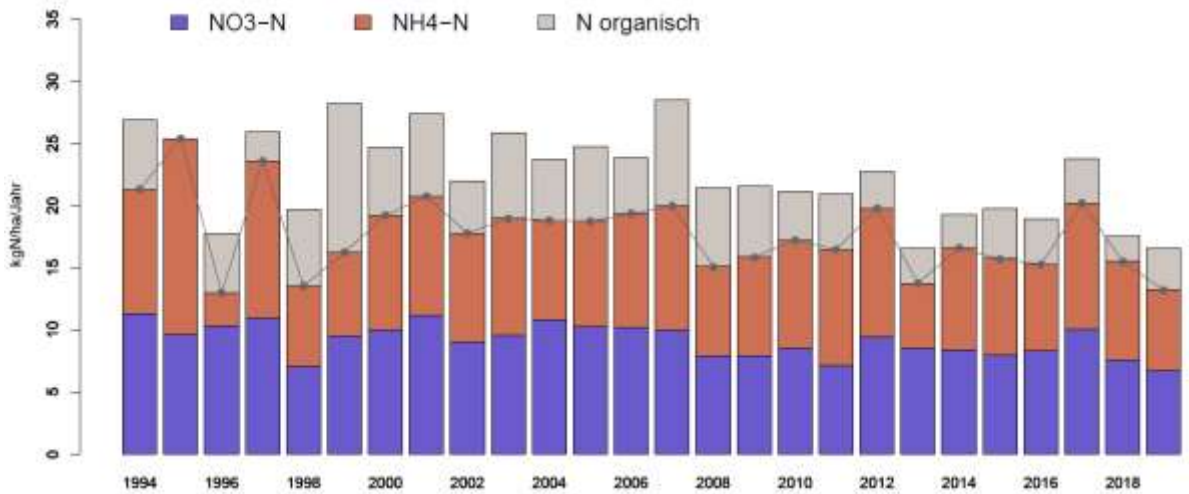
NITROGEN DEPOSITION

- N depostion peaked in the late 1980ies
- Chronic N deposition above or at the Critical Load of ~15 kg/ha/yr since 1960ies
- N deposition is slowly declining (mostly NOx emission reductions)





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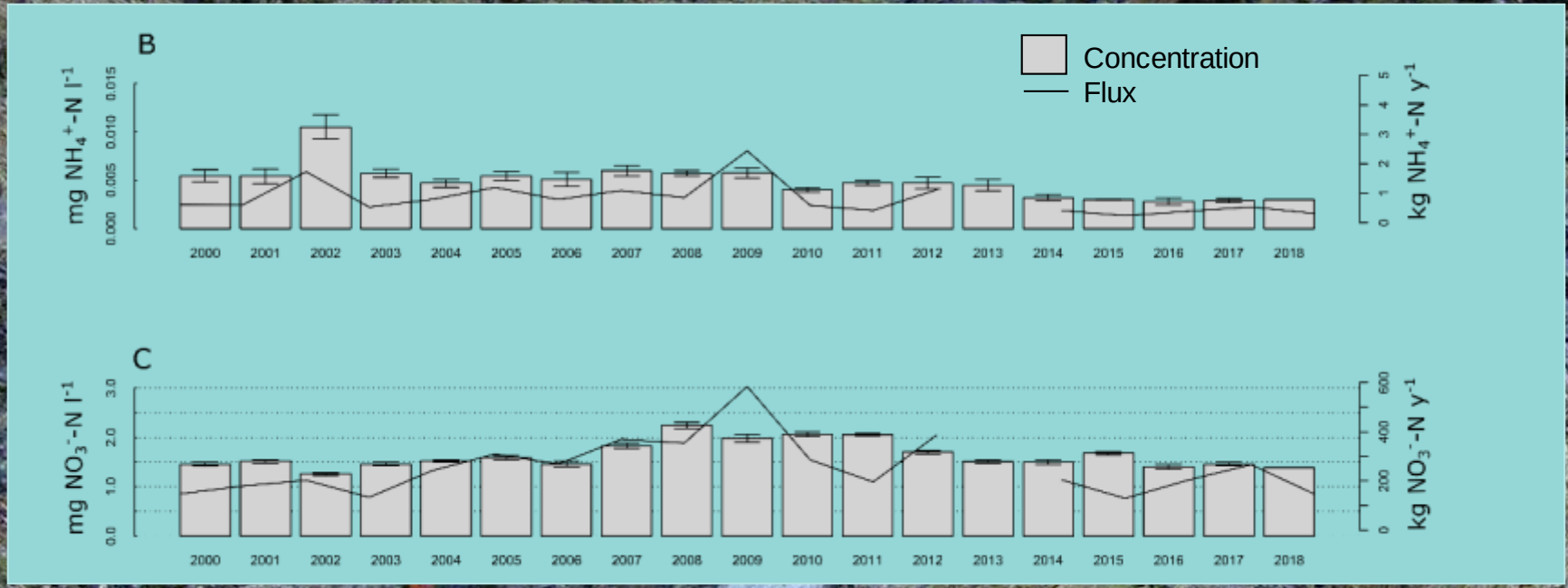


- **Catchment runoff:**
  - **Small decrease in Ammonium**
  - **Constant Nitrate runoff**
  - **Peak N runoff during forest disturban**

LONG-TERM TRENDS IN THE SOIL IN THE ENTIRE CATCHMENT

- N**o net accumulation of N in the soil** albeit increasing N stocks in the organic layer
- **Net loss of 19 kg N ha^{-1} yr^{-1}** annually from the soil between 1992 and 2004
- Significant **decrease in the mineral soil C:N ratio** between 1992 and 2014 (-1.6) might indicate an N effect

n=64	1992 - 2004	1992 - 2014
N concentration	–	–
C:N	(+)	–
O horizon N stock	+	
0-10 cm N stock	–	

N ADDITION EXPERIMENT (1x1m plots)

- N addition: 5x ambient N deposition
- Results confirmed that adding inorganic N to soil high in recalcitrant SOM (soil C:N ratio of 21:1) leads to a **decrease in decomposition** and effective **increase in soil C and N storage**.
  - **O horizon N stocks increased**
  - **No significant effect in A and B horizons**
- PLFA analyses and isotope tracing suggest that **decomposition was controlled by microbial activity rather than community structure**

Treatment	O-Horizon		A, B Horizons
	C [mg cm^{-2}]	N [mg cm^{-2}]	No significant difference
+N	112.3 ±73.3	4.9 ±3.2	
Control	60.0 ±65.3	3.0 ±3.3	

Significant ($p<0.001$) increase in C and N stocks in the O-horizon with 5x ambient N deposition

Hood-Novotny et al. (2021) Environ. Res. Commun. 3 (2021) 025001

FOLIAGE NUTRIENTS DO NOT INDICATE N SATURATION

Foliage concentrations/ratios in Norway spruce and European beech at Zöbelboden between 1992 to 2019. Arrows indicate significantly increasing and decreasing concentrations/ratios according to Mellert et al. 2012

g kg^{-1}	Spruce		Beech
	current year needles	one-year needles	
N	12.0±0.08 ↓	11.4±0.08 ↓	20.5±0.13
P	1.1±0.01	0.8±0.01 ↓	0.7±0.01
K	4.3±0.08	3.4±0.06	6.1±0.1
N:P	11.3±0.11	13.8±0.14	29.0±0.41
N:K	3.1±0.07	3.5±0.07	3.5±0.06 ↓

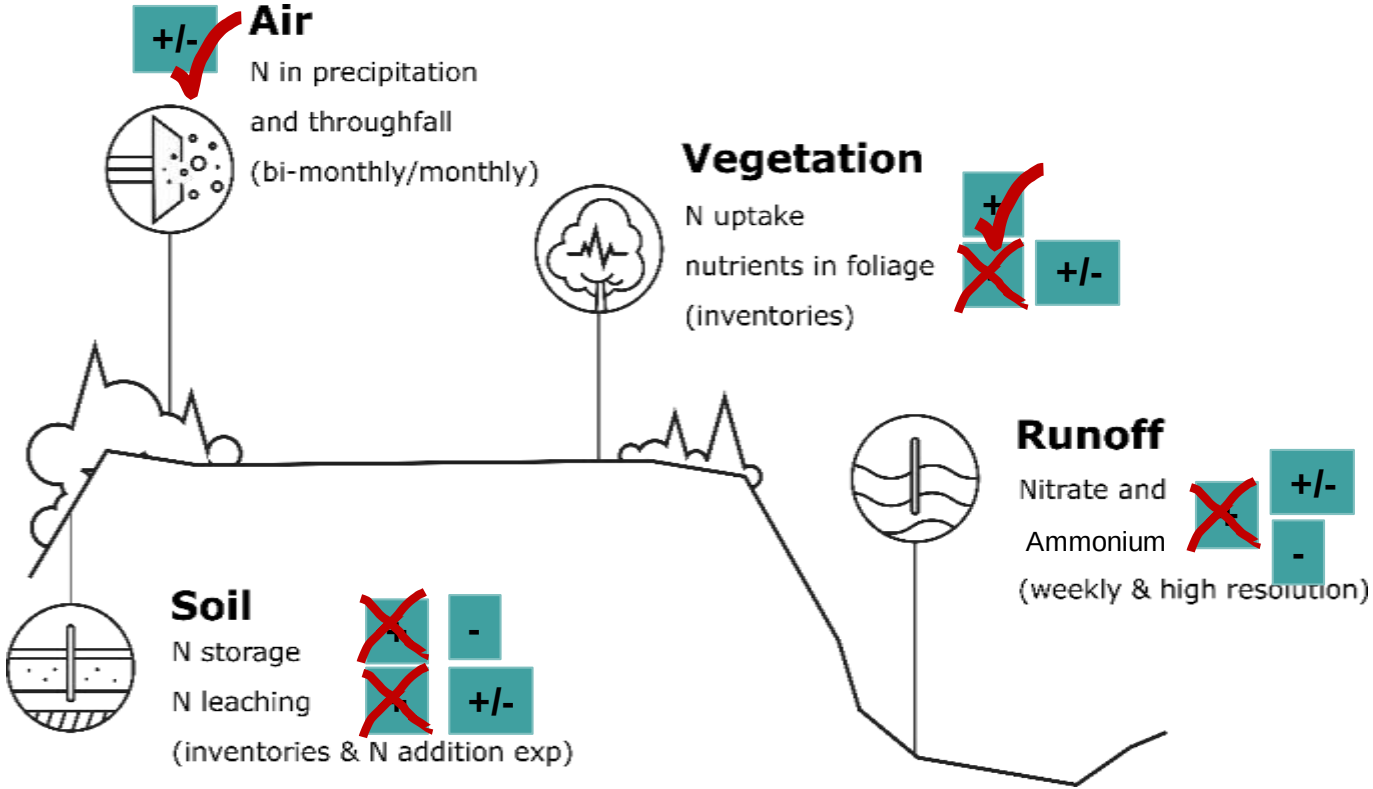
deficient above limit

normal

surplus below limit

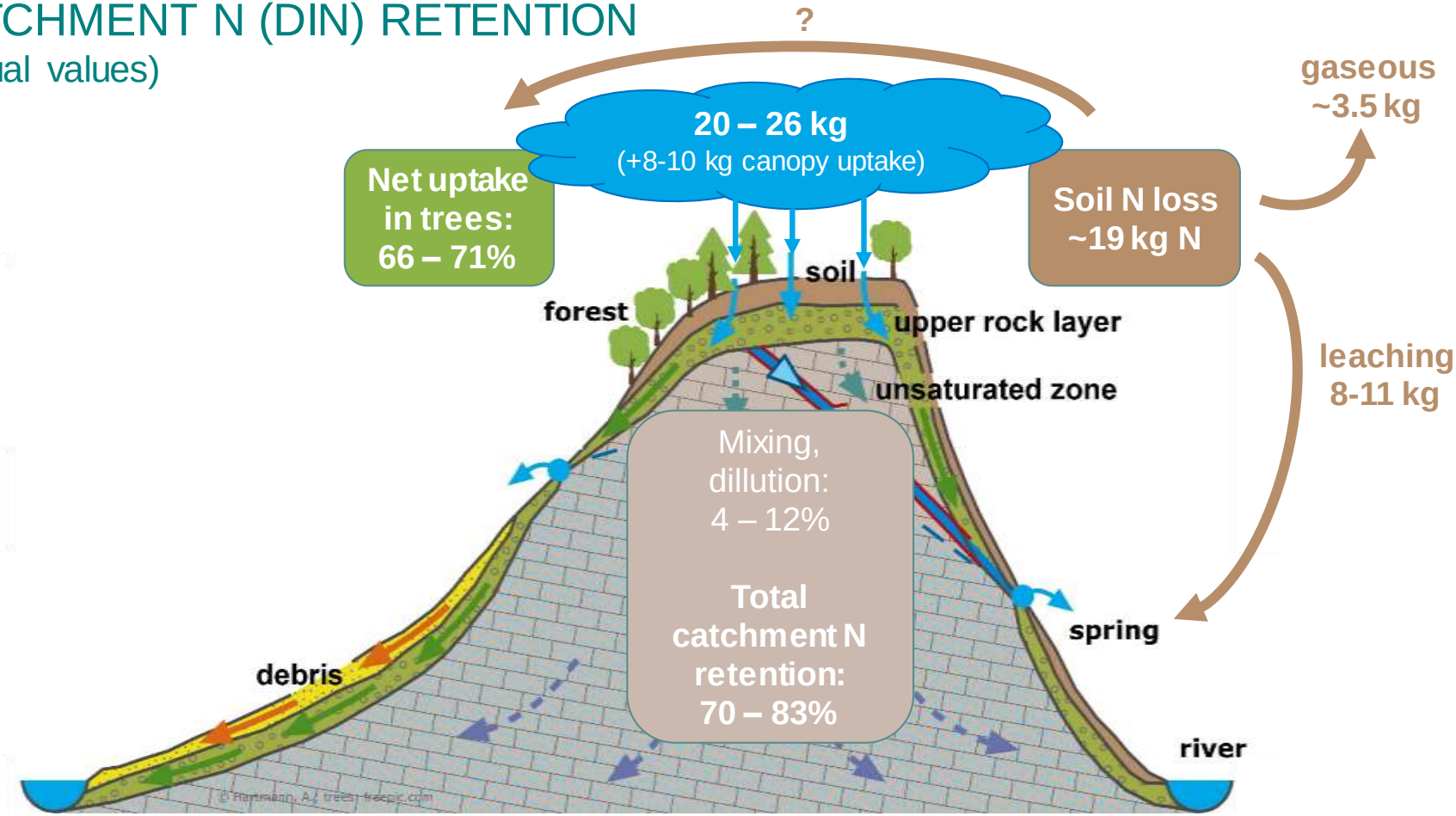
- Increasing N deficiency
- K and P deficiency did not worsen during the last 27 years

Summary of results



CATCHMENT N (DIN) RETENTION

(annual values)



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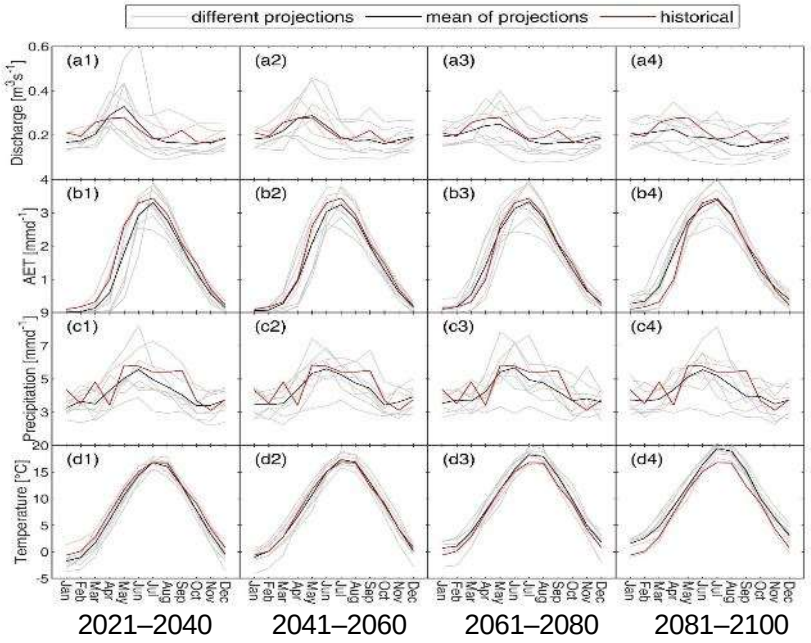
LIKELY FUTURE DEVELOPMENT

- **Hyopthesis 1.** N runoff will decrease because discharge will decrease (-12% until 2100) with climate change
  - Uncertainty: High-flow events may still increase N moblilization and runoff (unknown)
- **Hypothesis 2.** Increased tree growth due to warming will strengthen N immobilization
  - Uncertainty a: tree nutrition (not likely)
  - Uncertainty b: drought (no strong effects expected)
- **Hyopthesis 3.** N deposition will decrease
  - Uncertainty: depends upon the success of current policies (likely)
- **Hyopthesis 4**. Climatically triggered Spruce bark beetle outbreaks will cause pulses of N runoff

Comparisons between historical and projected mean monthly (a) discharge, (b) actual evapotranspiration, (c) precipitation, and (d) temperature (CORDEX RCP 8.5 climate model ensemble)



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