Plant & Food Research
Rangahau Ahumāra Kai

Soil structure and water storage properties: connecting management practices and soil functions

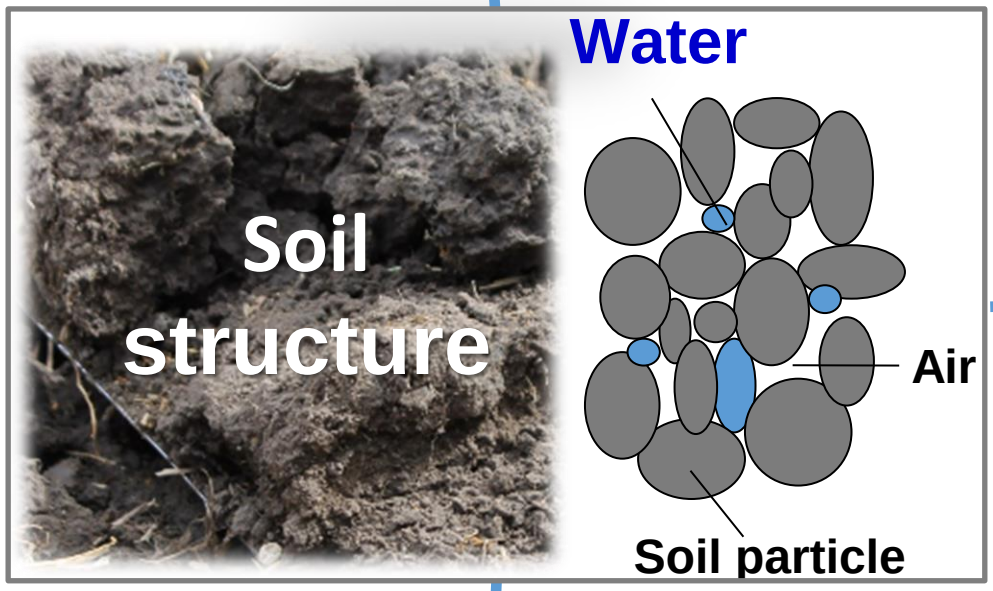
Wei Hu, Mike Beare, Brendon Malcom, Lingying Xu, Jun Yi, Zihuan Fu, Jinbo Li and many others

The New Zealand Institute for Plant and Food Research Limited

Soil structure

Clean air & water

Biodiversity



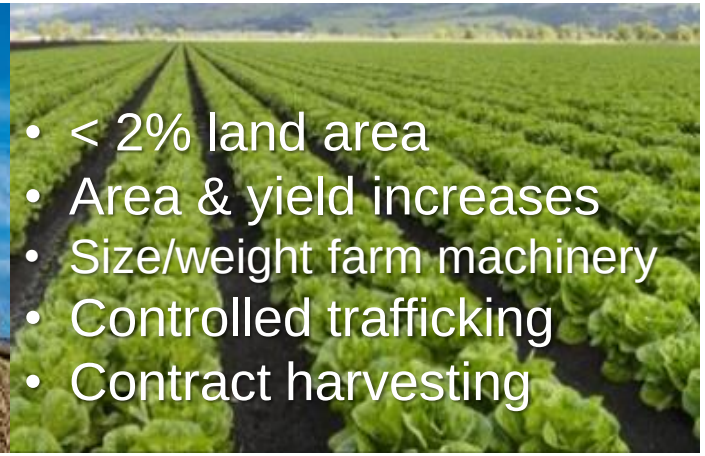
Agr. production

Climate change mitigation

Agricultural practices/intensification

Dairying

- Stock no. doubled cf 1980
- Stock rates & weights
- Supplementary feed
- Milk solids x3 cf 1990

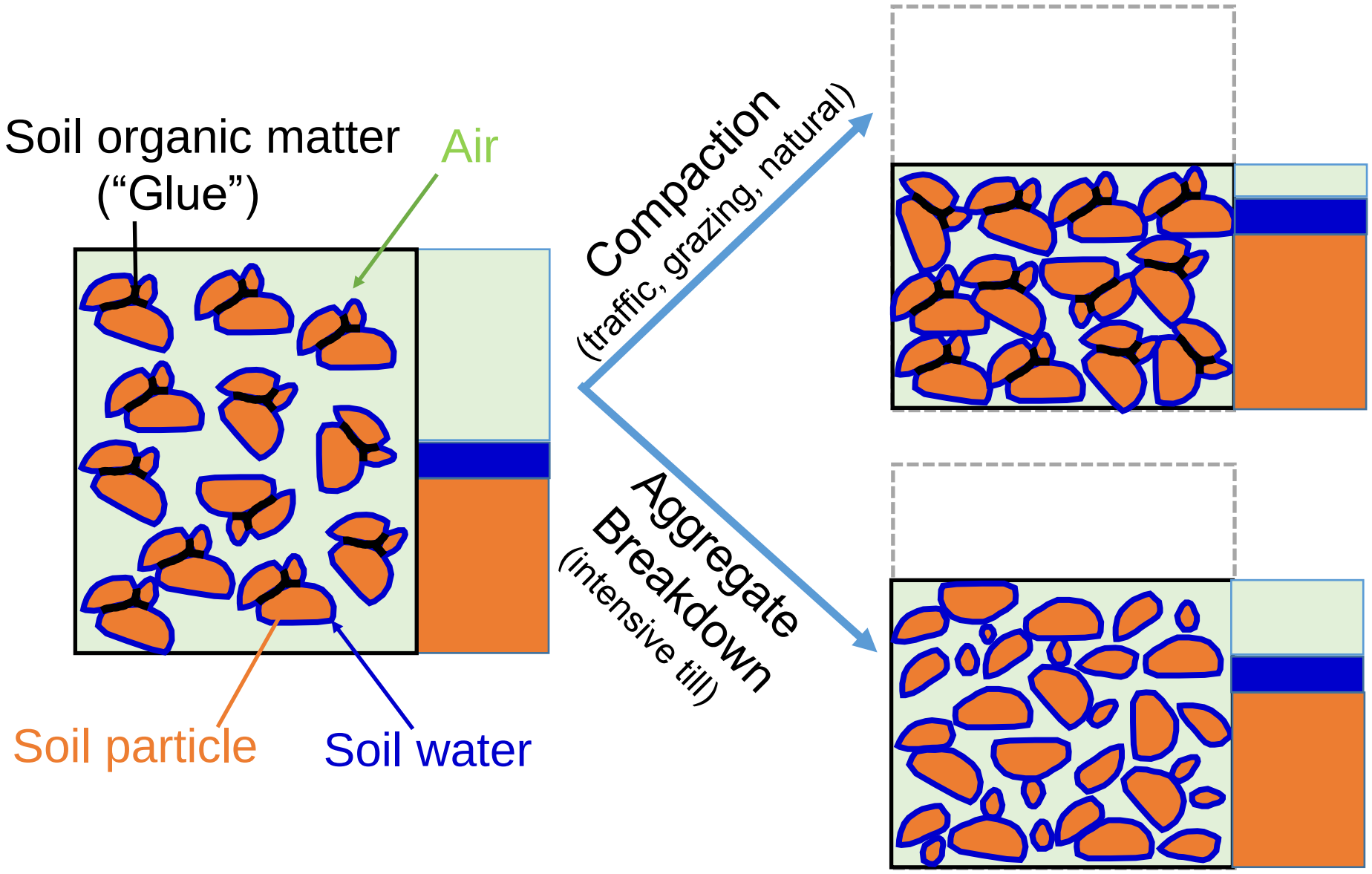


Arable /Horticultural farming

Irrigation expansion

(MfE & Stats NZ, 2021)

Intensification & soil structure



Indicators:

Bulk density
Penetration resistance
Aggregate stability
Infiltration capacity
Total porosity
Macro-porosity
Air capacity
Field capacity
Available water capacity

Soil structural degradation (SSD) in NZ

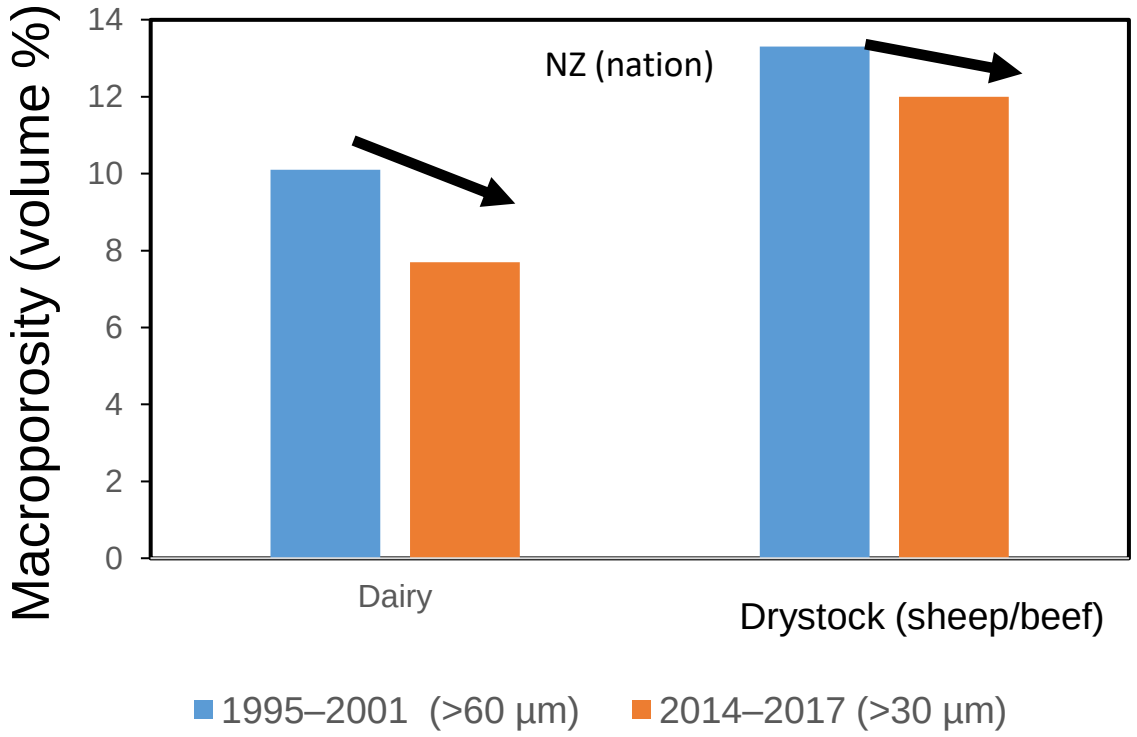
Subsoil compaction

Surface compaction

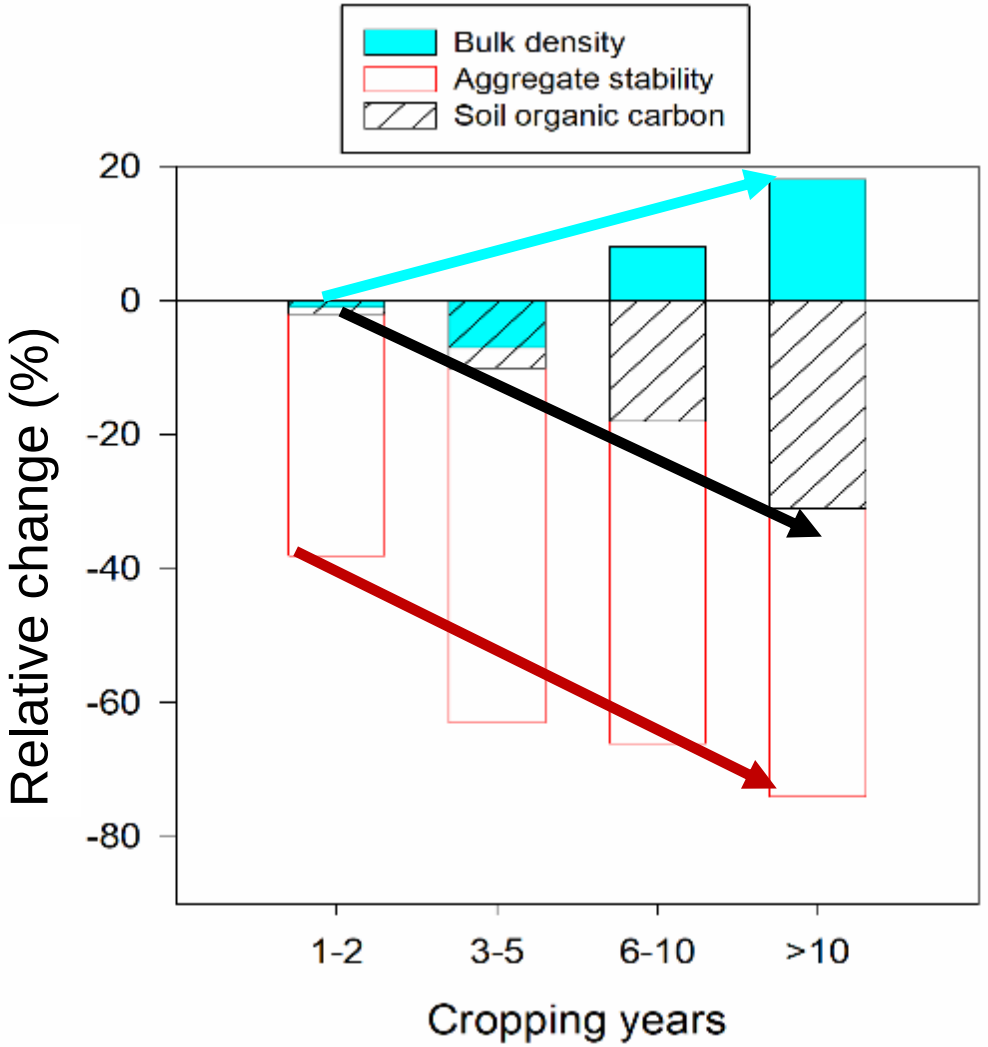
Surface sealing (capping)

SSD in different industry sectors

Macroporosity decreased over time



SSD increased with land use intensification



(Hu et al 2021)

Effect of land use on water storage properties

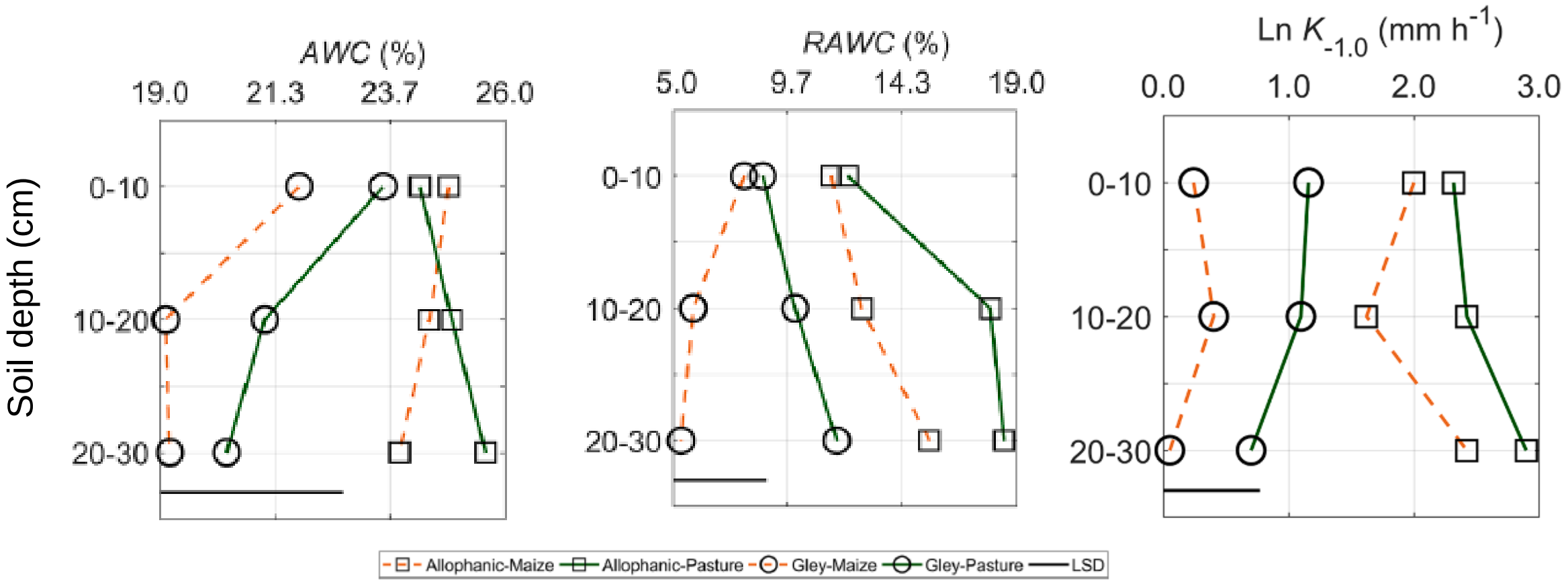
Templeton, Lismore, Waterton/Temuka, 0-30 cm (Canterbury)

	Dryland pasture (sheep/beef)	Irrigated pasture (dairy)	Irrigated crop
Air capacity (%)	15.6 a	10.2 b	14.0 a
S_{FC} (-kPa)	9.9 b	32.3 a	15.4 b
AWC (%)	21.8 a	16.9 c	18.8 b

- Interactions between land use and soil type (e.g., dryland pasture had higher AWC for Templeton soil)

(Fu et al 2021)

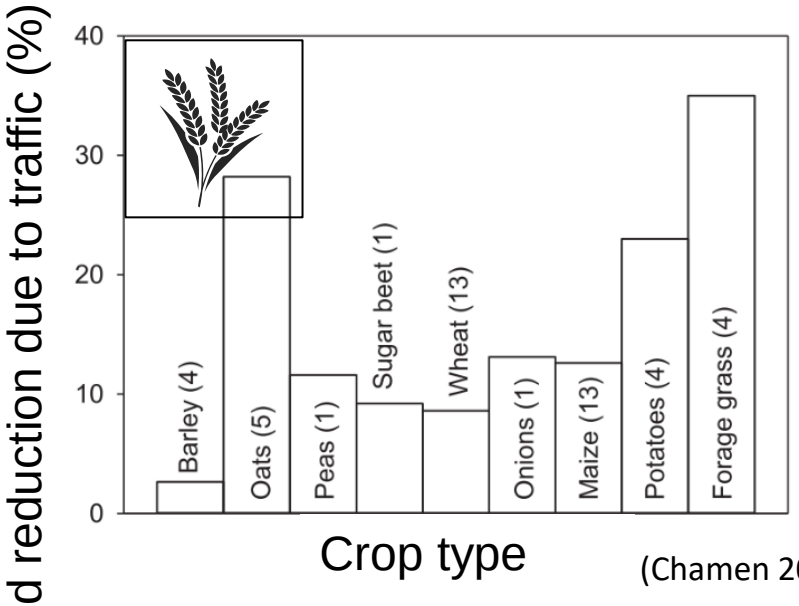
Maize cropping degrades water properties c/w grazed pasture



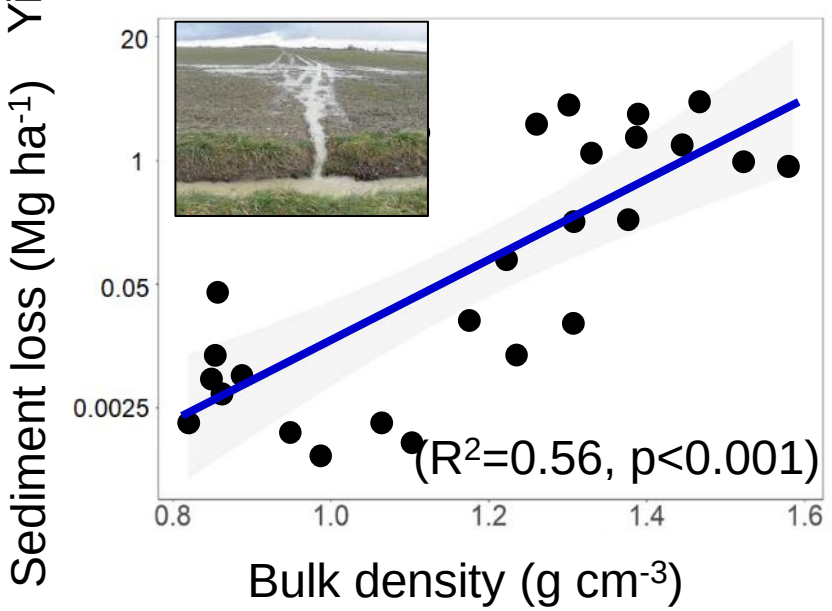
- Maize had lower AWC, RAWC and infiltration capacity than pasture (Waikato)

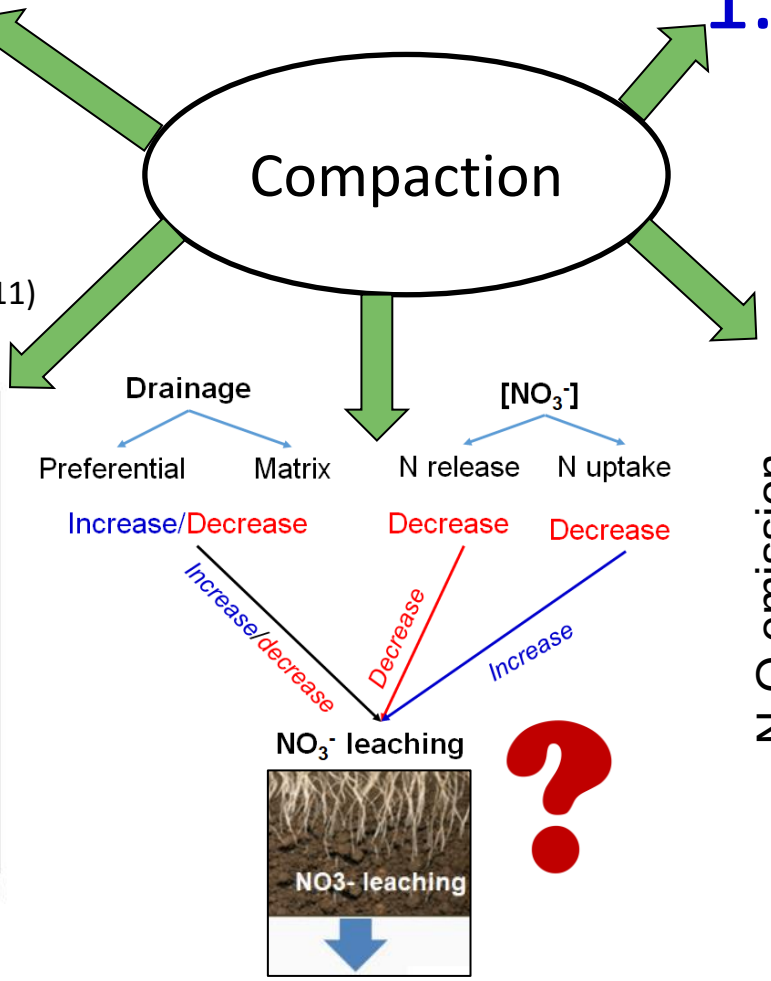
(Hu et al 2022)

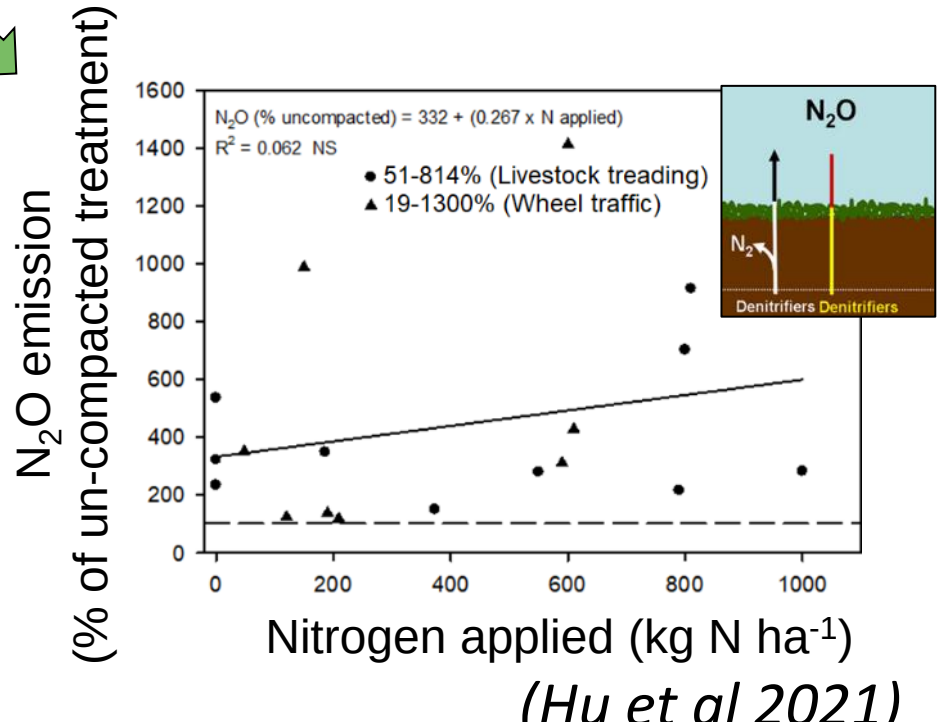
Effects of compaction on ecosystem services



(Chamen 2011)



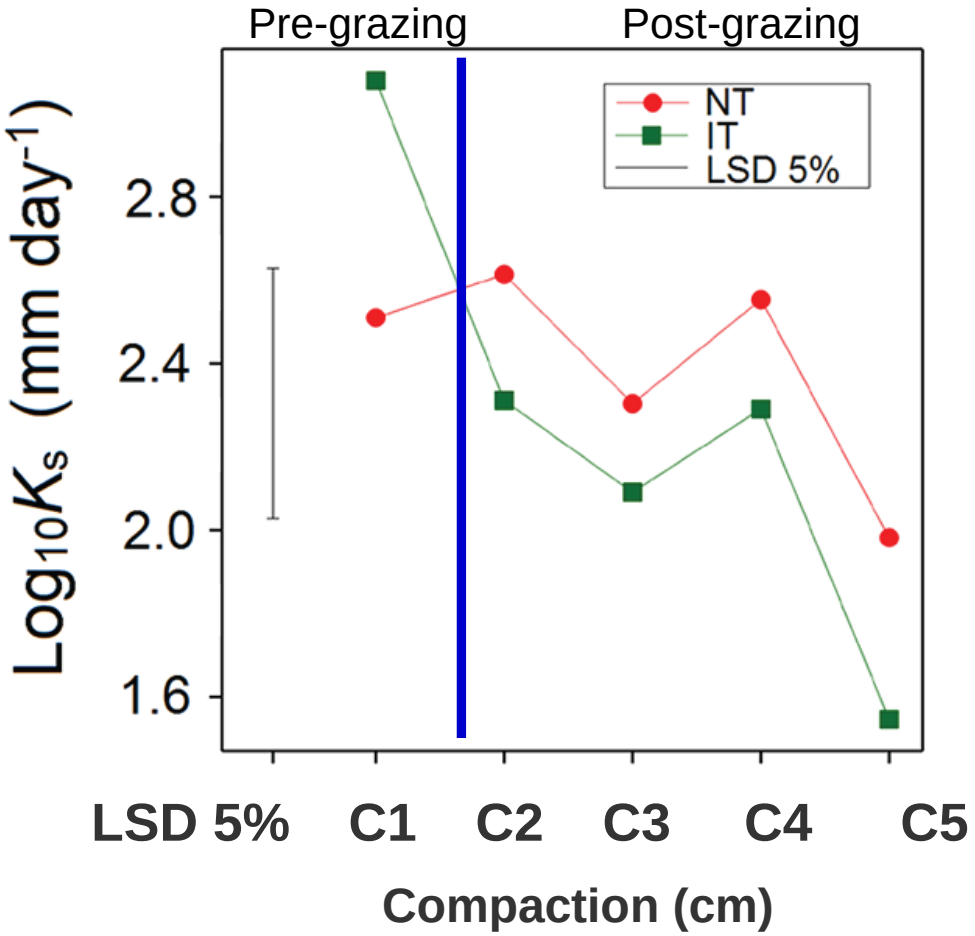


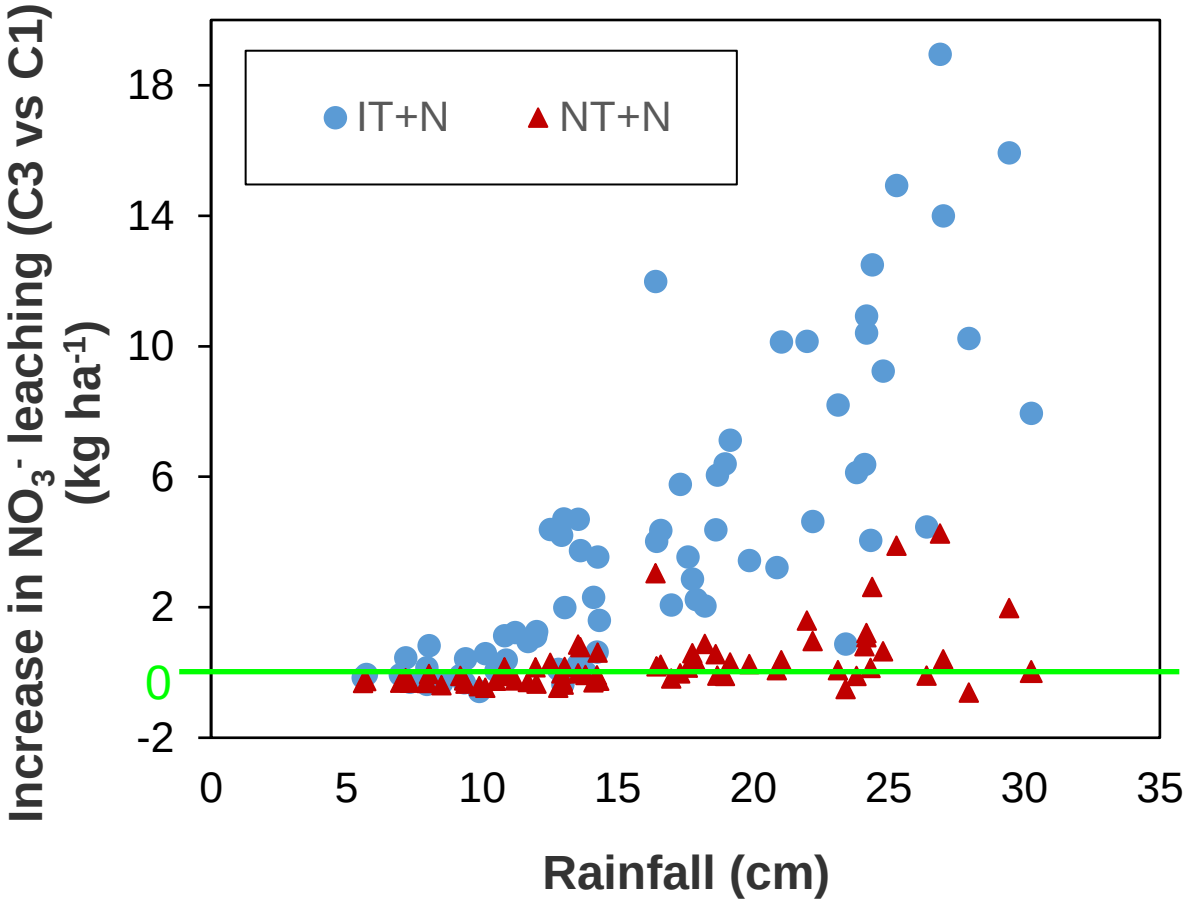


(Hu et al 2021)

Effect of compaction on nitrate leaching in WFC system

Templeton soil- flat area

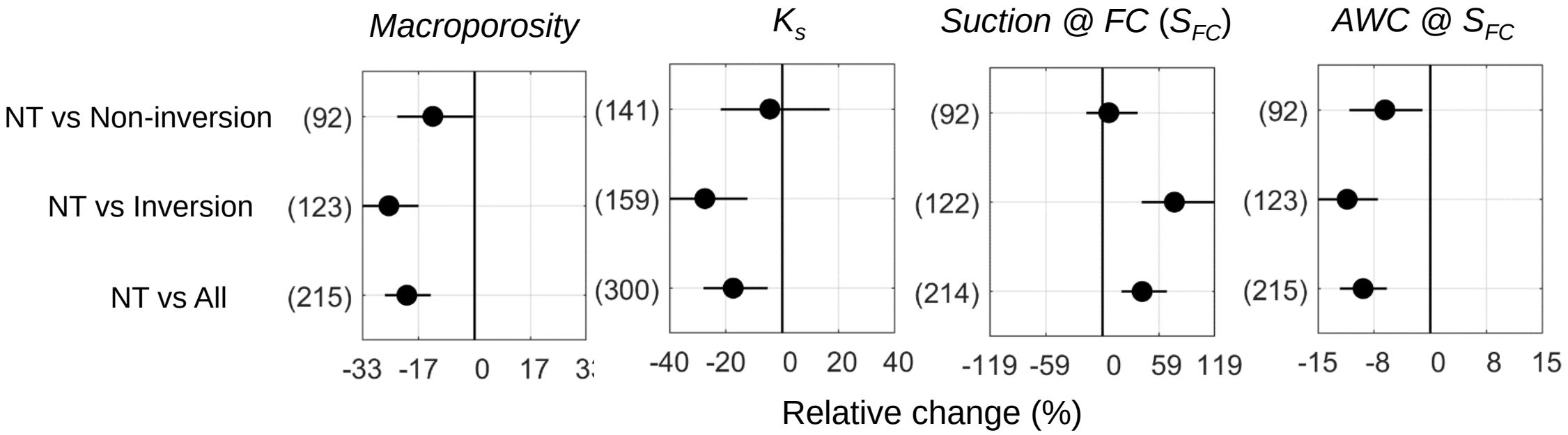




(Hu et al 2018)

(Yi et al 2022)

NT effect on water storage properties

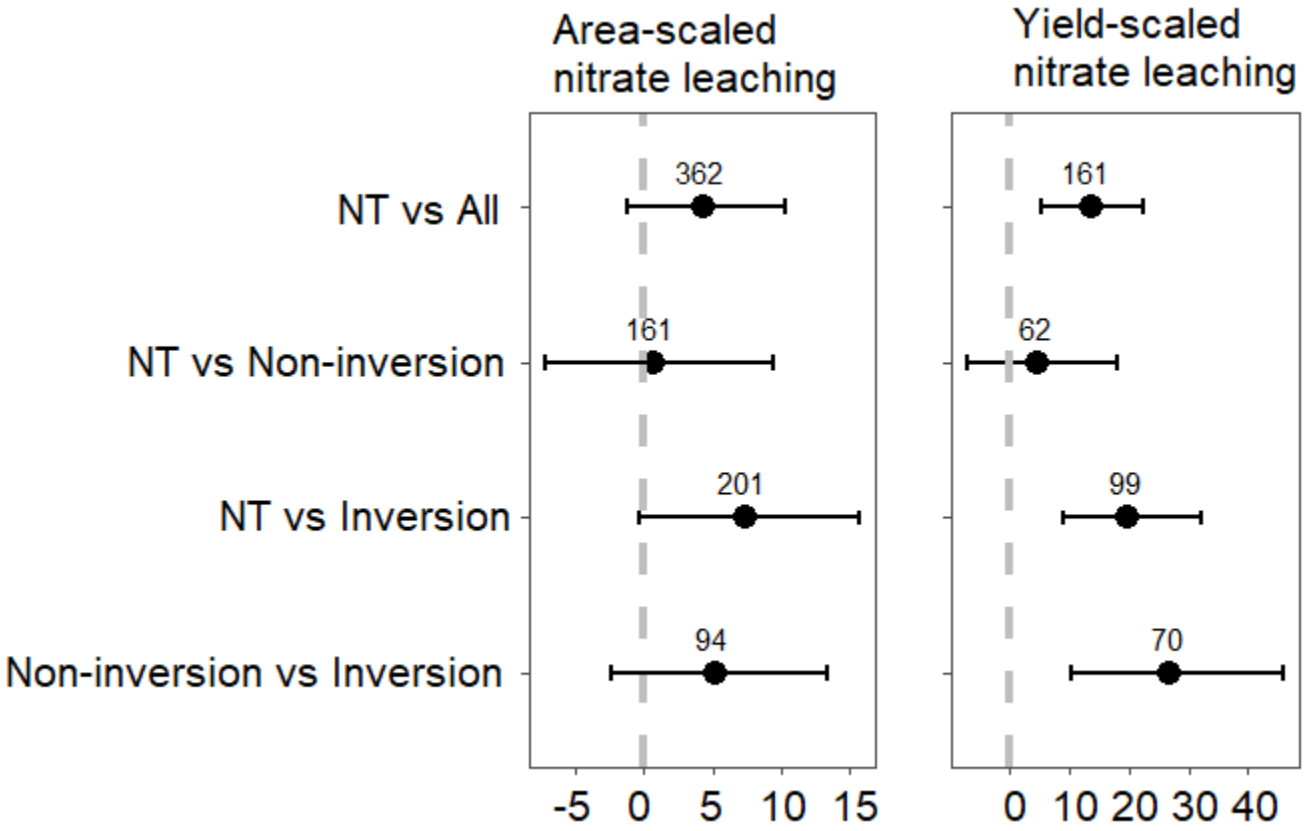


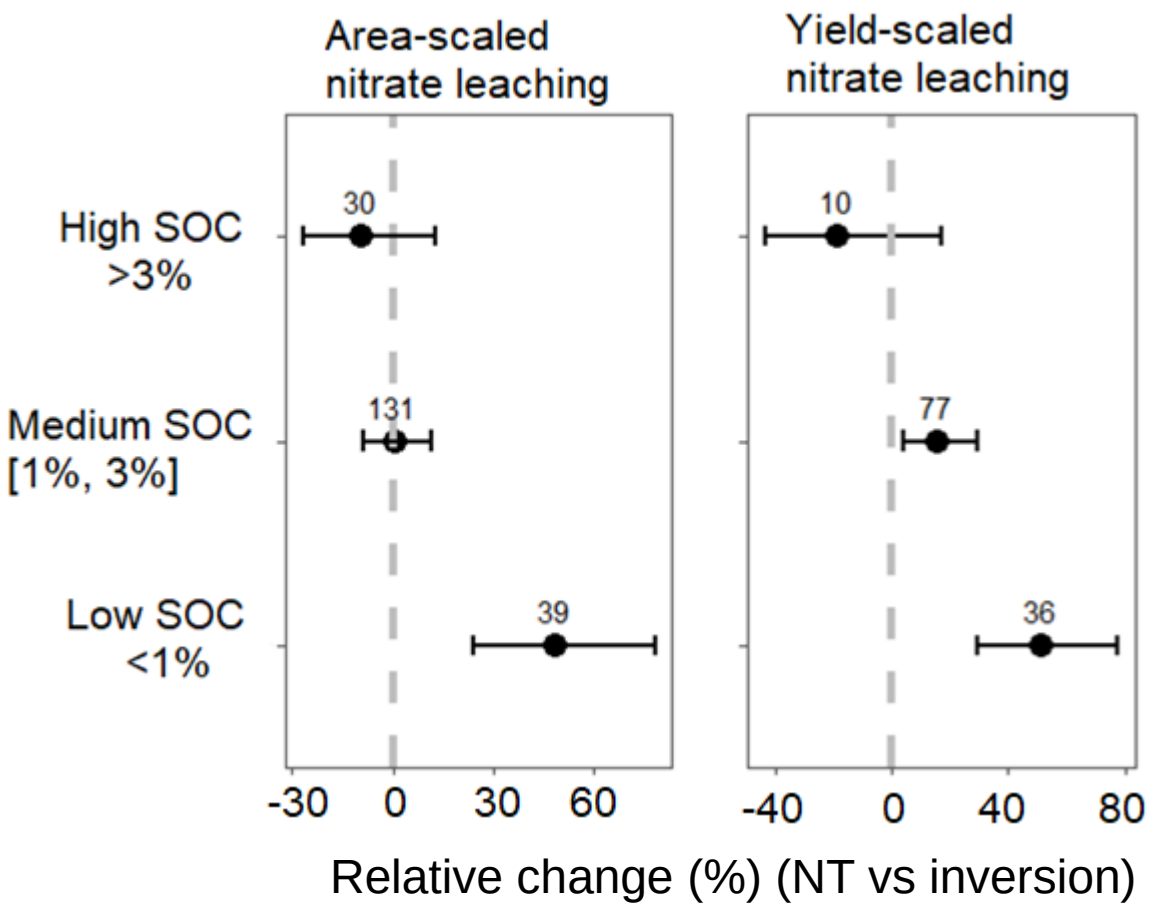
Non-inversion

Inversion

(Xu et al 2022 in preparation)

NT effects on nitrate leaching are context-specific





(Li et al 2022 in preparation)

Strategies for manage against compaction

Arable crops

Avoidance

Low ground pressure tyres

Tracked tractors

Controlled traffic farming (CTF)

Conservation agriculture

Mitigation

Subsoiling

Ploughing

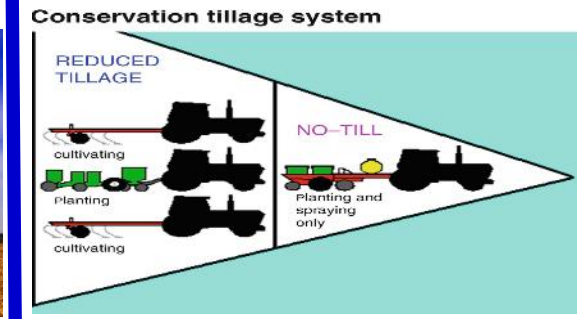
Targeted subsoiling

Green = economic

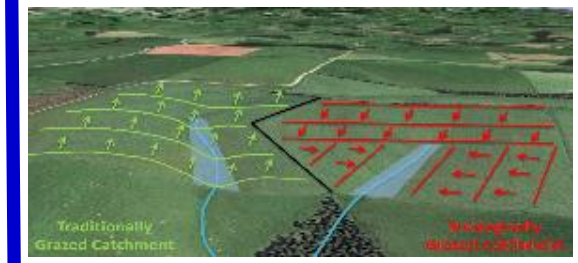
Red = uneconomic

(Chamen et al. 2015)

Winter Forage crops



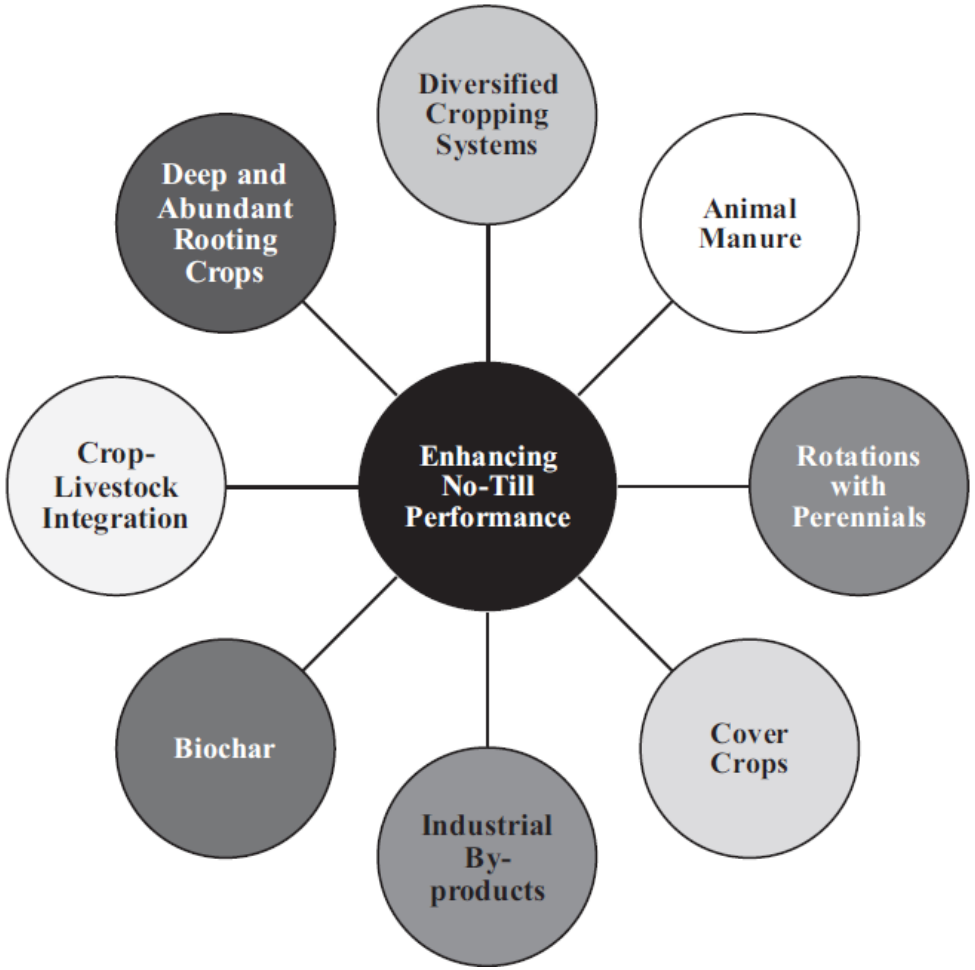
Reduced tillage

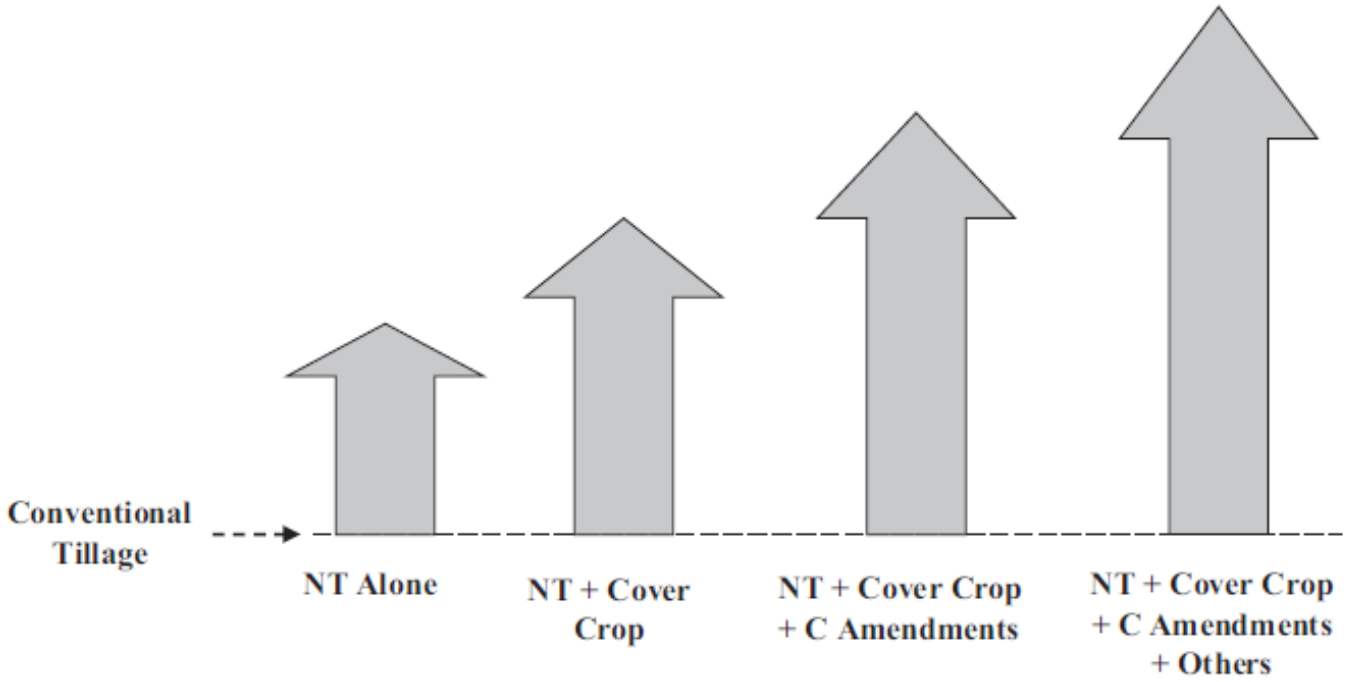


Strategic grazing

Catch crop

Management to enhance NT performance





Enhancement of soil structure

(Blanco-Canqui et al., 2018)

Take home messages

- Soil structural degradation (SSD) is common; full extent and severity of SSD across sectors yet to be determined
- SSD increased with intensification; vulnerability to SSD is unknown
- Evidences of adverse impacts of SSD; interactions b/w soil structure and other factors (e.g., soil moisture) on soil functions and ecosystem services are uncertain
- Current indicator targets are crude; better indicators/thresholds for different functions/ecosystem services are needed
- Management to avoid, mitigate & adapt to SSD – site specific examples known, guidelines/tools (e.g. models) for general application are needed.

Plant & Food™ Research
Rangahau Ahumāra Kai

Thanks to colleagues:
Mike Beare, Brendon Malcom, Lingying Xu, Jun Yi, Zihuan Fu, Jinbo Li and many others

Thanks to the funders:
MBIE (SSIF, Soil heath, Smap, Forages for Reduced Nitrate leaching)

Wei.Hu@plantandfood.co.nz

plantandfood.co.nz