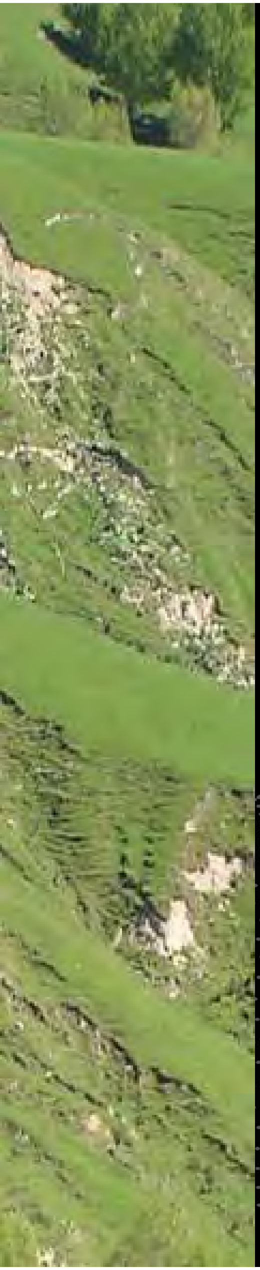

Understanding rainfall-induced shallow landslide susceptibility

Key findings from the STEC programme

Hugh Smith & team

Manaaki Whenua – Landcare Research

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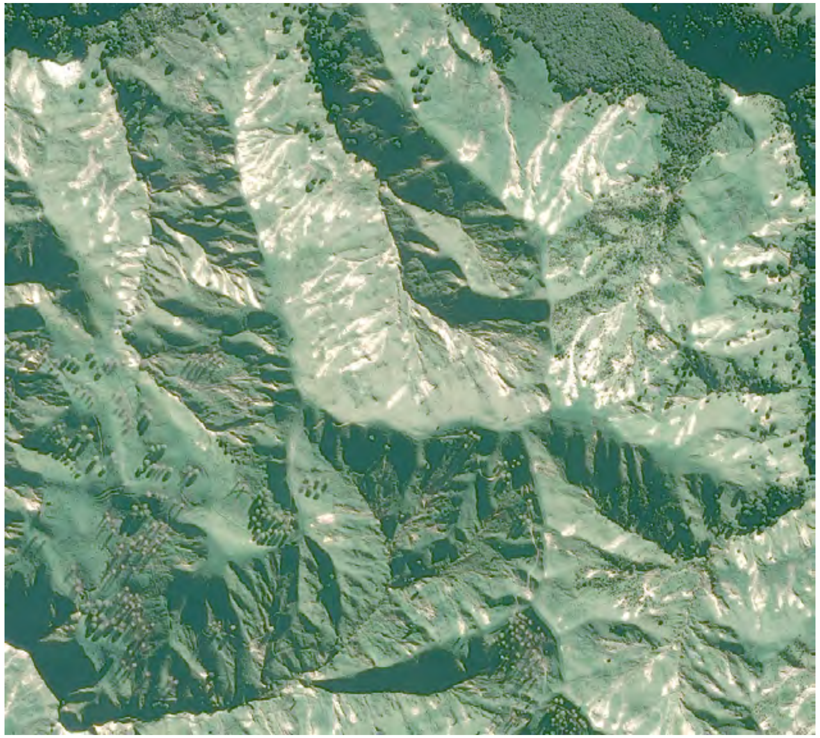
Outline

1. Background
2. Research questions
3. Main findings
4. Key messages
5. Publications

1. Background

- Shallow landslides occur frequently in NZ
- Dominant erosion process in hill country
- Impacts include:
    - reduced agricultural production
    - increased sedimentation
    - degraded water quality
    - damage to infrastructure
    - damage to culturally-significant sites
- Need higher resolution information to better target erosion control and reduce sediment delivery to streams

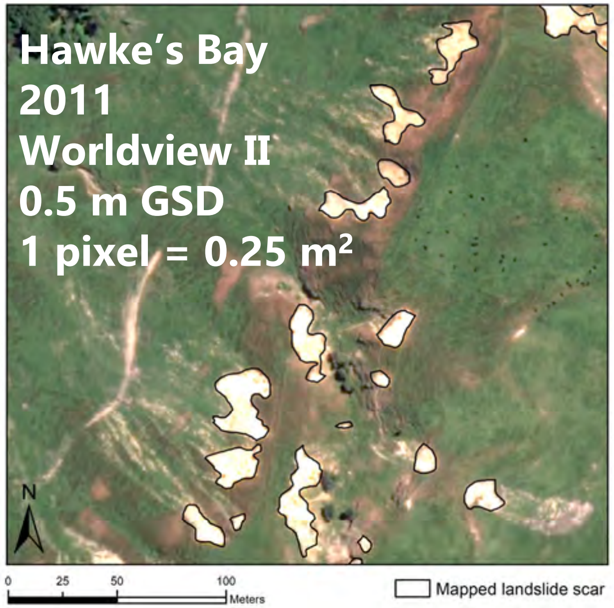


2. Research questions

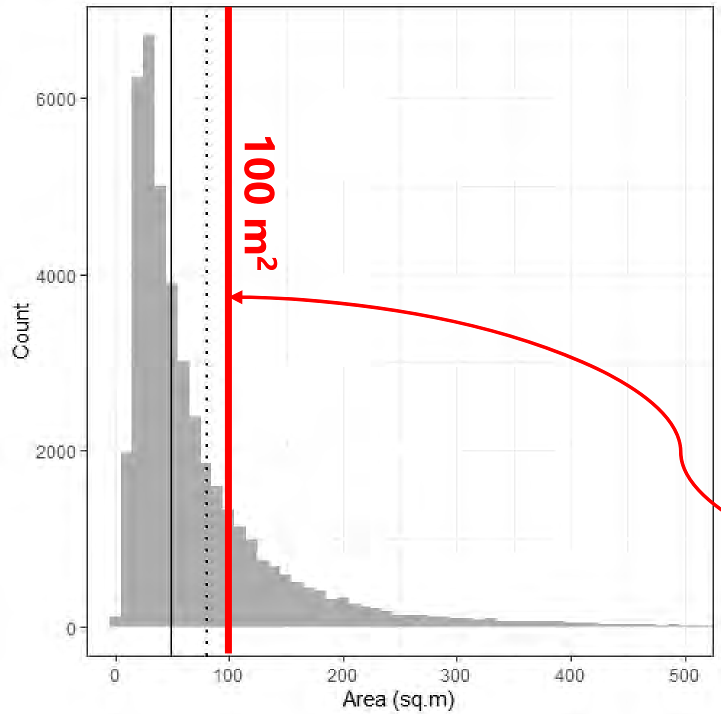
1. How do methods of landslide data acquisition influence susceptibility models?
    a) manual vs. automated mapping
    b) event vs. multi-temporal records
2. Which factors most influence the spatial occurrence and density of landslides?
3. To what extent does use of LiDAR DEMs improve model performance?
4. How do individual trees influence landslide susceptibility and sediment delivery?

3.1 Landslide data acquisition - imagery

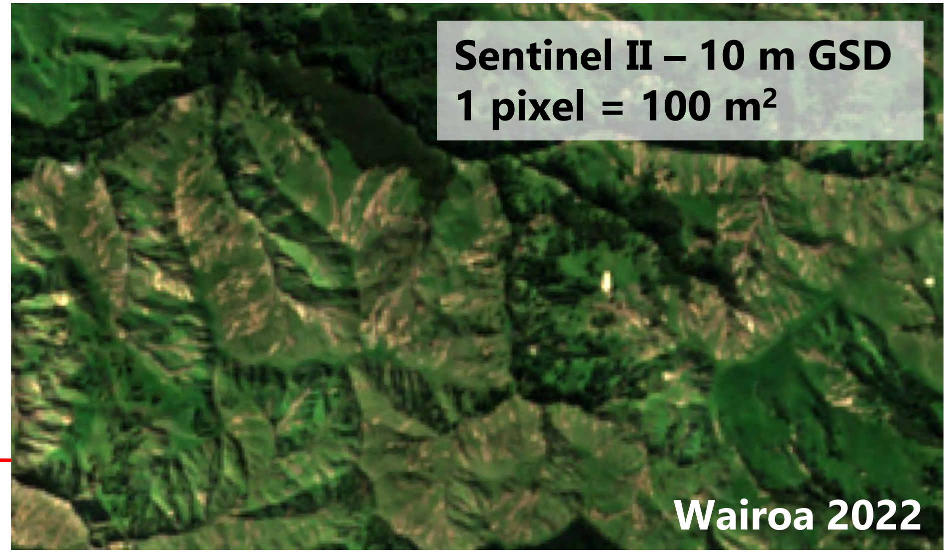
- Require high-res imagery to differentiate scars and deposits
- Assembled large inventory of shallow landslides



Median scar size = 50 m²

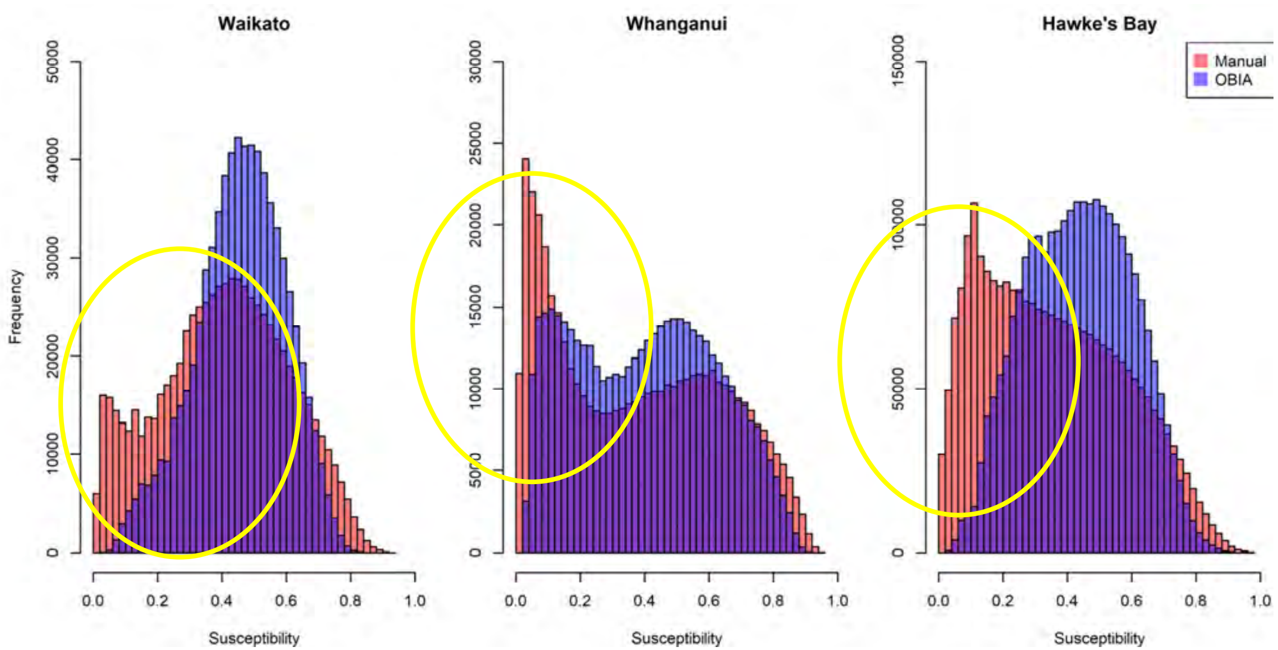


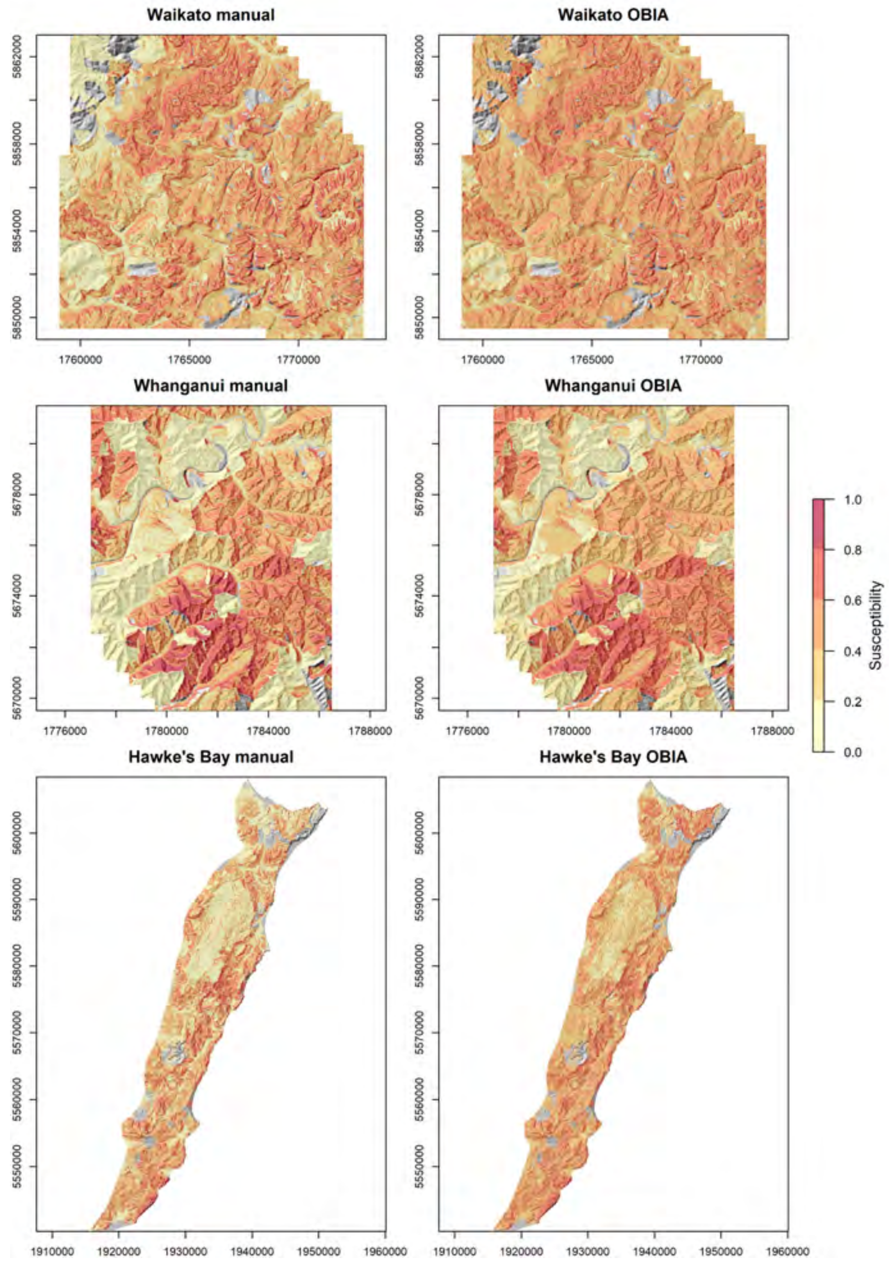
Typical distribution of scar size in soft rock hill country



3.1 Influence on susceptibility:
Manual vs. automated mapping

- Model performance reduced using unrefined OBIA
- Susceptibility patterns generally similar
- Under-predict stable areas - false positives



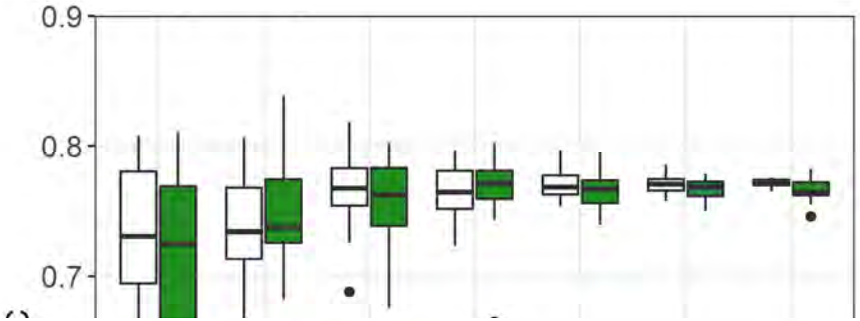


3.1 Influence on susceptibility:
Event vs. multi-temporal

- Challenges for landslide data acquisition:

Event-scale	Multi-temporal (historic)
• size of storm-affected areas • effect of rainfall pattern • need to target 'core' impact area	• preferred according to literature, but… • time and costs lead to focus on small areas • relies on lower res… historical imagery • delayed image ca… reduced detectab…

- Comparable performance across sample sizes



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Comparing methods of landslide data acquisition and susceptibility modelling: Examples from New Zealand

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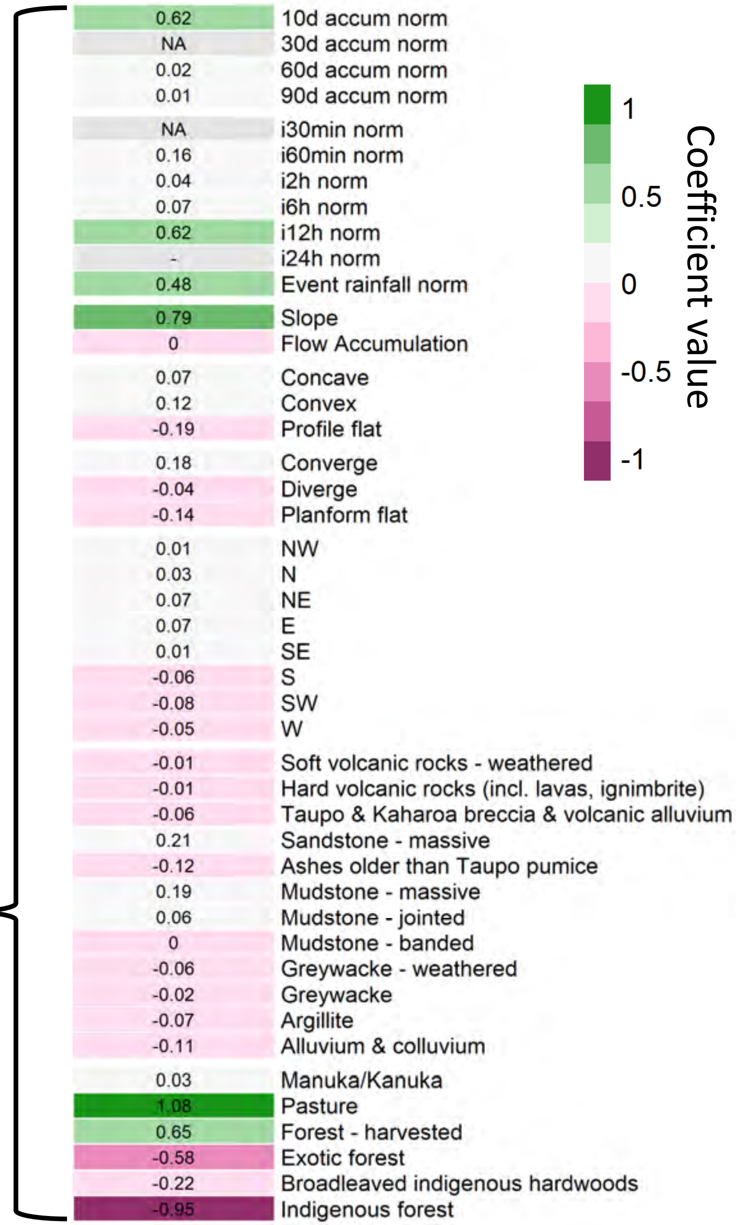
Manaaki Whenua – Landcare Research, Palmerston North, New Zealand

3.2 Factors influencing landslide occurrence

- Classify landslide & non-landslide data
- Automated variable selection & coefficient estimation
- Includes spatial rainfall (radar) and landscape factors
- Good predictive performance (AUC > 0.8)

Most influential variables:

Increase susceptibility (+)		Decrease susceptibility (-)	
Pasture	1.08	Indigenous forest	0.95
Slope	0.79	Exotic forest	0.58
Harvested forest	0.65	Broadleaf indigenous hardwoods	0.22
Max 12 h intensity	0.62	Planar or flat land	0.19
10 d pre-event	0.62	Ashes older than Taupo pumice	0.12
Event rainfall total	0.48	Alluvium & colluvium	0.11



3.2 Rainfall and landslide density

- **Step change** in landslide spatial density for pasture areas on soft sedimentary rocks:

  ➢ **Max 12-hr intensity exceeds 10-yr ARI by ≥ 25%**

  50 – 72 vs. 234 scars km^{-2} (**> 3-fold** ↑)

  ➢ **Event total ≥ 10% of mean annual rainfall**

  17 – 87 vs. 181 scars km^{-2} (**> 2-fold** ↑)

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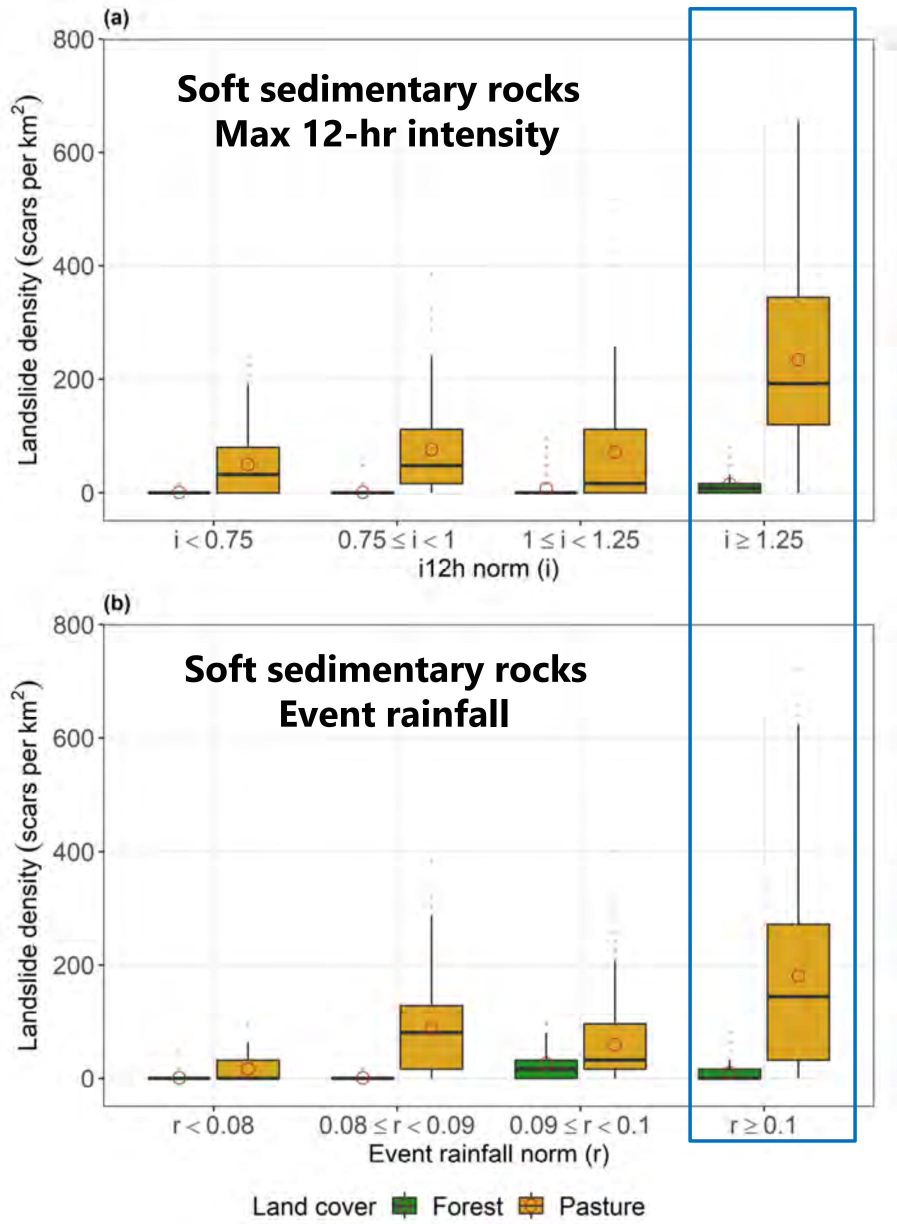
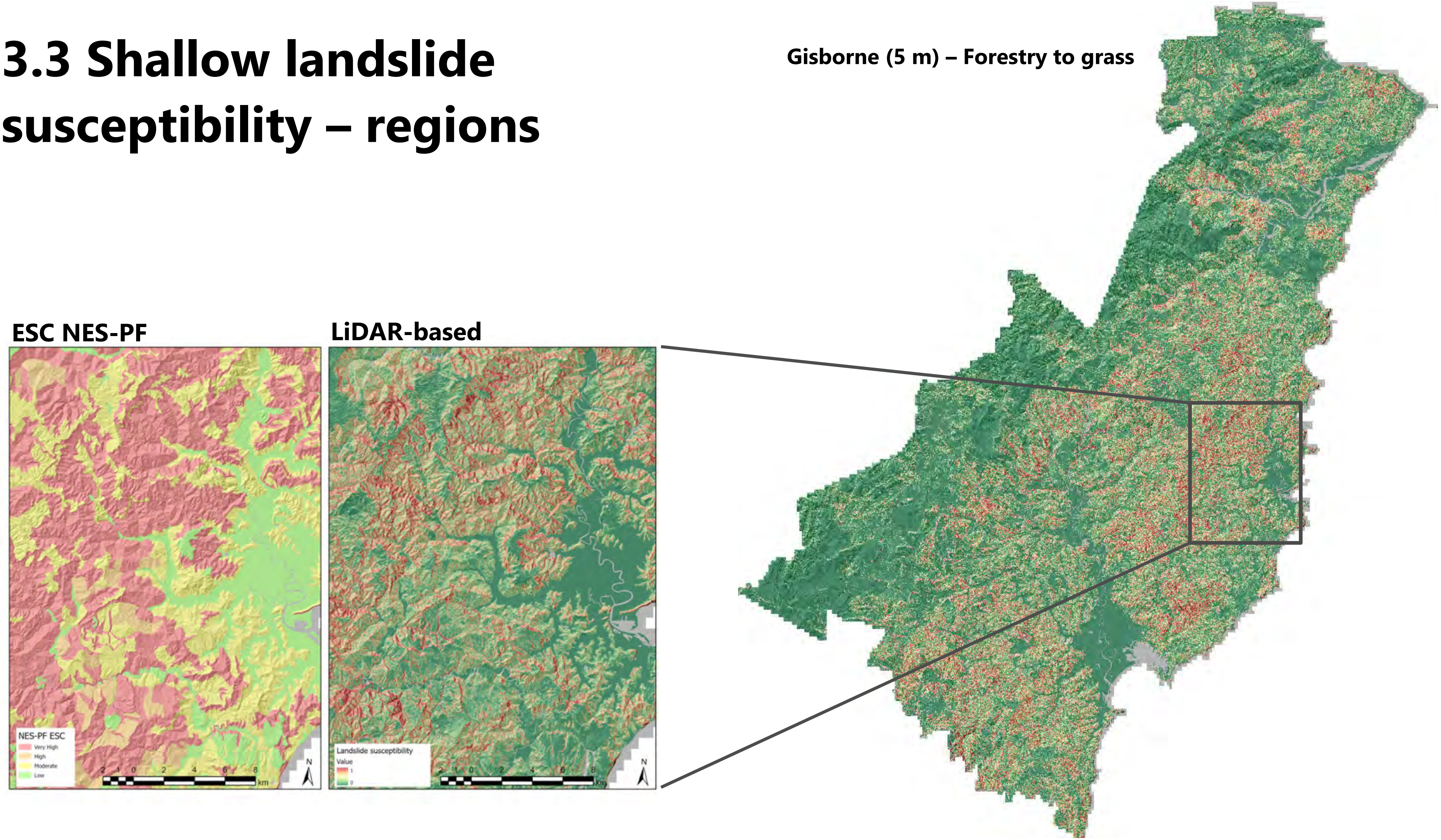
The influence of spatial patterns in rainfall on shallow landslides

Hugh G. Smith[a,*], Andrew J. Neverman[a], Harley Betts[a], Raphael Spiekermann[b]

[a] Manaaki Whenua – Landcare Research, Palmerston North, New Zealand
[b] GeoSphere Austria, Vienna, Austria

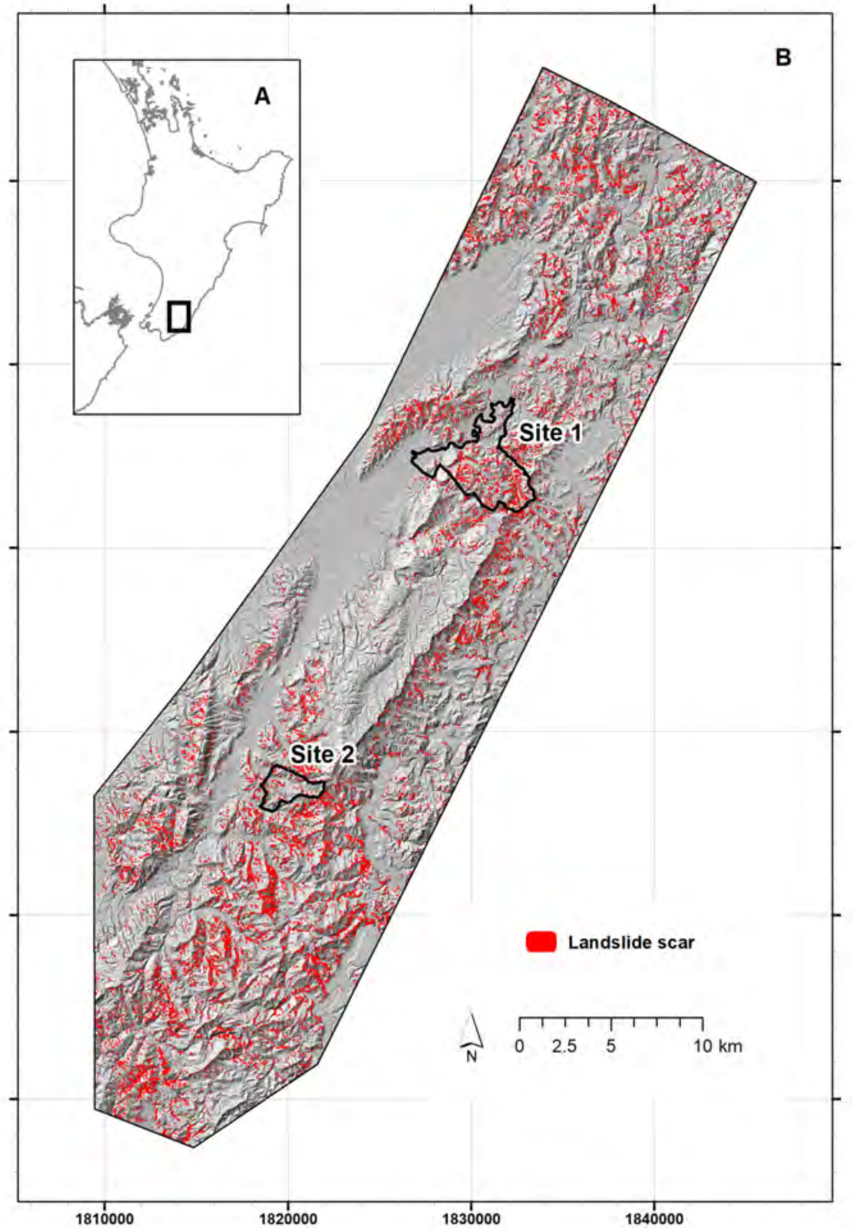


3.3 Shallow landslide susceptibility – regions



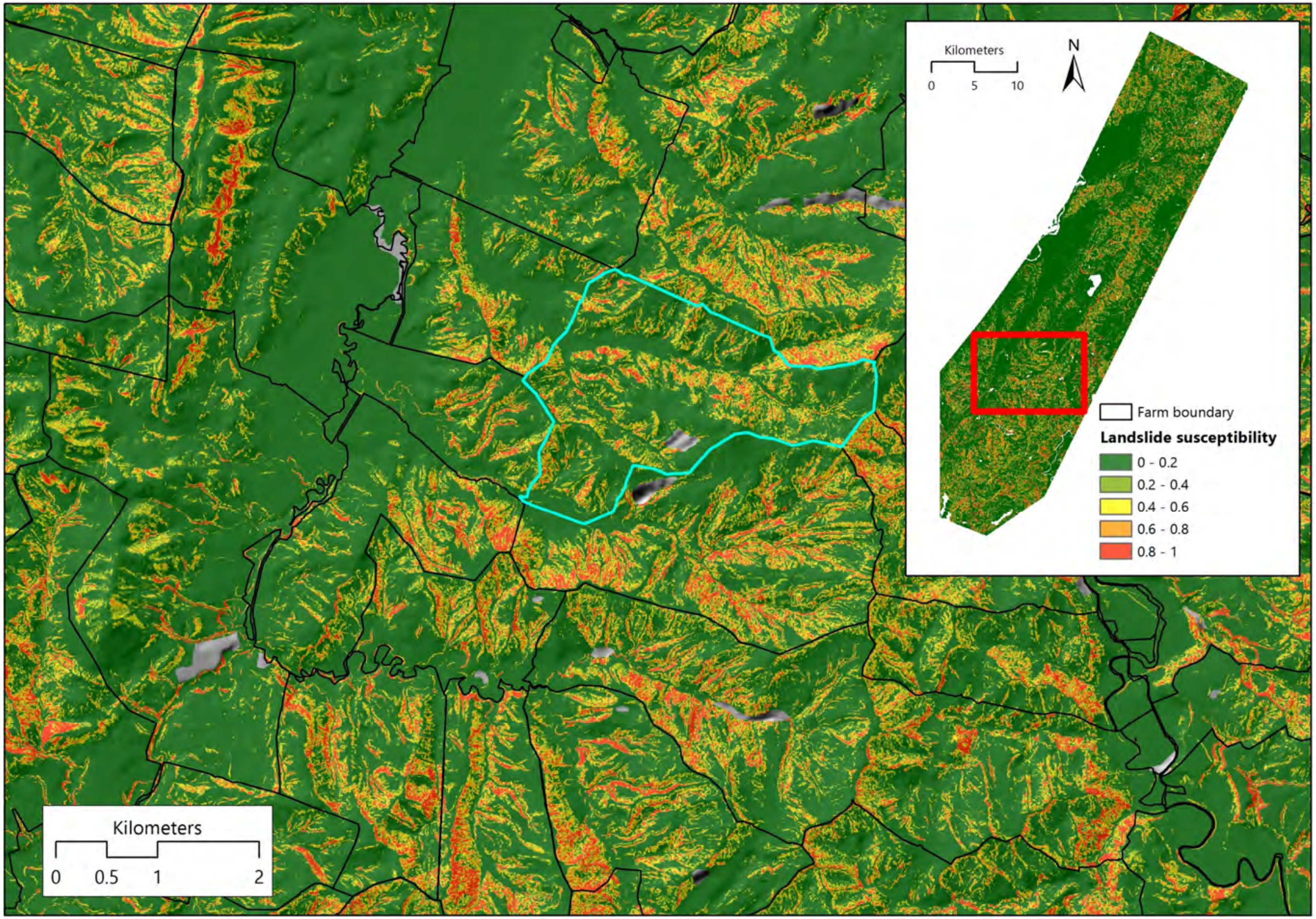
3.4 Shallow landslide susceptibility – individual trees

- **New opportunities with LiDAR**
  - ➢ High-res DEM
  - ➢ Map individual trees
  - ➢ Classify trees by species/genera
- 840 km^2 study area in Wairarapa
- Mapped shallow landslide scars (>43,000)
- Represent influence of individual trees on susceptibility



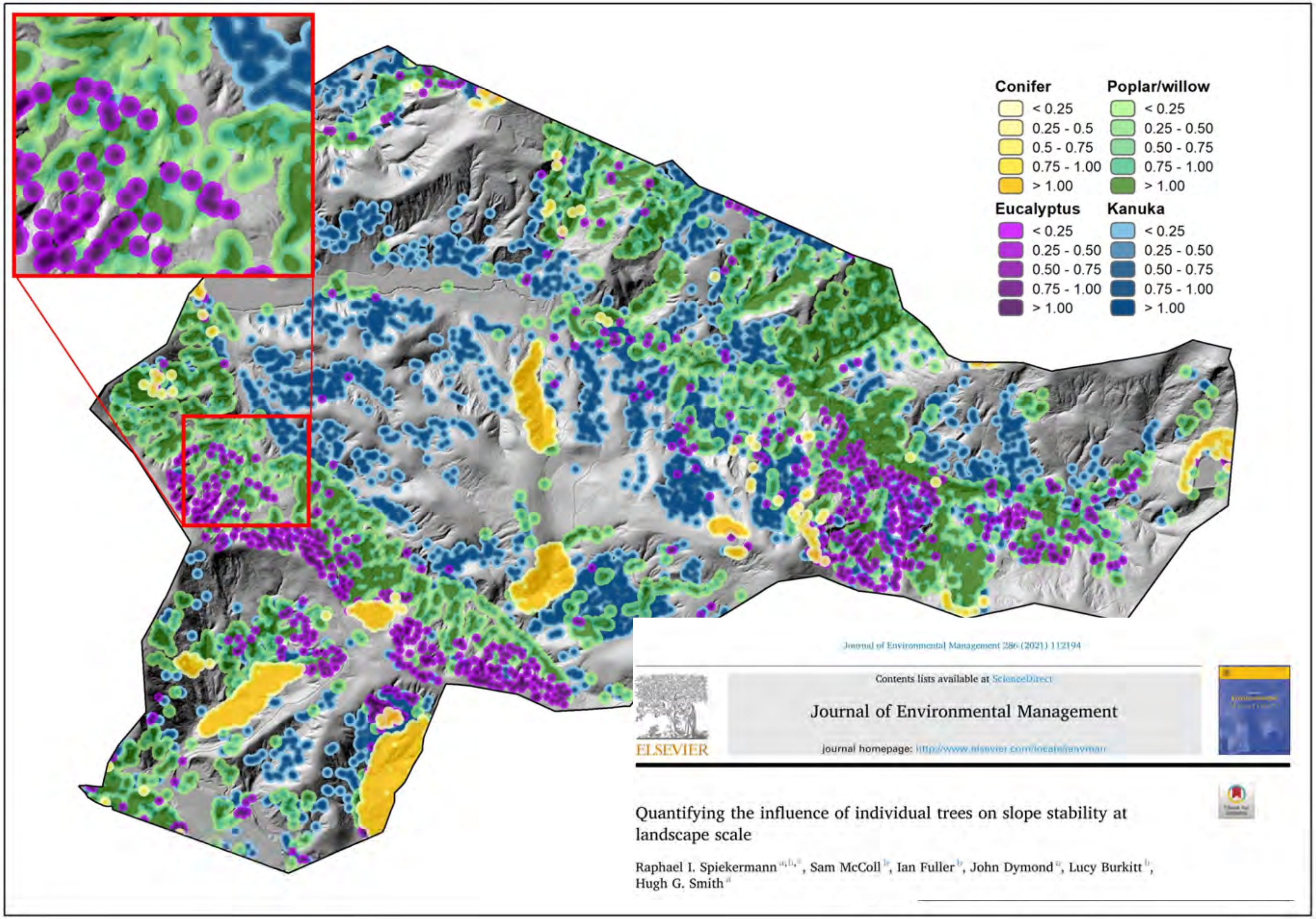
3.4 Landslide Susceptibility

Model using 5-m LiDAR DEM and LCDB



3.4 Tree influence

Tree influence model on slope stability (TIMSS)



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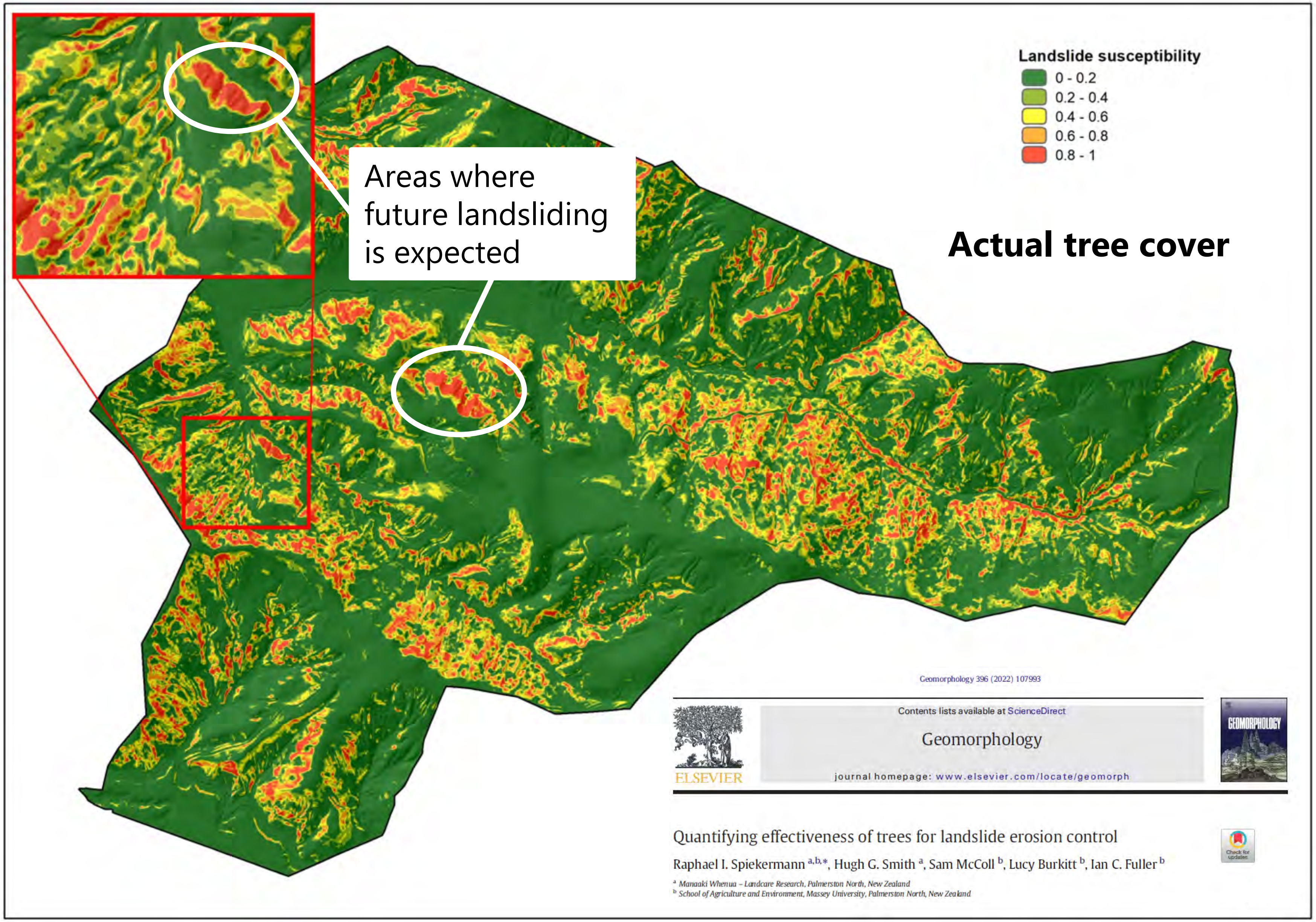
journal homepage: http://www.elsevier.com/locate/jenvman

Quantifying the influence of individual trees on slope stability at landscape scale

Raphael I. Spiekermann [a,b,*], Sam McColl [b], Ian Fuller [b], John Dymond [a], Lucy Burkitt [b], Hugh G. Smith [a]

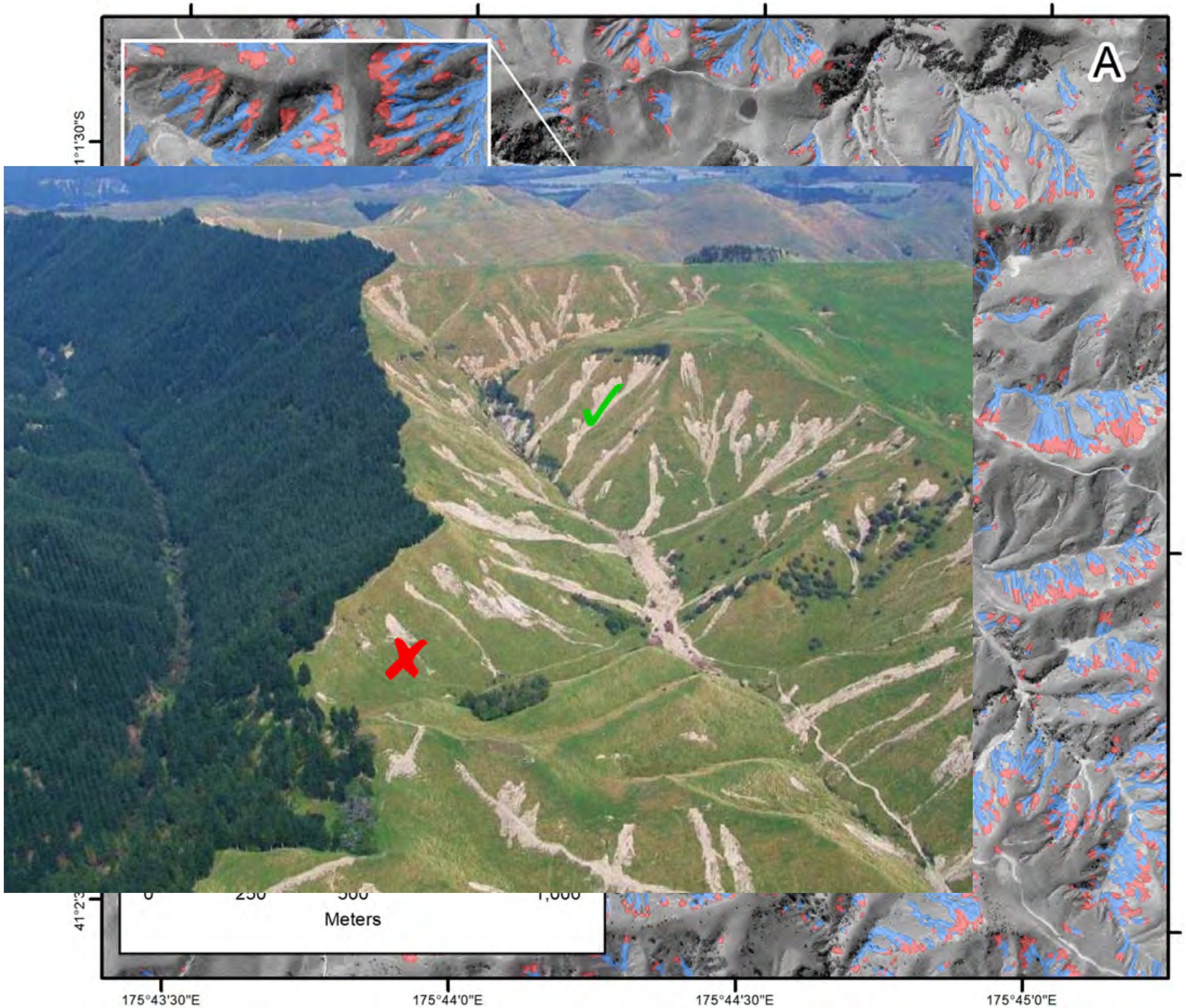
3.4 Tree influence



3.4 Landslide sediment delivery to streams

- Landslide scar and debris tail mapping
- Wairarapa 1977 rainfall event
- Data used to develop a statistical connectivity model

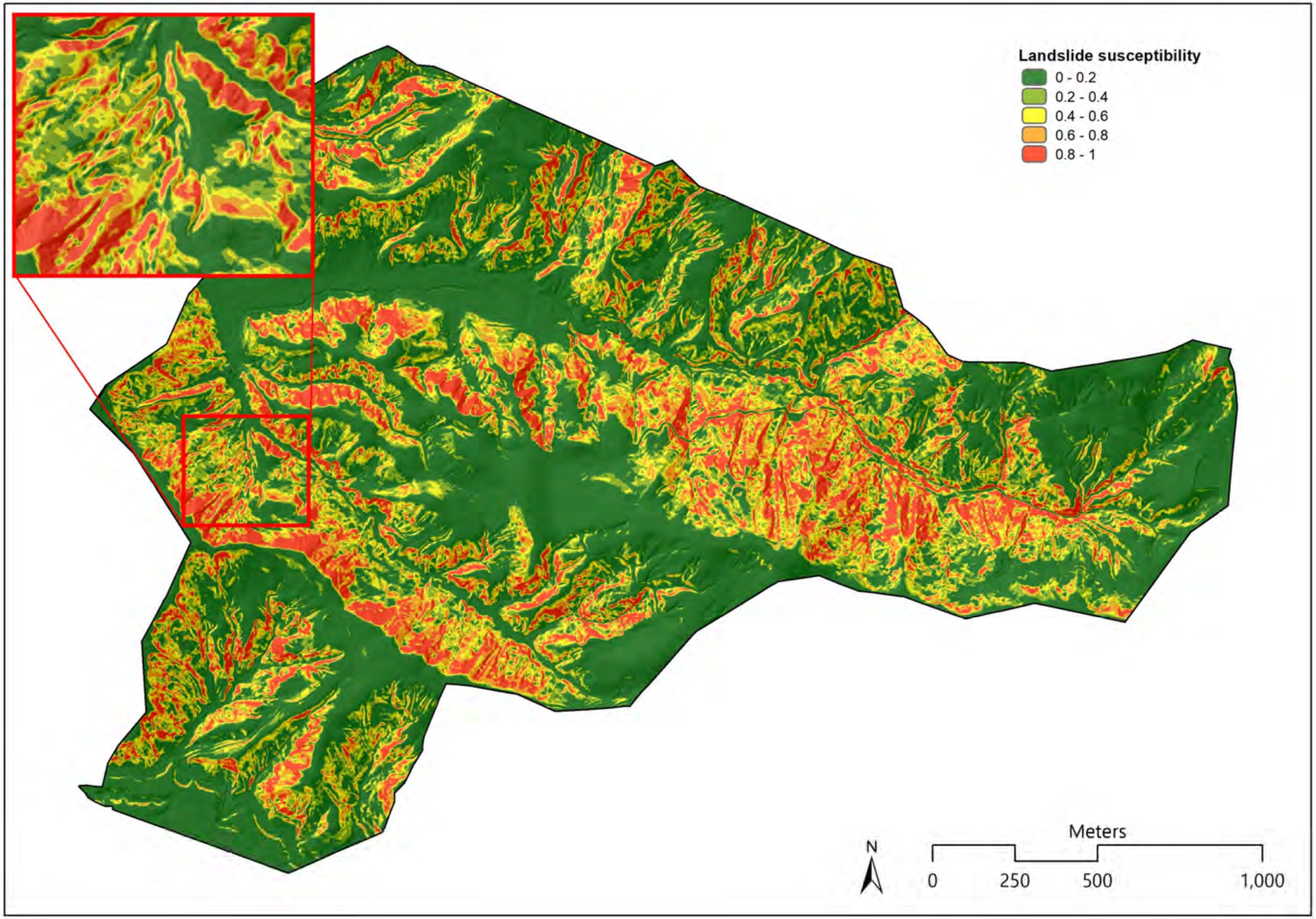
➢ Assess potential sediment delivery to streams



3.4 Sediment delivery

Treeless baseline

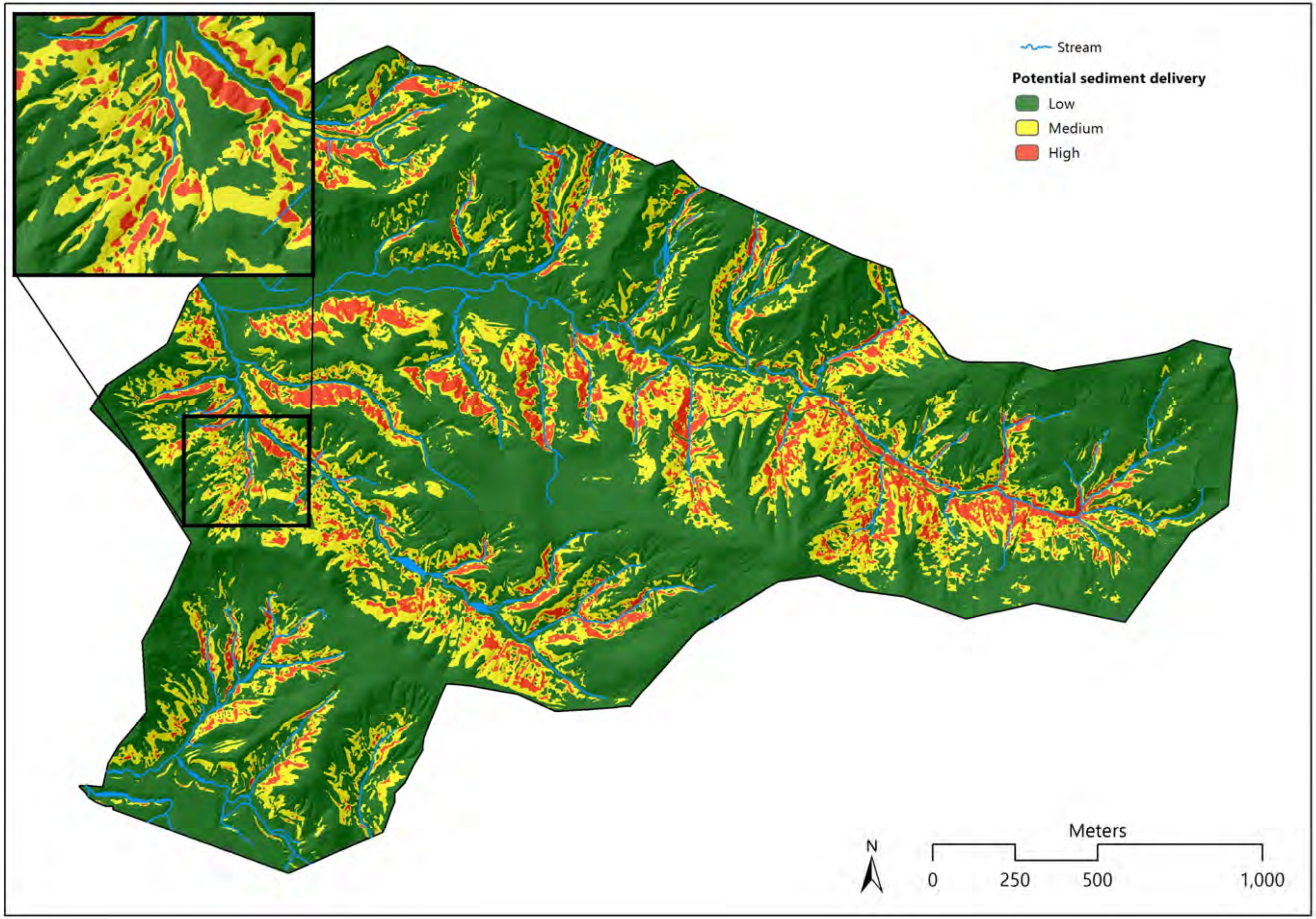
Susceptibility only



3.4 Sediment delivery

Treeless baseline

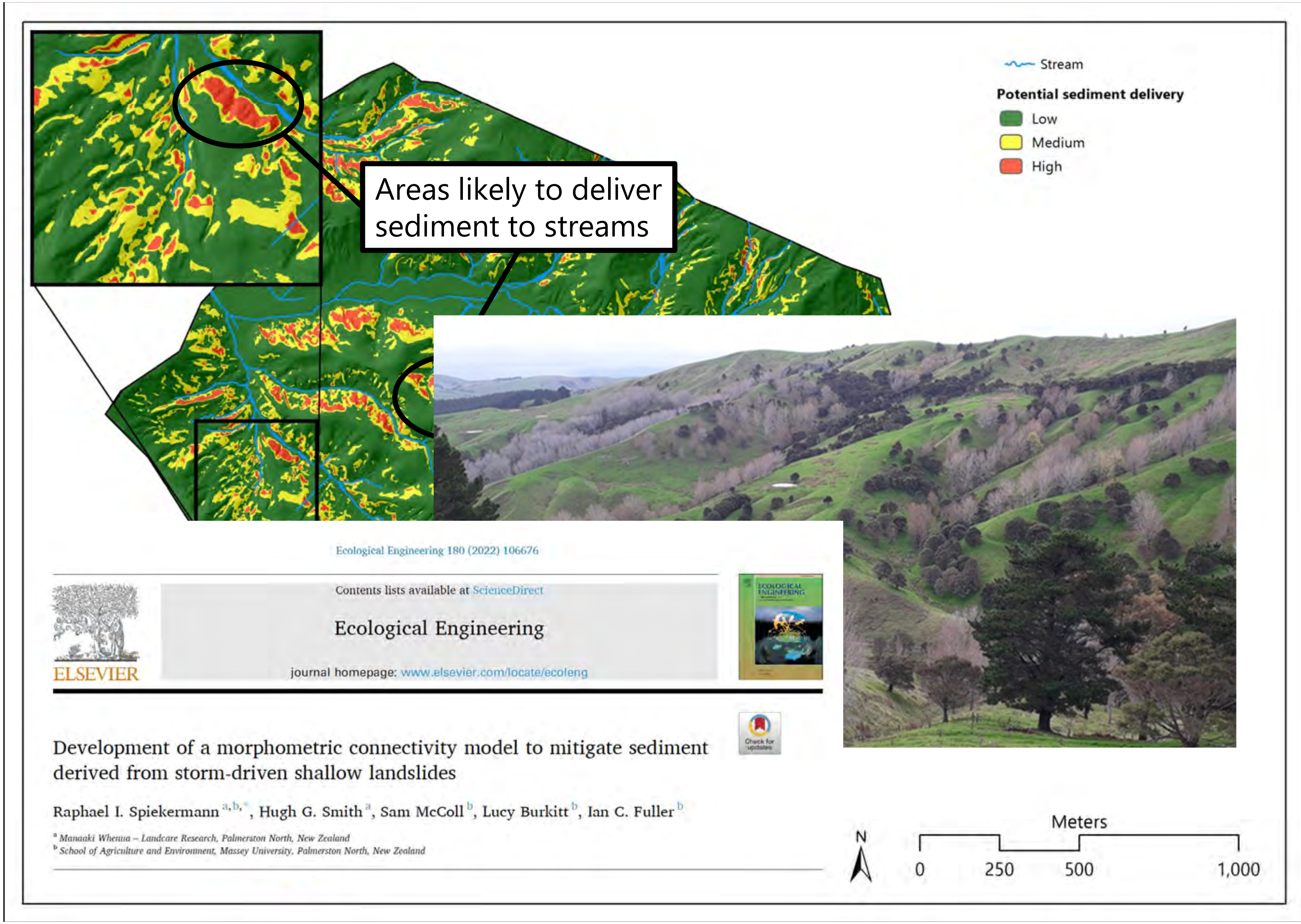
Integrate susceptibility & connectivity models



3.4 Sediment delivery

Actual tree cover

Integrate susceptibility & connectivity models



Ecological Engineering 180 (2022) 106676
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Development of a morphometric connectivity model to mitigate sediment derived from storm-driven shallow landslides

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[a] Manaaki Whenua – Landcare Research, Palmerston North, New Zealand
[b] School of Agriculture and Environment, Massey University, Palmerston North, New Zealand

4. Key messages

- Automated mapping with manual refinement enables **rapid acquisition** of landslide scar and deposit data for modelling.
- Statistical landslide susceptibility models provide a data-driven approach to better target erosion control **from region to tree scales**.
- **LiDAR** rollout is enabling new data collection, improved model performance, and higher resolution susceptibility maps.
- Statistical connectivity models support targeted erosion control to **reduce landslide sediment delivery to streams.**
- **Large increase** in landslide spatial densities with intense rainfall possible under the highest levels of future warming

5. Publications

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Ecological Engineering 173 (2021) 106436

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Ecological Engineering

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

Shallow landslides and vegetation at the catchment scale: A perspective

Chris Phillips [a,*], Tristram Hales [b], Hugh Smith [c], Les Basher [d]

Geomorphology 440 (2023) 108870

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.journals.elsevier.com/geomorphology

Comparing physical and statistical landslide susceptibility models at the scale of individual trees

Raphael I. Spiekermann [a,b,*,1], Feiko van Zadelhoff [c,d,1], Jan Schindler [a], Hugh Smith [a], Chris Phillips [a], Massimiliano Schwarz [c]

Geomorphology 396 (2022) 107993

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Raphael I. Spiekermann [a,b,*], Hugh G. Smith [a], Sam McColl [b], Lucy Burkitt [b], Ian C. Fuller [b]

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