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European Joint Programme

Soil management impacts on soil structural properties in ten European long-term experiments

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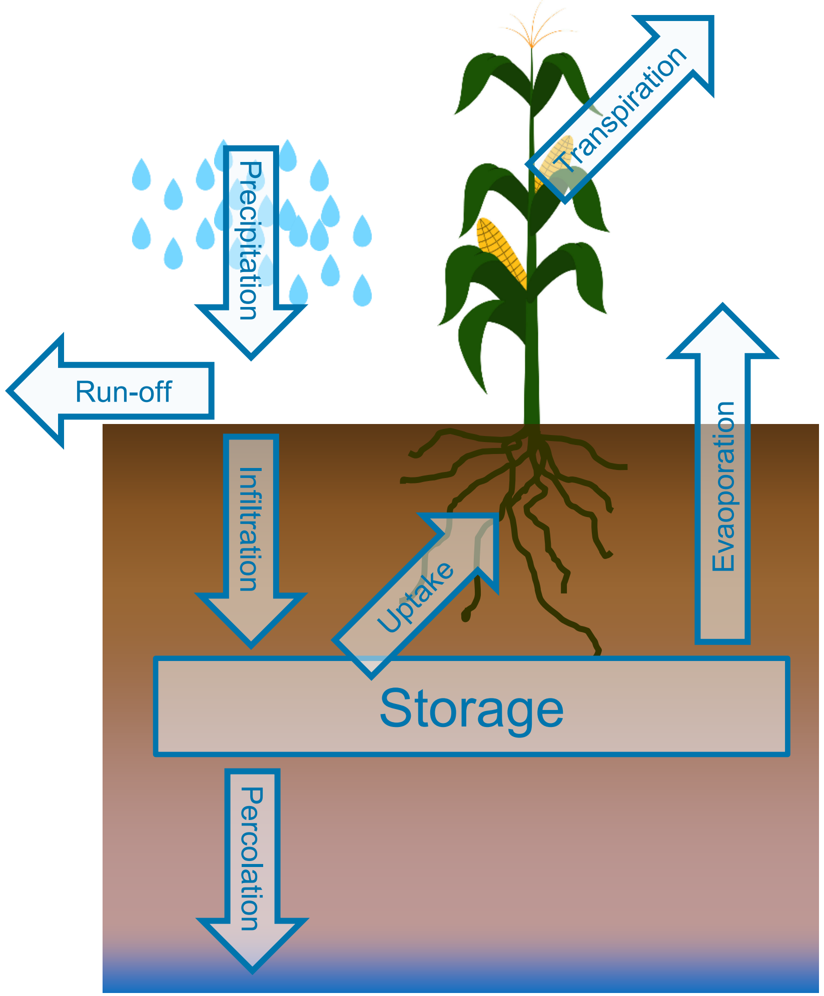
September 9th 2025, EUROSOIL

SOILX

Soil management needs to adjust to more frequent extreme weather events



Reduce soil erosion risk during heavy rainfall events

Improve water supply during dry periods

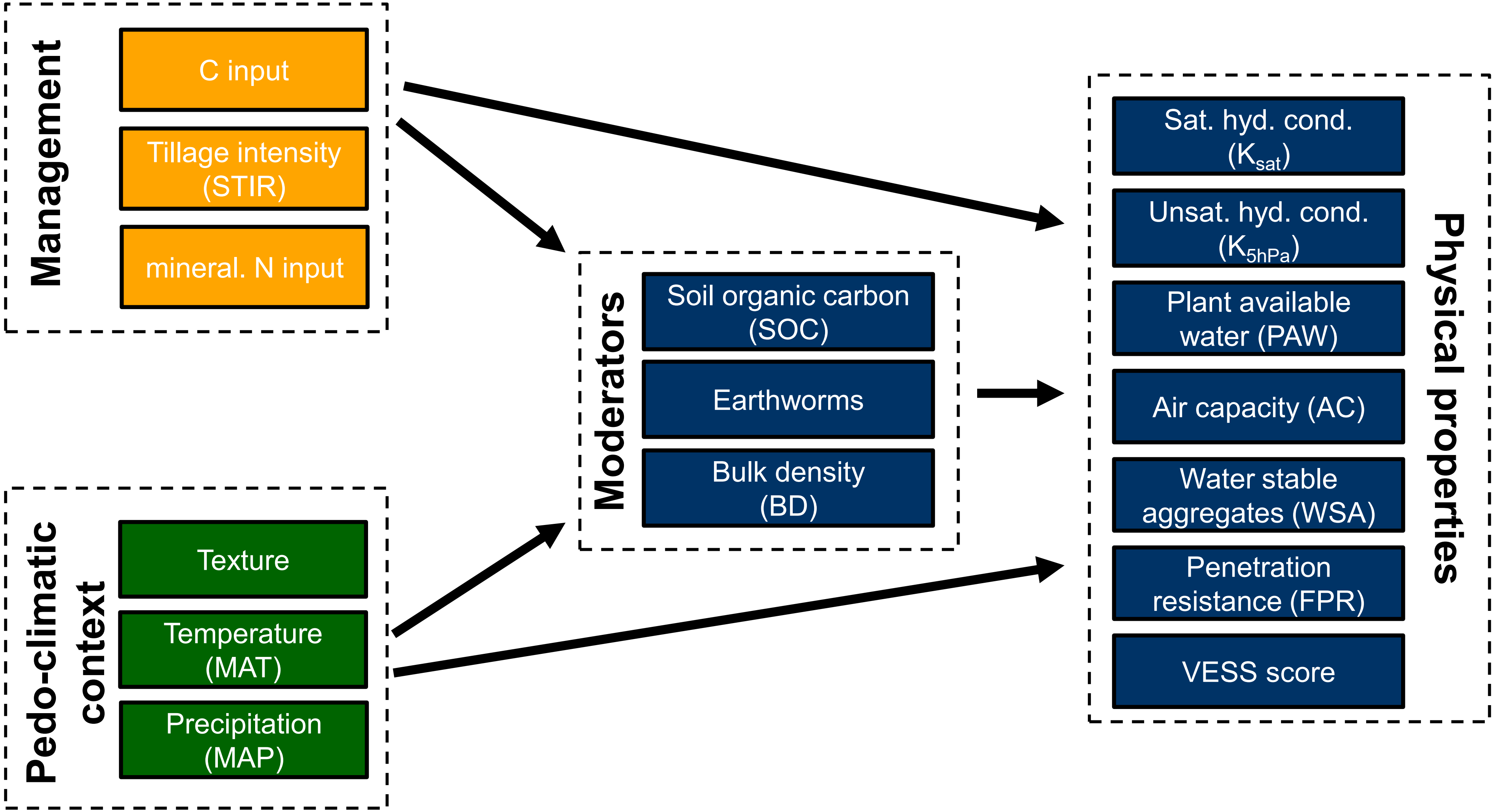
Aim and Hypotheses

Aim: Quantification of management effects on climate-change adaptation related soil physical properties

Hypotheses:

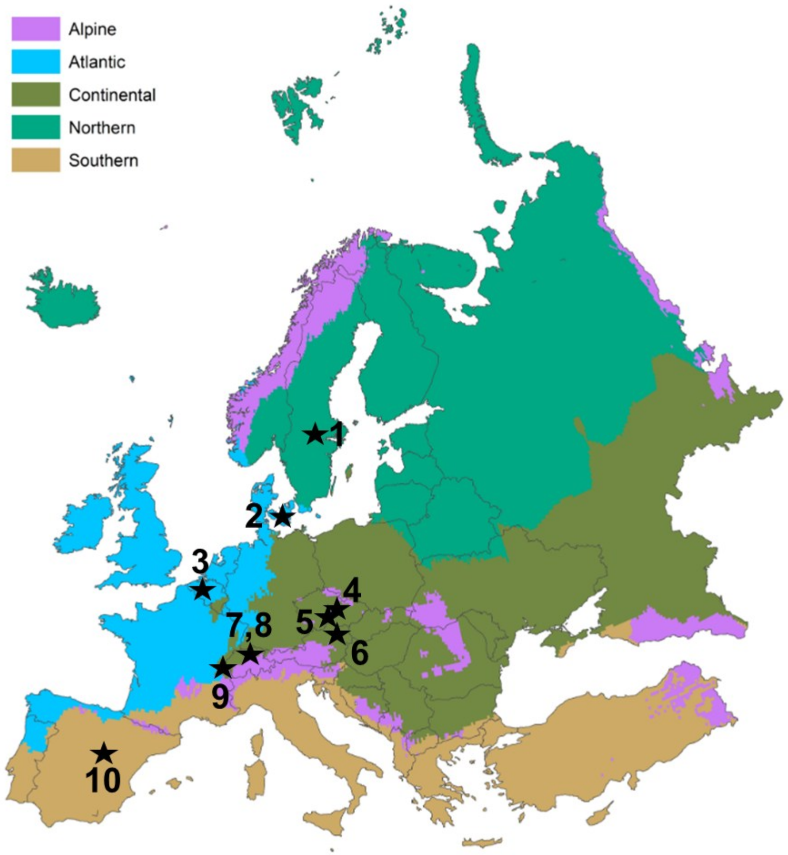
1. Pedo-climatic conditions, in particular soil texture and climate, are the dominant drivers of soil physical properties, especially in the subsoil.
2. Management influences soil physical properties by modifying *SOC*, *BD*, and *earthworm* abundance.
3. The effects of management on soil functions are mediated through these key properties rather than acting directly.

Assumed cause-effect-relations



Sites and methods

Sampling in ten long-term experiments (LTE)



Map from Metzger (2018), doi.org/10.7488/ds/2416

#	LTE / Country	Factors	Treatments	Blocks
1	Säby (SE)	rotation	2	3
2	CENTS (DK)	tillage, organic matter	2	4
3	BOPACT (BE)	tillage, organic matter	4	4
4	Čáslav (CZ)	organic matter	2	4
5	Lukavec (CZ)	organic matter	2	4
6	Hollabrunn (AT)	tillage	2	3
7	FAST (CH)	tillage	2	4
8	ZOFE (CH)	organic matter	2	4
9	P24A (CH)	organic matter	2	4
10	INIA (ES)	tillage, rotation	4	4

in total 92 plots

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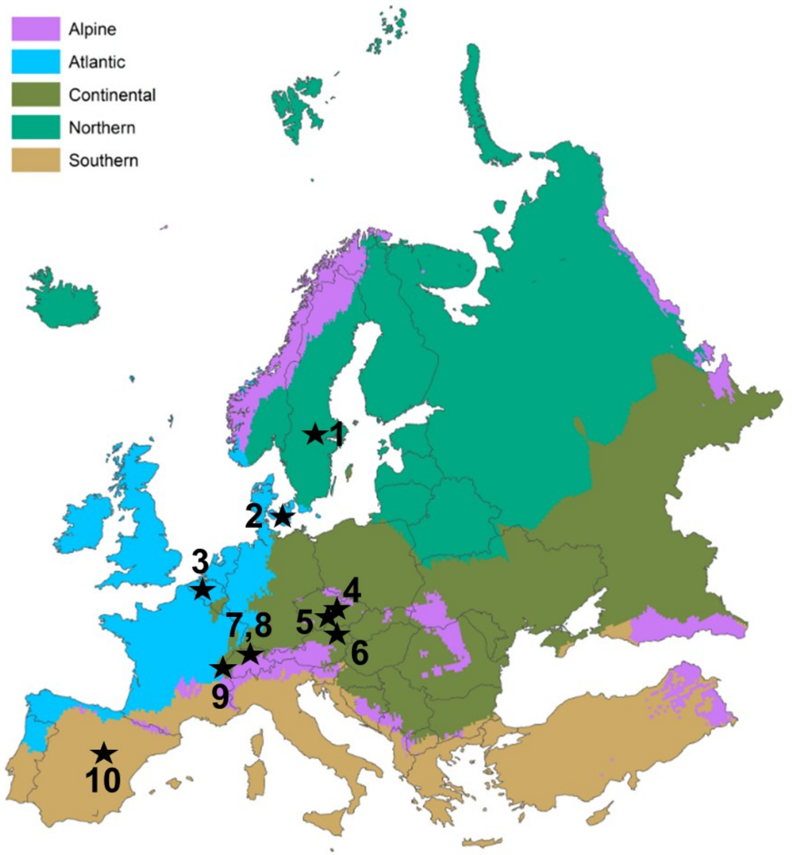
Soil sampling



Map from Metzger (2018), doi.org/10.7488/ds/2416

VESS score

Earthworms

Soil organic carbon (SOC)

Bulk density (BD)

Sat. hyd. cond. (K_{sat})

Unsat. hyd. cond. (K_{5hPa})

Plant available water (PAW)

Air capacity (AC)

Water stable aggregates (WSA)

Penetration resistance (FPR)

Texture

SoilManageR to calculate management indicators

Management Data (categorical and numerical)

date	category	operation	device	value	unit
2009-08-24	sowing	sowing_cover_crop	direct_drill	50.00	kg/ha
2009-10-08	tillage	stubble_cultivation	mulching	NA	NA
2009-10-08	tillage	primary_tillage	plough	20.00	cm
2009-10-20	tillage	seedbed_preparation	rotary_harrow	10.00	cm
2009-10-21	sowing	sowing_main_crop	direct_drill	190.00	kg/ha
2009-10-21	crop_protection	fungicide	seed_coating	0.38	l/ha
2010-03-19	fertilizer_application	mineral_fertilization	solid_broadcast	50.00	kg N/ha
2010-03-25	crop_protection	weed_herbicide	sprayer_broadcast	3.00	l/ha
2010-04-09	fertilizer_application	mineral_fertilization	solid_broadcast	30.00	kg N/ha
2010-05-17	fertilizer_application	mineral_fertilization	solid_broadcast	30.00	kg N/ha
2010-08-04	harvest	harvest_main_crop	combine_harvester	NA	NA
2010-08-09	harvest	straw_removal	square_baler	NA	NA
2010-08-10	tillage	stubble_cultivation	fine_cultivator	10.00	cm
2010-08-13	sowing	sowing_cover_crop	direct_drill	50.00	kg/ha
2011-04-15	tillage	stubble_cultivation	mulching	NA	NA
2011-04-18	tillage	primary_tillage	plough	20.00	cm
2011-04-28	tillage	seedbed_preparation	rotary_harrow	10.00	cm
2011-04-29	sowing	sowing_main_crop	direct_single_grain	95000.00	plants/ha
2011-04-29	crop_protection	insecticide	seed_coating	142.50	g/ha
2011-05-10	fertilizer_application	mineral_fertilization	solid_broadcast	30.00	kg N/ha
2011-05-10	fertilizer_application	mineral_fertilization	solid_broadcast	47.00	kg P2O5/ha
2011-05-31	crop_protection	weed_herbicide	sprayer_broadcast	1.00	l/ha

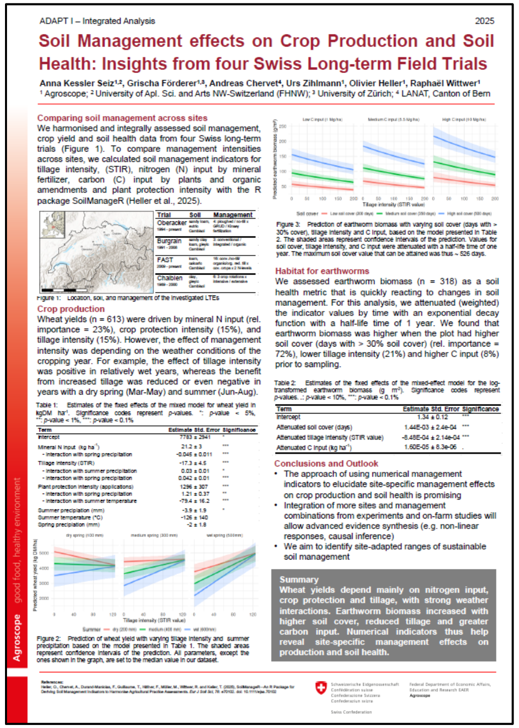
SoilManageR

Soil Management Indicators (numerical)

Carbon (C) input

Tillage intensity (STIR)

Mineral Nitrogen (N) input



Poster #1058 in GT 06 Ground Floor (Wed-Thu)

Heller et al., (2025), SoilManageR—An R Package for Deriving Soil Management Indicators to Harmonise Agricultural Practice Assessments. Eur J Soil Sci, 76: e70102. https://doi.org/10.1111/ejss.70102

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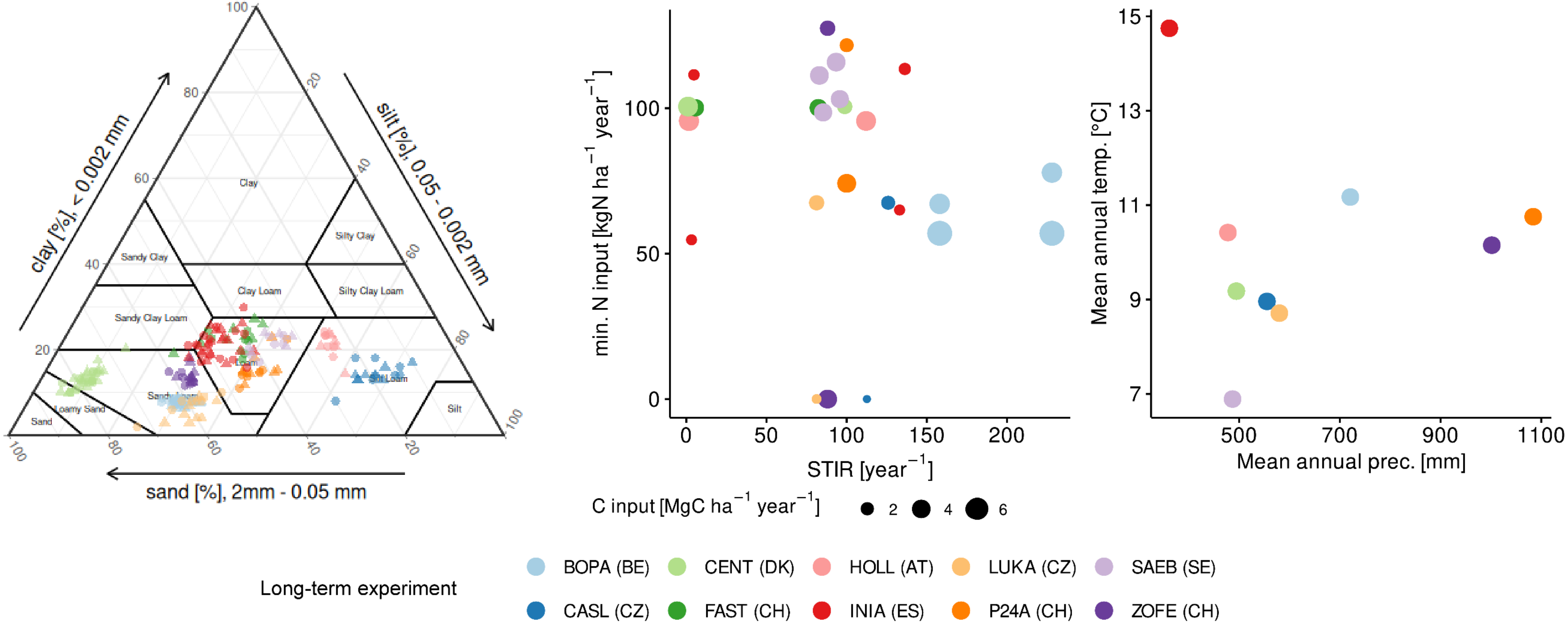
Soil texture, management indicators and climate



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Correlation of soil physical properties

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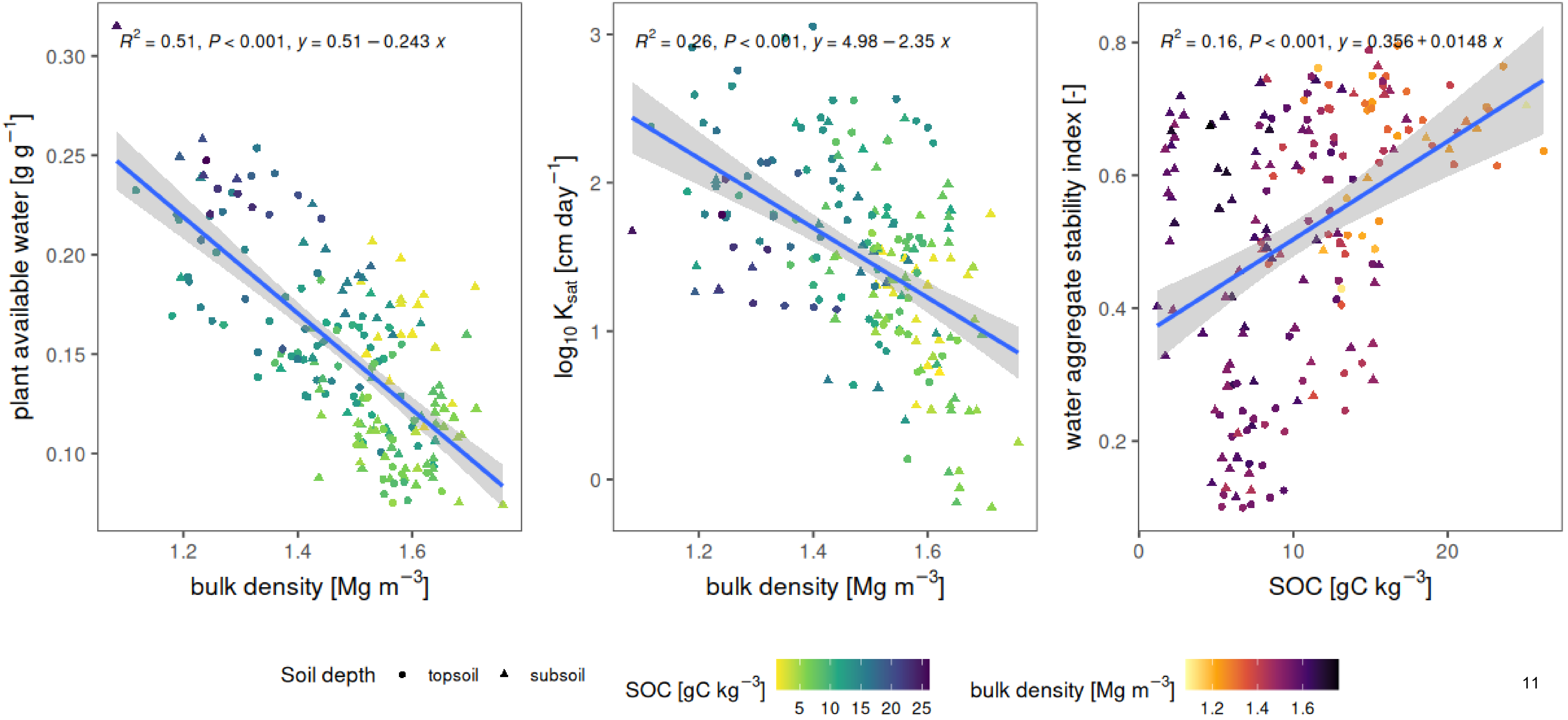
Soil physical properties are correlated with BD and/or SOC



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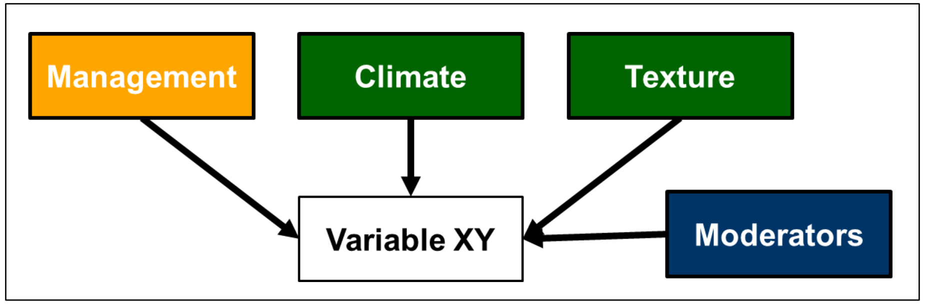
Disentangling direct and indirect effects

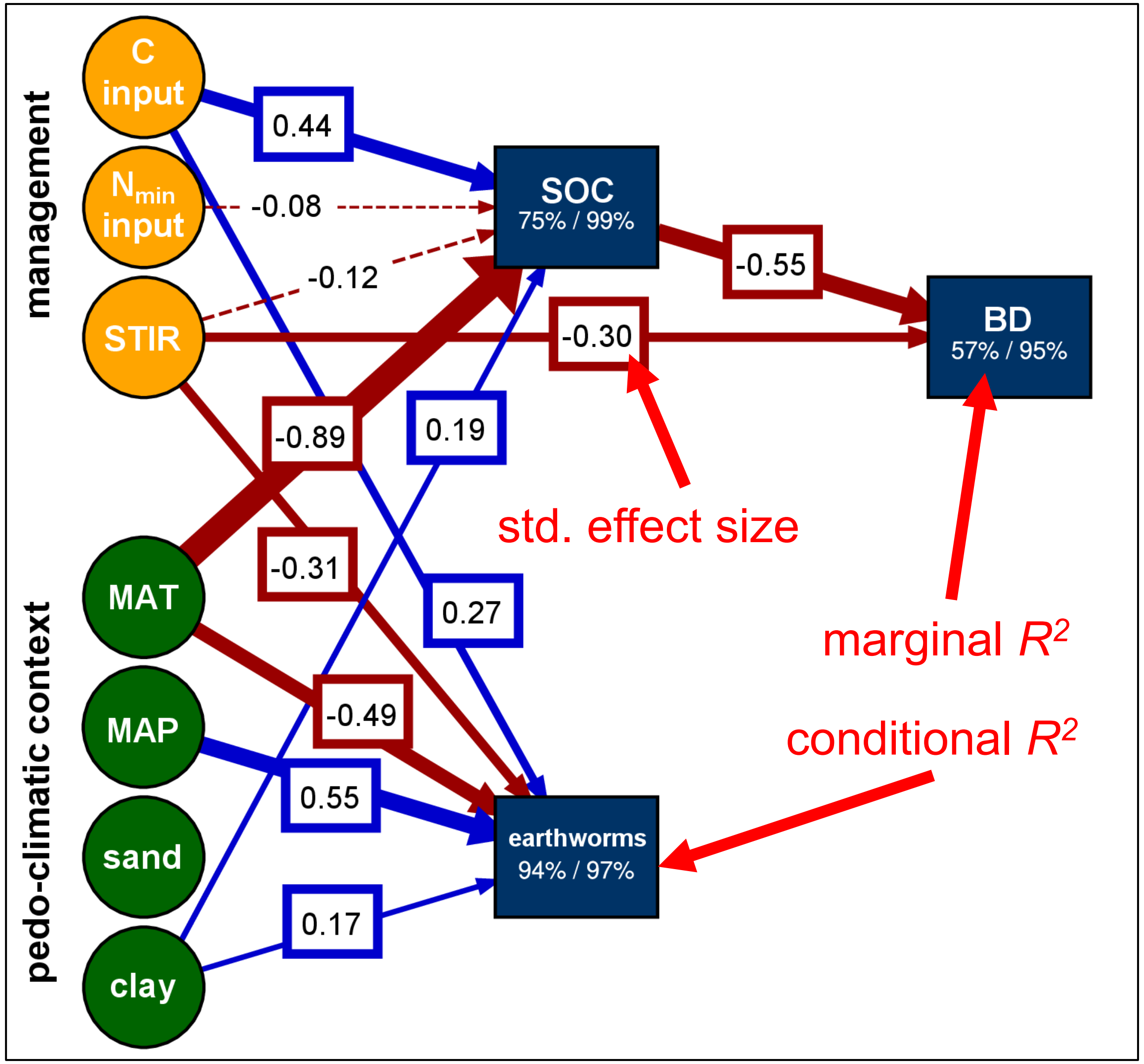
Variable selection and path analysis



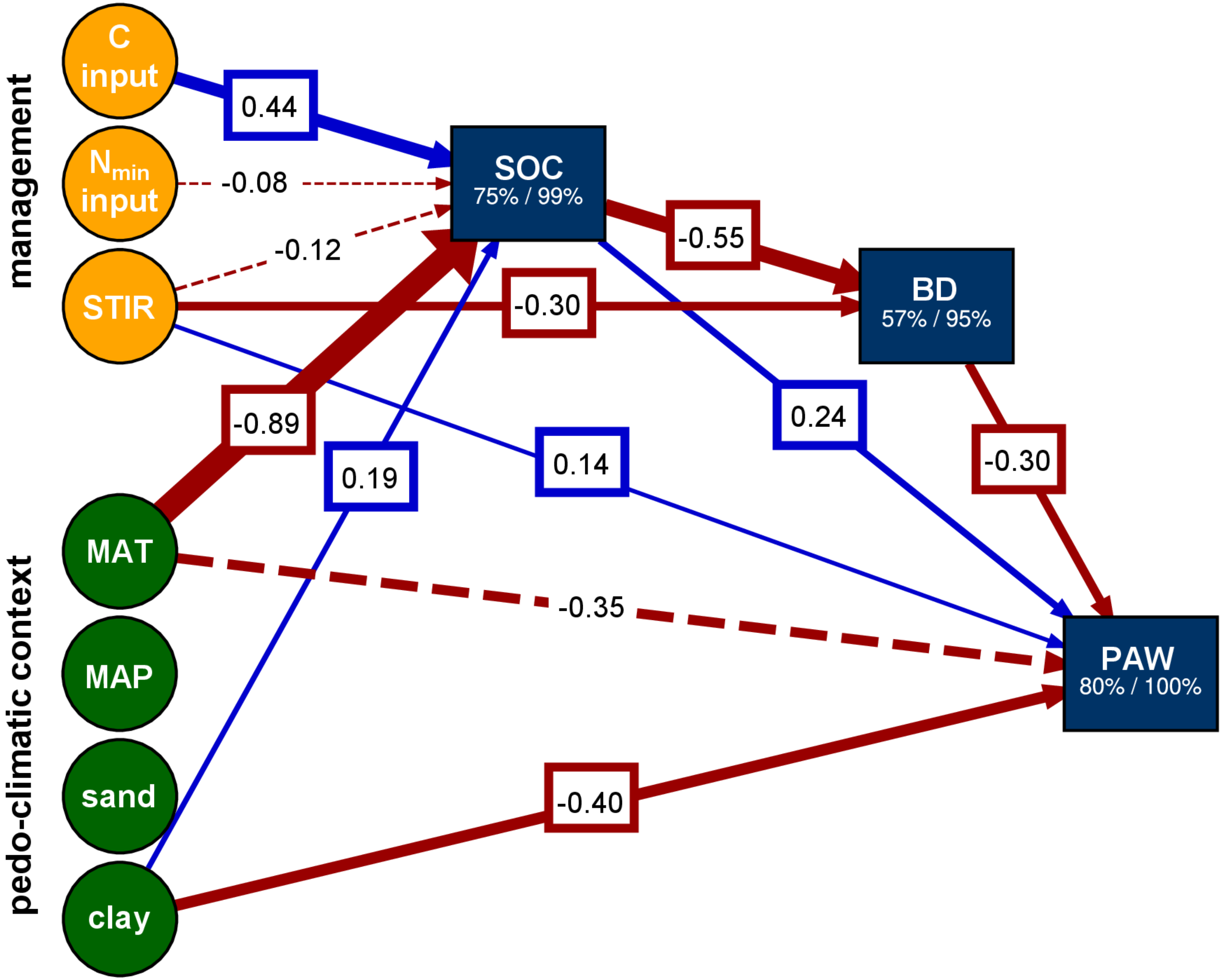
variable selection

SOC ~
C input + **STIR** +
min N input +
MAT + **clay** +
(1 | **LTE**)

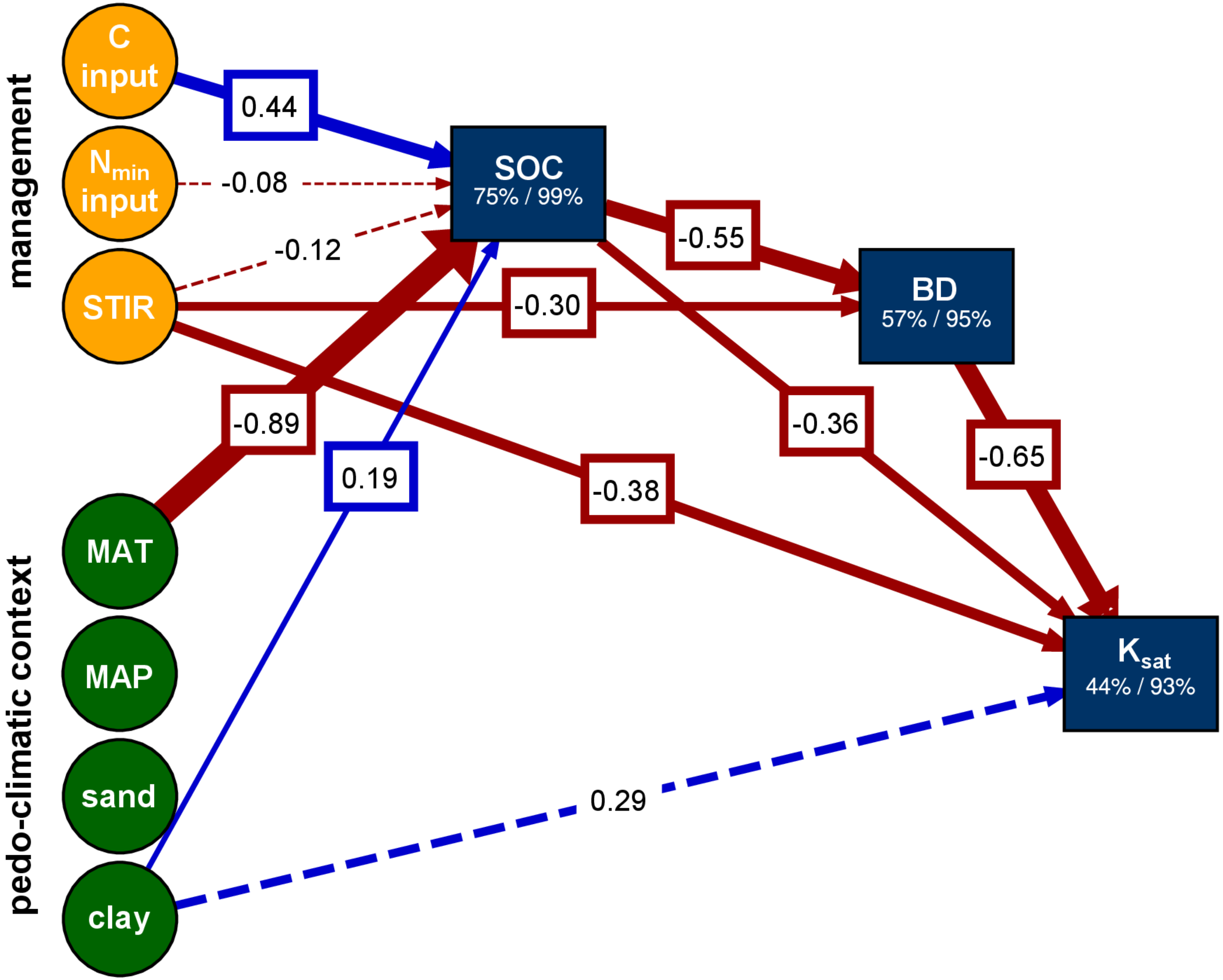
combination of models



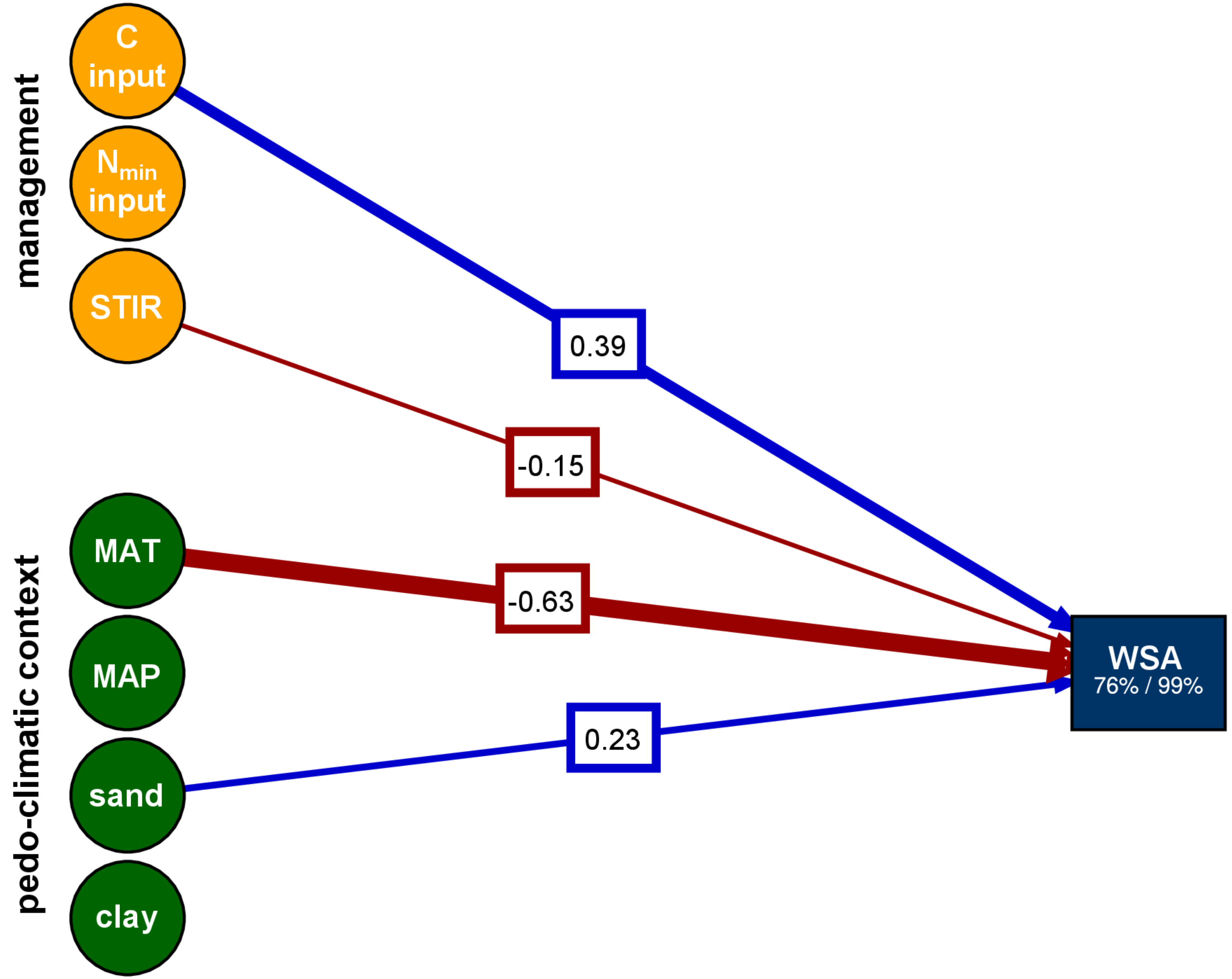
Drivers of plant available water (PAW)



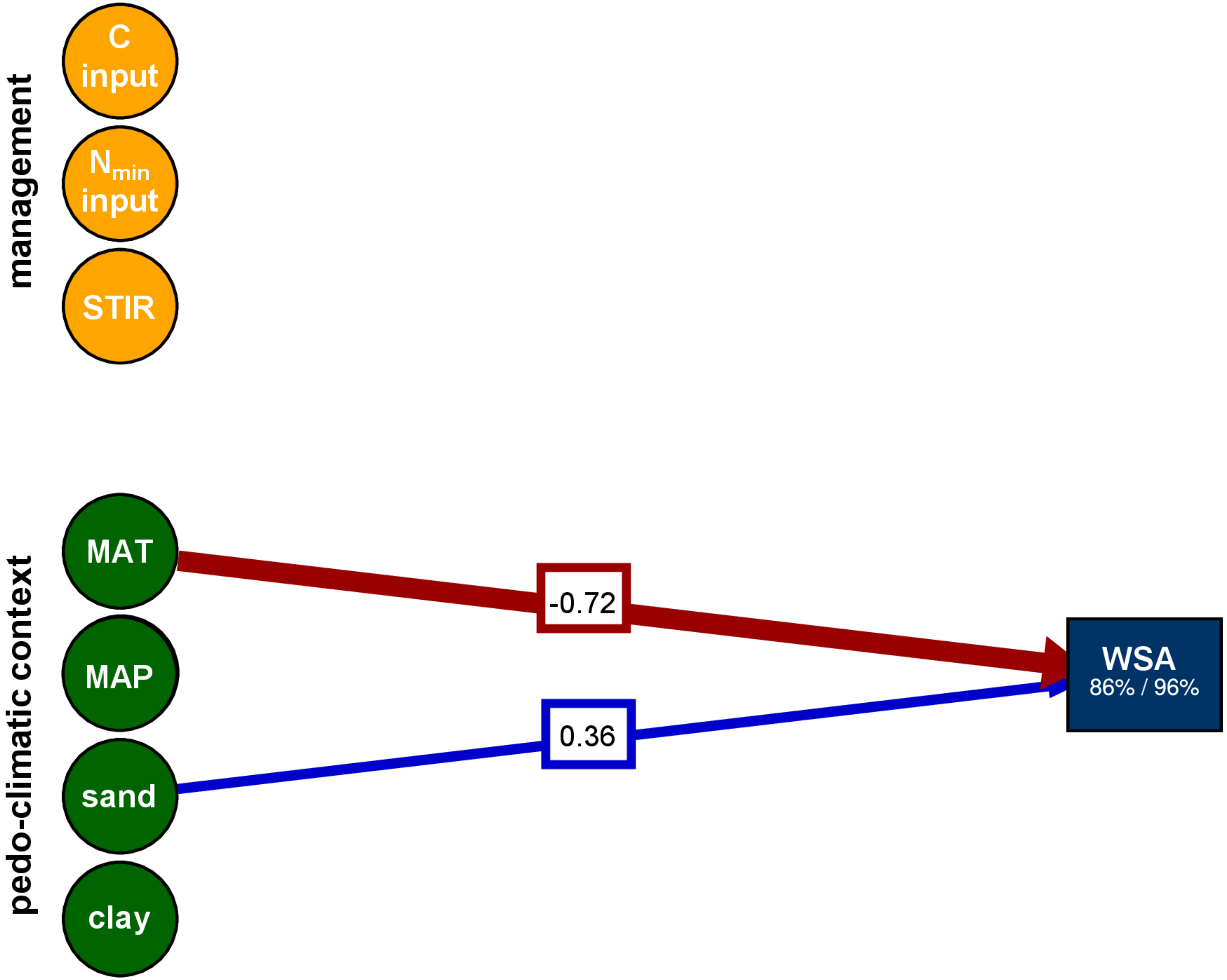
Drivers of saturated hydraulic conductivity (K_{sat})



Drivers of aggregate stability (WSA)

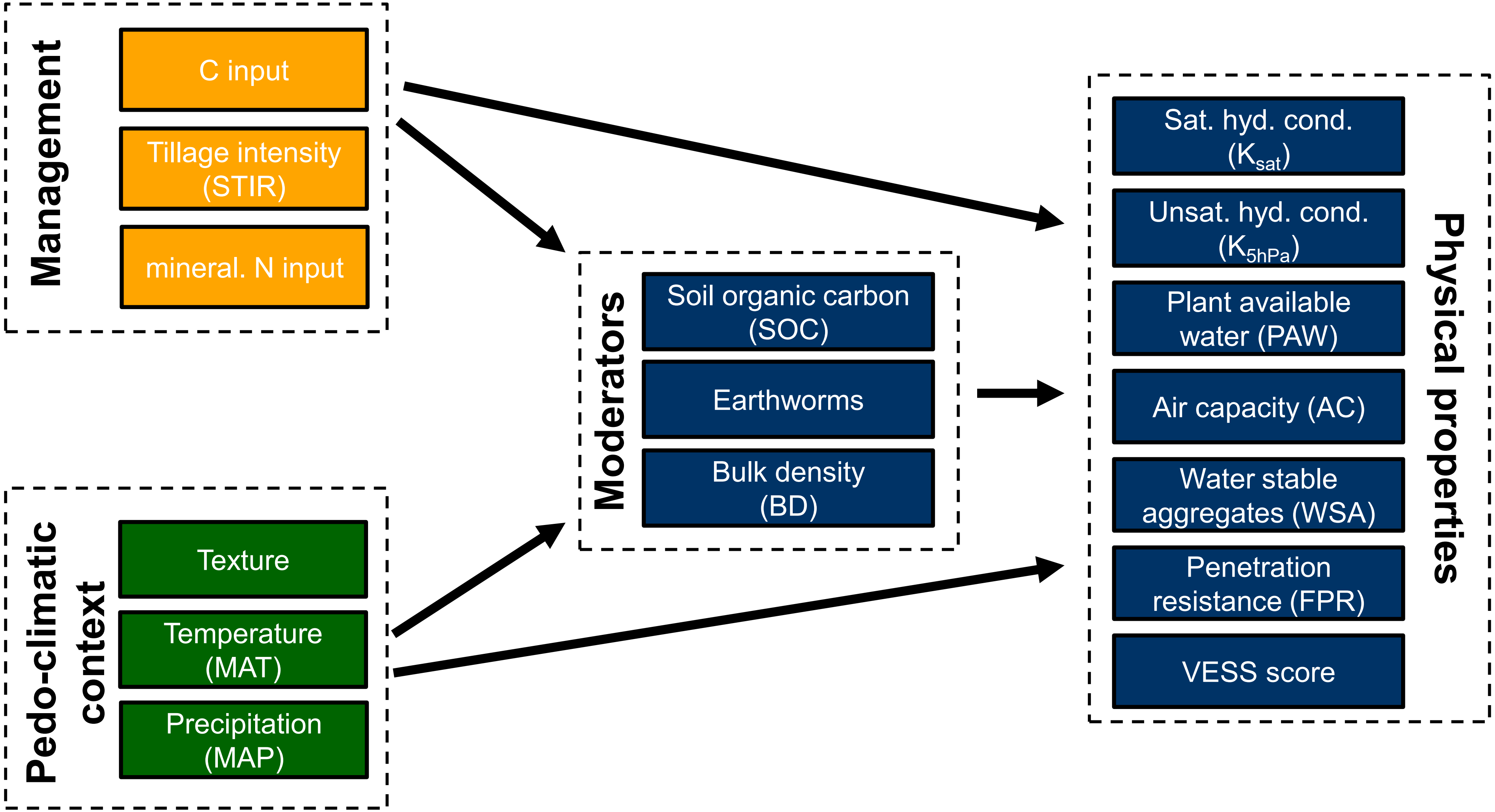


Drivers of aggregate stability (WSA) in the subsoil



Summary and Conclusions

Assumed cause-effect-relations



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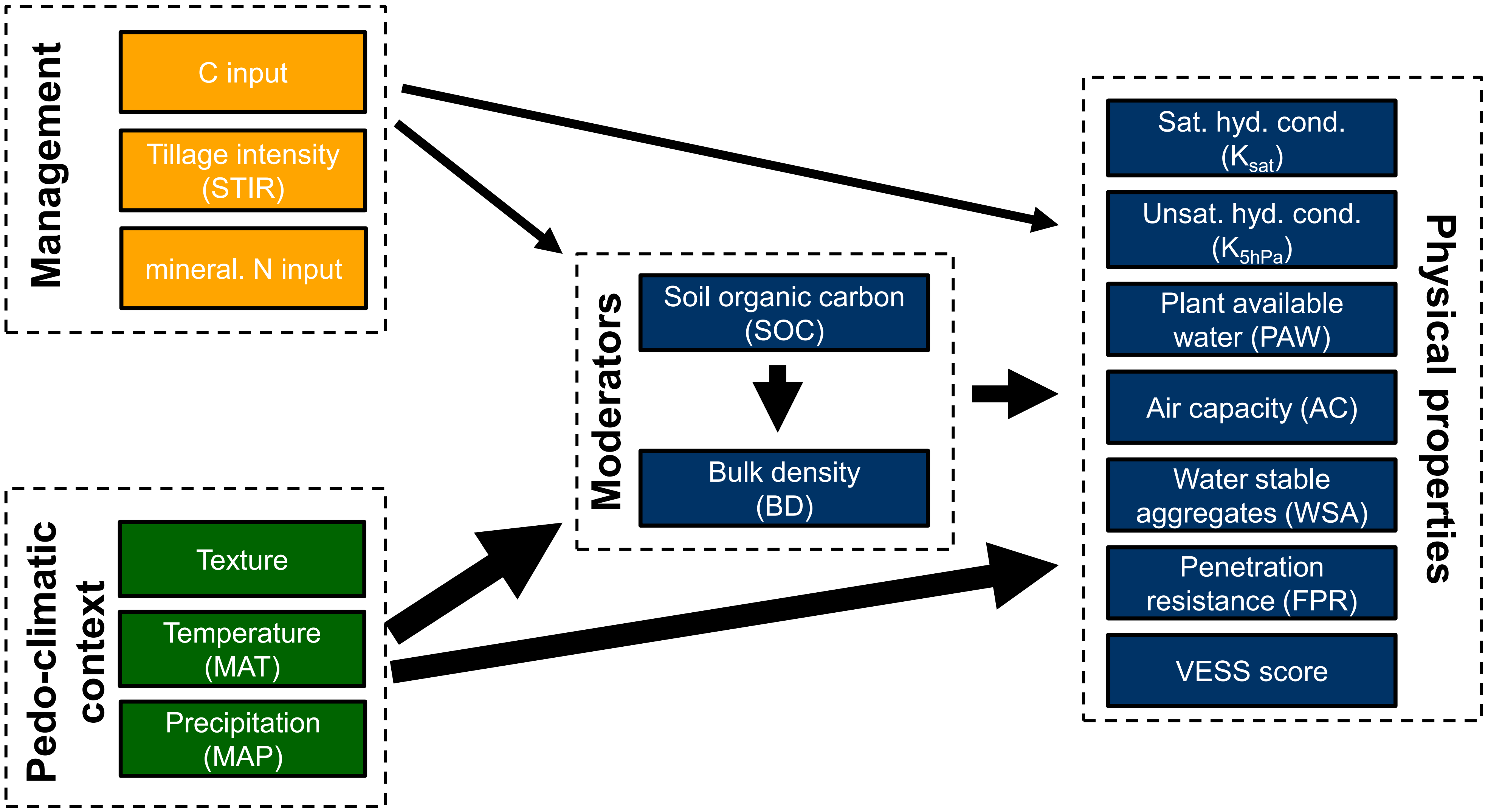
Pedo-climatic context dominates management



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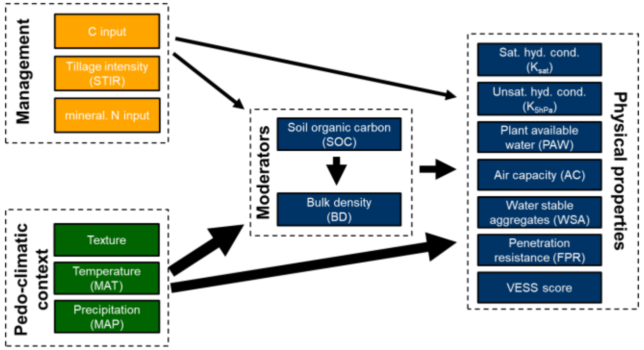
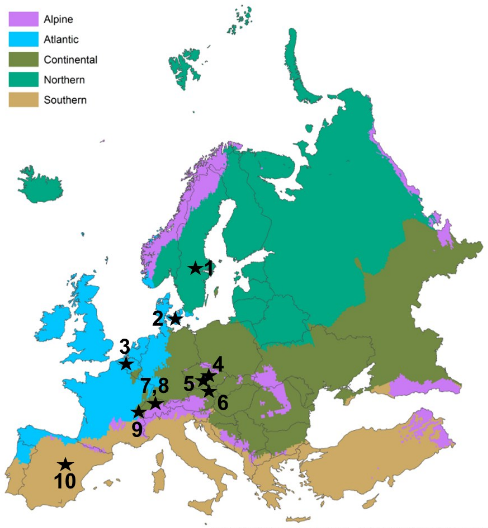
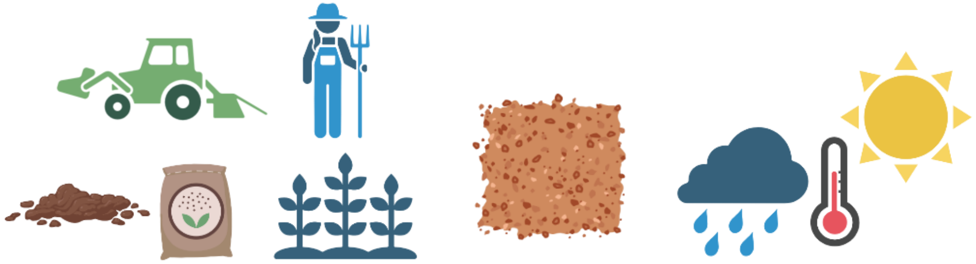
Management effects are much stronger in the topsoil

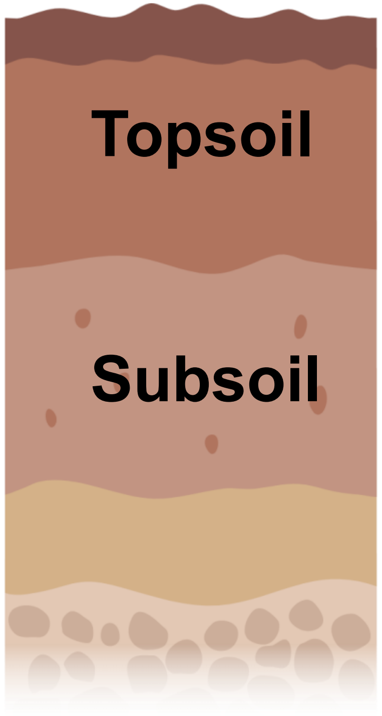




Map from Metzger (2018), doi.org/10.7488/ds/2416



Management Soil Climate



Topsoil: 1 : ½ : 2

Subsoil: 1 : 1½ : 6½

Conclusion

Management vs. pedo-climatic context

- Pedo-climate dominates managment effects on the continental scale by 2½ :1 in the topsoil and 8:1 in the subsoil.
- Downscaling needed for better recommendations (smaller climatic gradient)

Management effect on soil functions

- **Water regulation** enhanced by SOC and low soil density, but tillage can reduce infiltration
  - +3% PAW per +1% SOC
  - +6% PAW per +1% SOC (if BD effects are considered)
  - Loss of continuous biopores by tillage
- **Erosion prevention** increased with C input and tillage reduction
- Habitat for **Earthworms** improved by higher C input and tillage reduction

Acknowledgments

Coordination

- Holzkämper, Annelie

LTEs and measurements

- Böning, Kristin
- Bragazza, Luca
- Bürge, Diane
- Ding, Friederike
- Guillaume, Thomas
- Ghiasi, Shiva
- Jørgensen, Palle
- Kunzová, Eva
- Madaras, Mikuláš
- Mayer, Jochen
- Nielsen, Jørgen M.
- Ribes Bargues, Marta
- Pöschl, Stephanie
- Pullens, Johannes W. M.
- Rasmussen, Stig T.
- Scheiblmair, Sarah
- Schittli, Dominik
- Sommer, Marlies
- Stumpp, Christine
- van der Heijden, Marcel
- Volpe, Valerio
- Wittwer, Raphaël

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