Manaaki Whenua
Landcare Research

Digging deeper on soil compaction and pugging

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LINK seminar 27 January 2022

Outline

What is pugging and compaction?

How pugging and compaction impact soil health

Extent of pugging and compaction

Case study - soil quality monitoring in Wellington region

What happens to soil physical properties under irrigation in Canterbury

What is pugging?

- Pugging occurs in very wet conditions from treading damage
- Slurry-induced conditions - pores contain water, poor soil strength
- Very visible

Pasture

Winter forage crop

What is compaction?

- Compression of large pores (macropores) and large water storage pores

- Much ‘less visible’ than pugging

- Quantitative (laboratory) indictors pick up subtle differences, e.g. macroporosity

Not compact

Many roots, worms, macropores, good structure

Very compact!

Few roots, few macropores, blocky, poor structure

Difference between pugging and compaction?

Pugging

- Very visible damage, very wet
- Often bare ground
- Slurry, pasture burial, weeds

- Visible sediment erosion to water
- Often need drastic action - cultivation

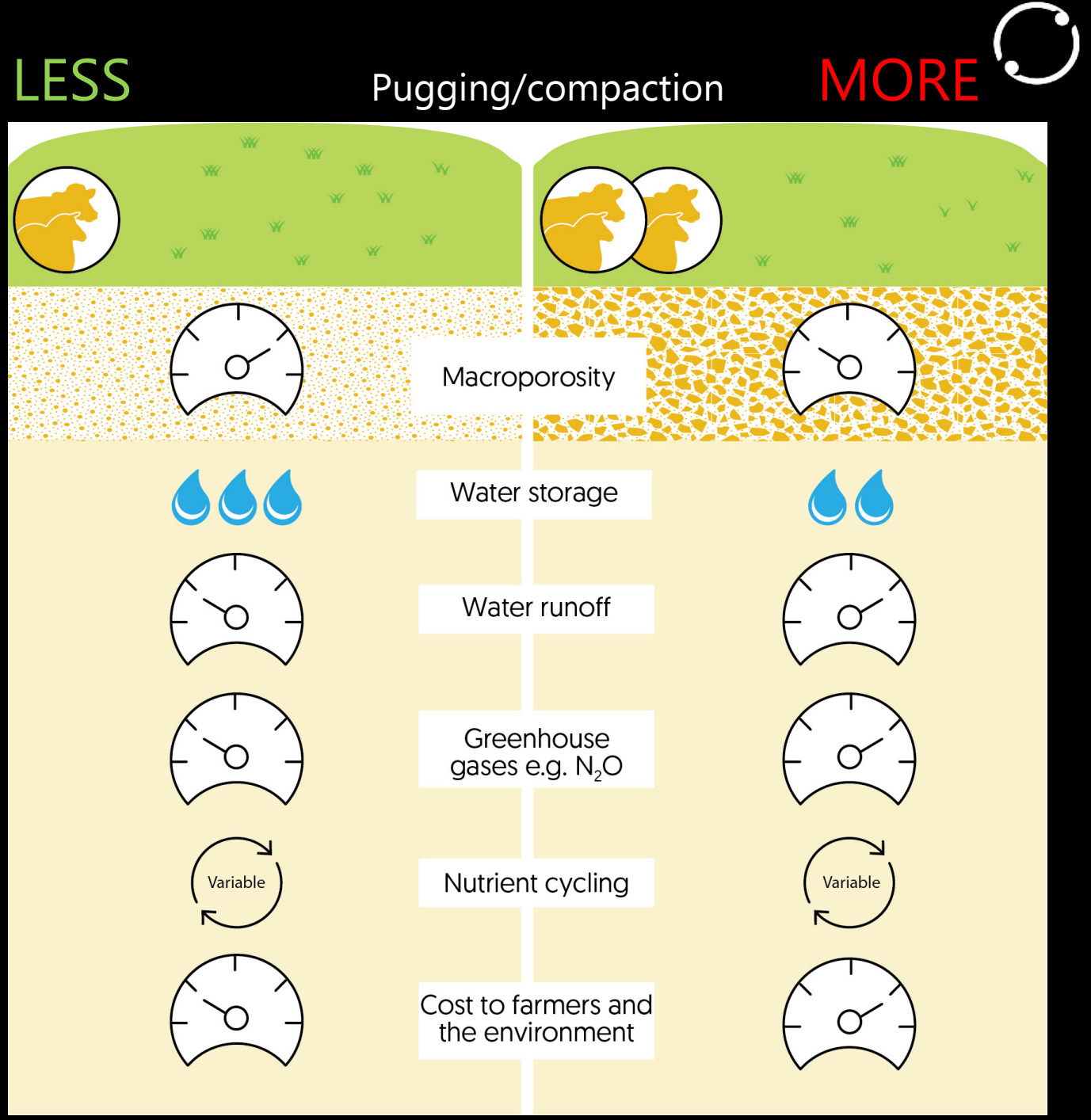
Shades of “grey”

Compaction

- Less visible damage
- ‘Normal’ pasture

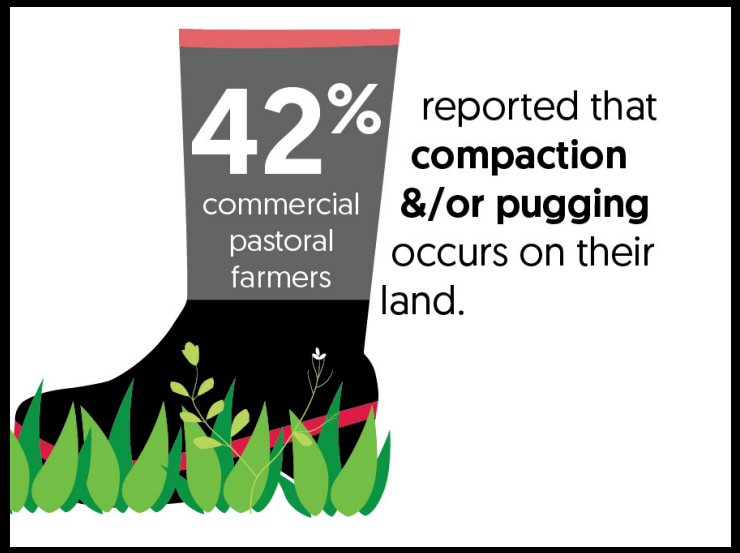
Pugging and compaction impact soil health by:

- Pores, air, roots, production
- Water storage … irrigation and climate change adaption
- Infiltration…which affects leaching, runoff, storage, flooding (…. water quality)
- Nutrient cycling, production
- Impact and cost: all the above

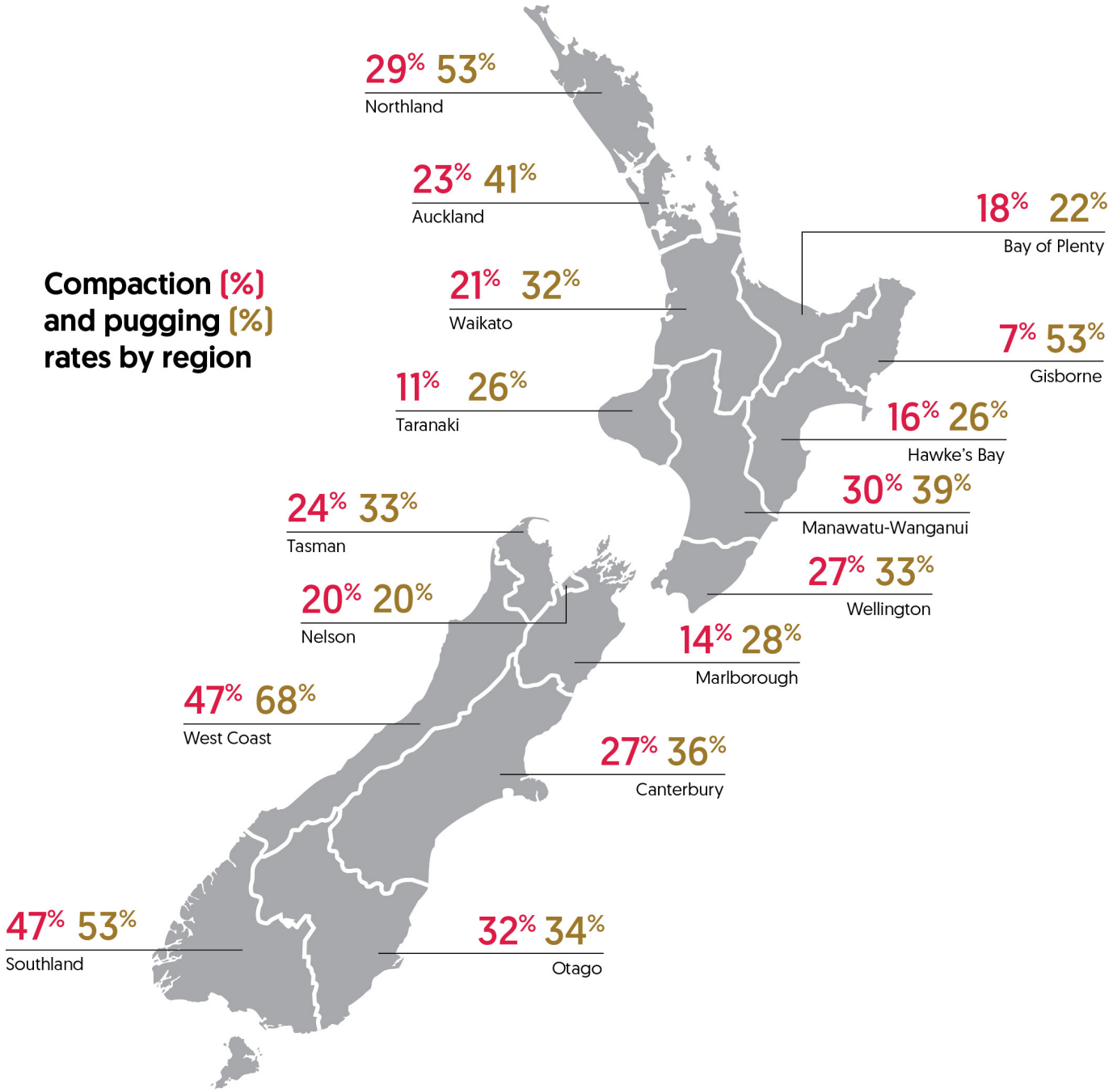


Extent of pugging and compaction MWLR 'Survey of Rural Decision Makers' 2021

- Farmer's opinion on percentage of their land affected by soil compaction and pugging?



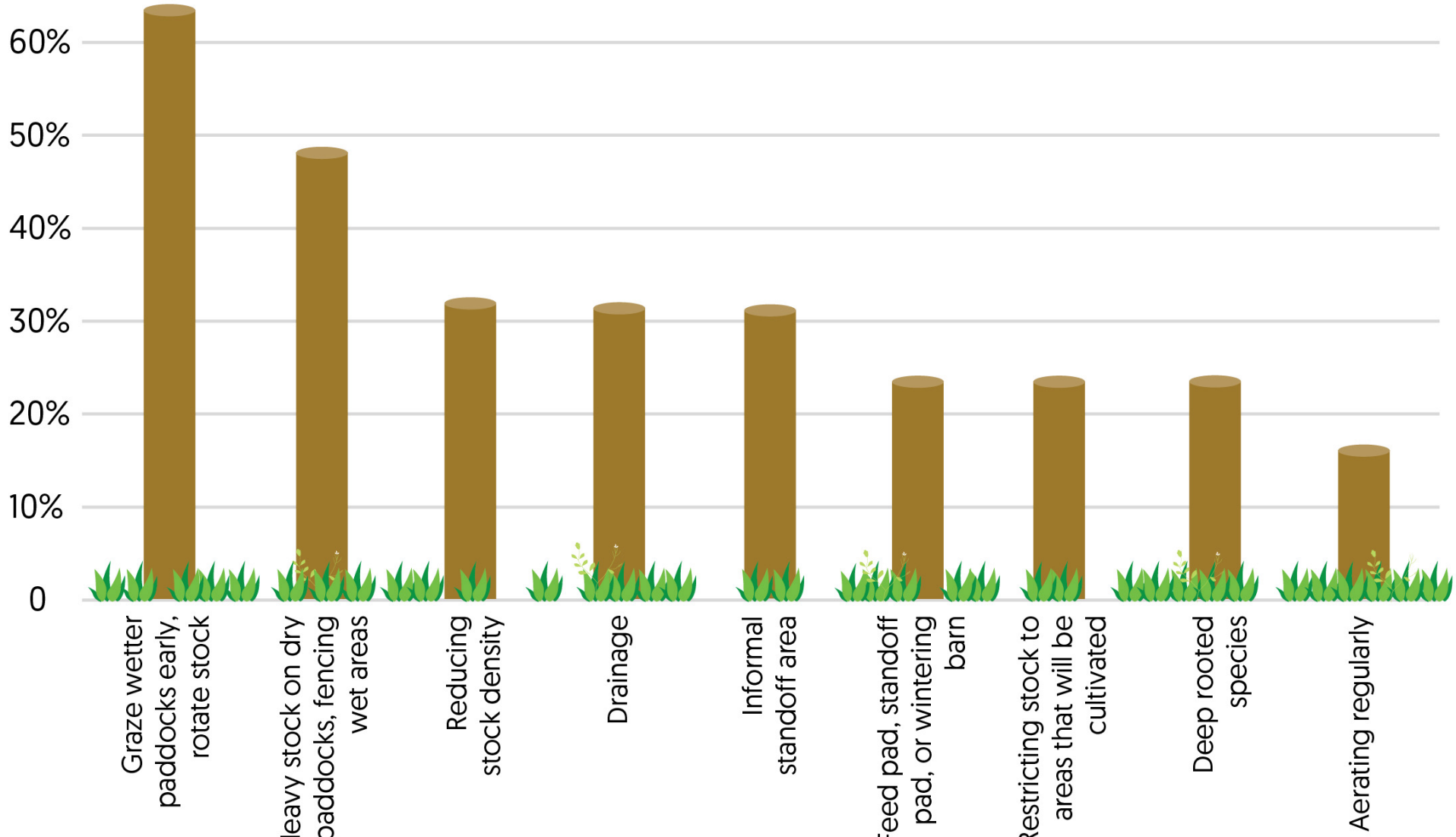
Data source: Stahlmann-Brown P 2021. Survey of Rural Decision Makers. MWLR



MWLR

Rural Decision Makers SURVEY2021

Among those who identify compaction &/or pugging to be a problem, 76% actively manage it by:



Extent of pugging - monitoring winter forage crop grazing from space

- National study

Journal of Environmental Management
journal homepage: www.elsevier.com/locate/jenvman
2022

Mapping bare ground in New Zealand hill-country agriculture and forestry for soil erosion risk assessment: An automated satellite remote-sensing method

Heather North [a,*], Alexander Amies [a], John Dymond [b], Stella Belliss [a], David Pairman [a], John Drewry [b], Jan Schindler [c], James Shepherd [b]

[a] Manaaki Whenua – Landcare Research, PO Box 69040, Lincoln, 7640, New Zealand

- Big potential for pugging
- Slopes ≥7°, 47,000 ha of winter forage causing bare ground in 2018 (= erosion)
- 73% of winter forage area is in Canterbury, Otago, Southland

- Pilot study

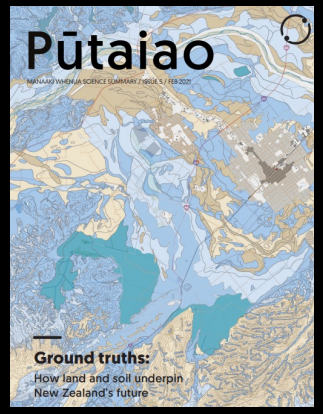
Research article 129

Winter-forage crop grazing in the Gore-Mataura area of Southland: using time-series mapping to estimate location and frequency of cropping

John J. DREWRY[1*], Heather NORTH[2], Stella E. BELLISS[2], Alexander AMIES[2].
[1]Manaaki Whenua – Landcare Research, Private Bag 11052, Palmerston North 4442, New Zealand

Journal of New Zealand Grasslands 82: 129–137. 2020

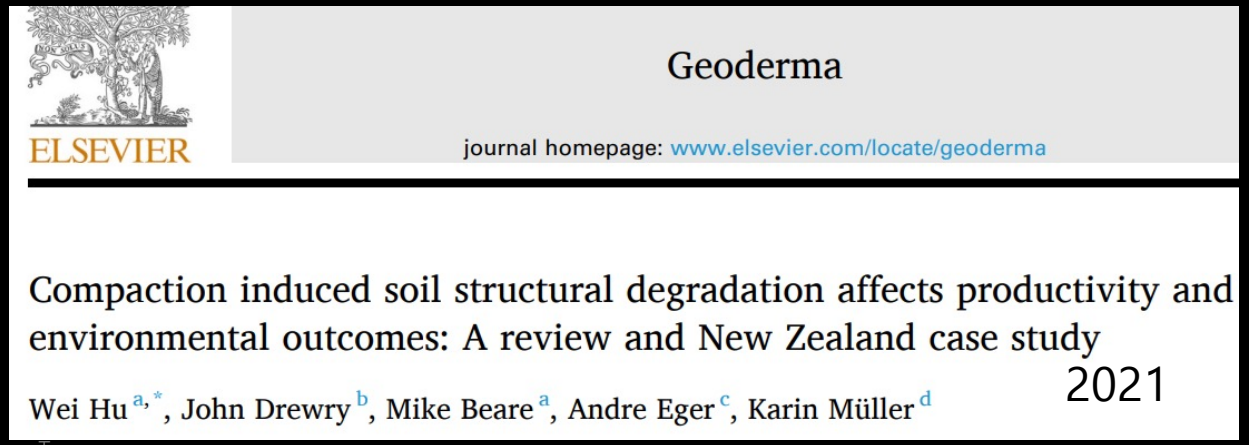
- Two consecutive years of winter crop grazing in the *same paddock*, occurred around a quarter of the time



Winter forage both years

Winter forage one year or other

Extent – reviews of soil compaction and pugging



ELSEVIER

Geoderma

journal homepage: www.elsevier.com/locate/geoderma

Compaction induced soil structural degradation affects productivity and environmental outcomes: A review and New Zealand case study

2021

Wei Hu [a,*], John Drewry [b], Mike Beare [a], Andre Eger [c], Karin Müller [d]

Soil structure: its importance to resilient pastures in New Zealand (review)

David J. HOULBROOKE[1,*], John J. DREWRY[2], Wei HU[3], Seth LAURENSON[4], Sam T. CARRICK[5]
[1]AgResearch,10 Bisley Lane Ruakura Research Centre, Hamilton
[2]Manaaki Whenua Landcare Research, Riddet Road Massey University, Palmerston North

Resilient pastures symposium of New Zealand Grasslands Association. Agricultural Practice Series 17: 271–281. 2021

- Common in NZ
- Reduced pasture and crop production, increased N_2O emissions

- *Key knowledge gaps:*
- Effects on contaminant losses (runoff, N leaching)
- Soil quality indicator thresholds (regional and national reporting)
- Impact of new pugging regulations
- Cost to environment and cost to farmers

Extent of compaction - regional and national soil quality monitoring

Macroporosity below target range in 65% of dairy sites, 48% of drystock sites etc.

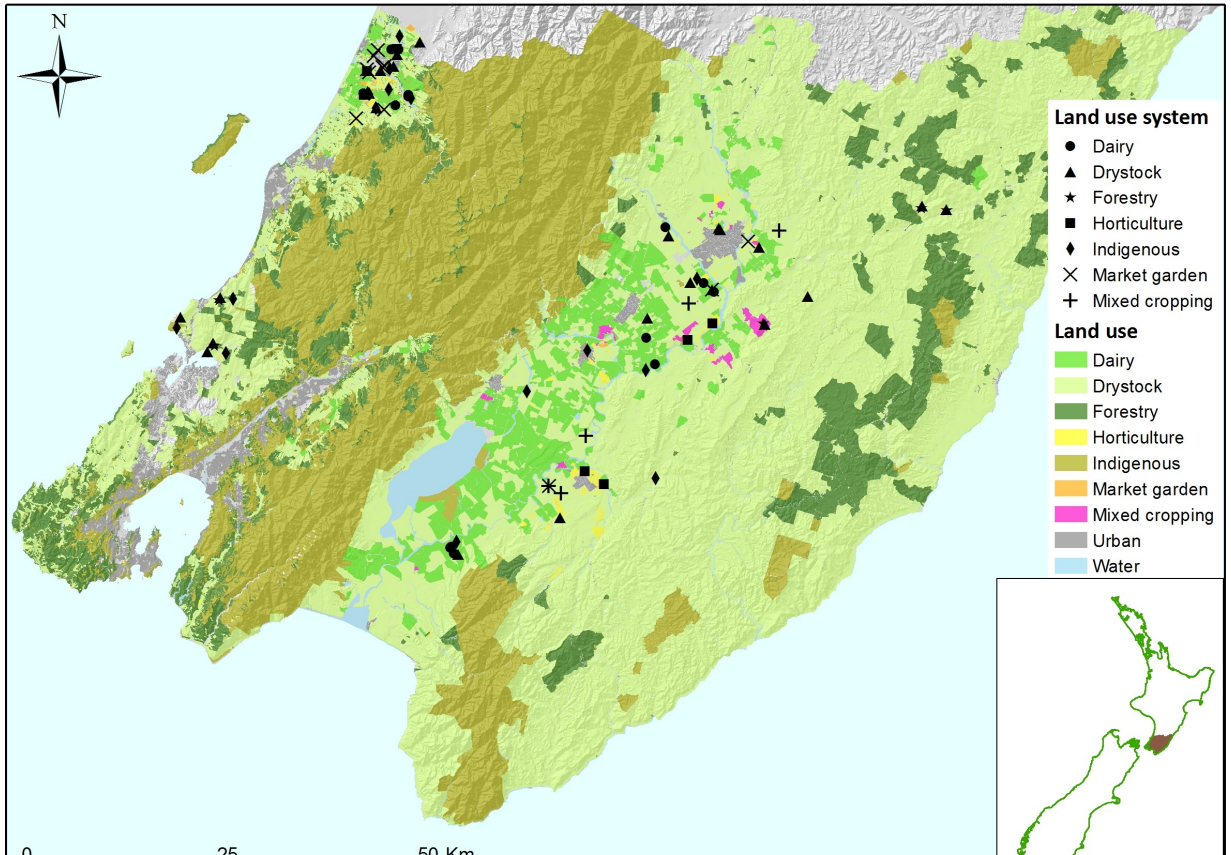
Greater Wellington soil quality – case study

- 19 years data
- 7 land uses

- Aims of study: Recent sampling results vs target range
- Effect of land use system
- Assess changes over time

- *Macroporosity , bulk density*
- (Cd, Cu, Zn, N, P, C)

- Up to 5 repeat samplings
- 0-10 cm depth
- Mixed-effects statistical modelling
- Sites with consistent *farm system*



Wellington region - sites within target ranges

Macroporosity is a more sensitive indicator than bulk density

Macroporosity should be above 10% v/v

- Dairy had lowest median (7.7% v/v) macroporosity (shows compaction)

- Percentage of sites within macroporosity target range:
- Dairy 36% 
- Cropping 60% 
- Drystock 71% 

- Percentage of sites within bulk density target range:
- Dairy 93% 
- Cropping 80% 
- Drystock 100% 

Change over time

Few soil quality monitoring programmes have endured long-term internationally

Soil quality changes over 19 years evaluated for 7 land uses

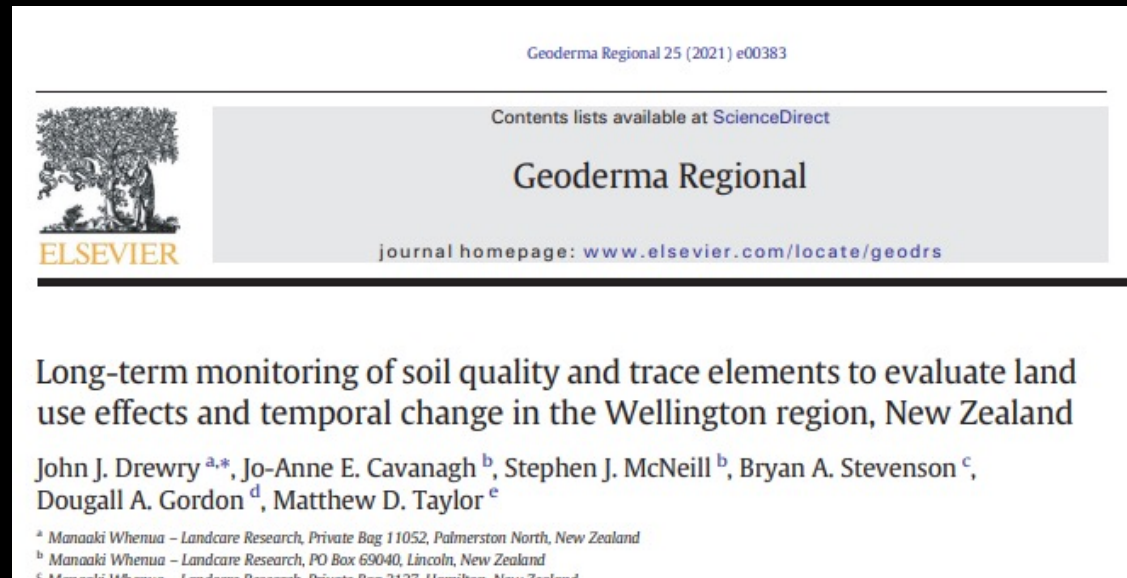
- Significant change over time for bulk density for drystock
- No significant change for macroporosity

<u>But</u> absence of a significant change over time is not necessarily bad e.g. stable conditions

Is the trend actually meaningful?

Relativity to guideline?

See paper for methods, N, P, C, trace elements, improvements to monitoring programmes



Geoderma Regional 25 (2021) e00383

Contents lists available at ScienceDirect

Geoderma Regional

journal homepage: www.elsevier.com/locate/geodrs

Long-term monitoring of soil quality and trace elements to evaluate land use effects and temporal change in the Wellington region, New Zealand

John J. Drewry [a,*], Jo-Anne E. Cavanagh [b], Stephen J. McNeill [b], Bryan A. Stevenson [c], Dougall A. Gordon [d], Matthew D. Taylor [e]

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[b] Manaaki Whenua – Landcare Research, PO Box 69040, Lincoln, New Zealand

Physical properties under irrigation in Canterbury – a pilot study

3 sites. Dairy site typically had lower macroporosity and greater bulk density (compaction)
Dairy site typically had greater water contents, e.g. at field capacity

Soil pores are key for water storage for irrigation scheduling and plant growth
Readily available water content (important for irrigation) generally lower at dairy site
Deficit irrigation may be useful practice

Compaction evident to at least 30 cm….*need to 'dig deeper'*

NEW ZEALAND JOURNAL OF AGRICULTURAL RESEARCH
https://doi.org/10.1080/00288233.2021.1905670

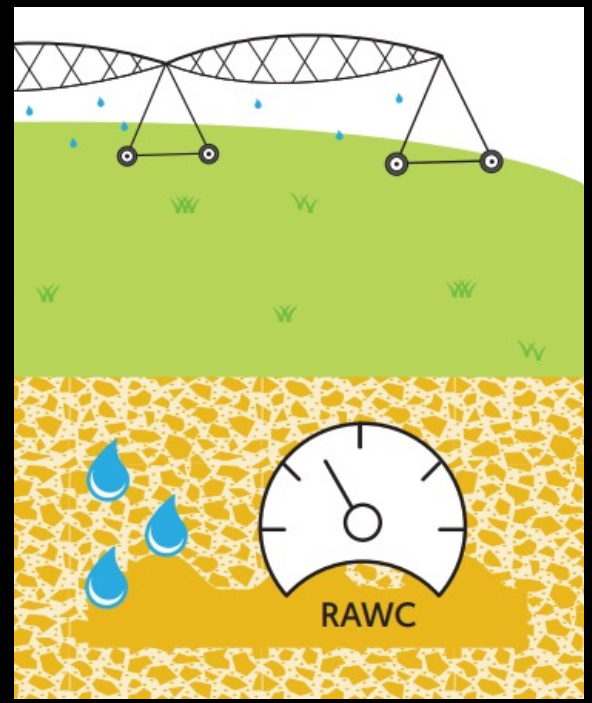
Taylor & Francis
Taylor & Francis Group

BRIEF REPORT

Check for updates

The effect of irrigated land-use intensification on the topsoil physical properties of a pastoral silt loam

John J. Drewry [a], Sam Carrick [b], Nicole L. Mesman[c], Peter Almond [c], Karin Müller [d], Fiona L. Shanhun[c] and Henry Chau [c]



Physical properties under irrigation in Canterbury – a regional study

S Carrick and V Penny's Sustainable Farming Fund project with Federated Farmers
48 paired irrigated and dryland sites across Canterbury, 24 stony soil, 24 deep soil
Measured to 60 cm. Topsoil and subsoil

Paper submitted

Deep soils… differences in several key soil water holding properties important in irrigation

- Readily available water content reduced under irrigated sites
- Compaction evident to 30 cm

Take home messages

Compaction and pugging common under some land uses

Quantitative indicators valuable, e.g. macroporosity, readily available water capacity (for irrigation)

Compaction/pugging impact aeration, drainage, runoff, soil water storage, nutrients and production

Compaction effects beyond 10 cm depth….*need to 'dig deeper'…*

Key gaps for policy and farmer questions ….*need to 'dig deeper'…*

- Impact on contaminant losses
- Soil quality indicator thresholds
- Impact of new pugging regulations
- Costs

Thanks to

- Farmers, regional councils, collaborators, and MWLR soil physics laboratories
- Funding by Ministry of Business, Innovation and Employment for MWLR led programmes:
  - Soil health and resilience: oneone ora, tangata ora,
  - Next generation S-map
  - Maximising the value of irrigation
- Ministry for Primary Industries – Sustainable Farming Fund - Canterbury paired site project (Federated Farmers)
- Soil monitoring – Greater Wellington Regional Council

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