# Table 1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Response | Model type | Predictor | Main effect | | SWAFR effect | | SWAFR interaction | |
| (a) *S*QDS | Main effect × region | Elevation | 140.2 | \*\*\* | 124.4 | \*\*\* | -56.1 | \* |
|  |  | MAP | 172.0 | \*\*\* | 54.5 | \*\* | -54.1 | \*\* |
|  |  | PDQ | 73.4 | \*\*\* | 55.6 | \* | 61.9 | \*\* |
|  |  | NDVI | 154.9 | \*\*\* | -7.8 |  | -102.2 | \*\*\* |
|  | Main effect + region | PC1 | 67.0 | \*\*\* | 92.5 | \*\*\* |  |  |
|  | Main effect only | Surface T | 62.1 | \*\*\* |  |  |  |  |
|  |  | CEC | 14.7 |  |  |  |  |  |
|  |  | Clay | 42.1 | \*\*\* |  |  |  |  |
|  |  | Soil C | 62.9 | \*\*\* |  |  |  |  |
|  |  | pH | 21.9 | \* |  |  |  |  |
| (b) *S*HDS | Main effect × region | MAP | 399.0 | \*\*\* | -41.5 |  | -185.0 | \*\* |
|  |  | Clay | -12.8 |  | -216.1 | \*\* | 173.6 | \* |
|  | Main effect only | Elevation | 163.7 | \*\*\* |  |  |  |  |
|  |  | PDQ | 226.3 | \*\*\* |  |  |  |  |
|  |  | Surface T | 135.9 | \*\*\* |  |  |  |  |
|  |  | NDVI | 246.6 | \*\*\* |  |  |  |  |
|  |  | Soil C | 159.4 | \*\*\* |  |  |  |  |
|  |  | PC1 | 123.1 | \*\*\* |  |  |  |  |
|  | Region only | CEC | -26.3 |  | -251.9 | \*\* |  |  |
|  |  | pH | 53.8 |  | -193.0 | \* |  |  |
| (c) *S*DS | Main effect × region | Elevation | -1455.9 | \* | -2278.4 | \*\* | 1668.5 | \* |
|  |  | MAP | 683.3 | \*\*\* | -519.1 | \*\* | -382.1 | \* |
|  |  | CEC | -933.3 | \*\* | -1043.4 | \*\*\* | 837.1 | \* |
|  | Main effect + region | Clay | 273.0 | \* | -542.8 | \* |  |  |
|  |  | Soil C | 246.5 | \* | -615.4 | \* |  |  |
|  | Main effect only | PDQ | 363.1 | \*\* |  |  |  |  |
|  |  | Surface T | 336.7 | \*\* |  |  |  |  |
|  |  | NDVI | 475.3 | \*\*\* |  |  |  |  |
|  |  | pH | 448.4 | \*\*\* |  |  |  |  |
|  |  | PC1 | 231.1 | \*\*\* |  |  |  |  |

# **Table 2** […] All correlation coefficients were significant (*P* < 0.05; two-sided *t*-test).

|  |  |  |
| --- | --- | --- |
|  | Correlation | |
| Spatial scale | Predicted *S* | Residual *S* |
| QDS | 0.680 | 0.908 |
| HDS | 0.699 | 0.834 |
| DS | 0.723 | 0.369 |

A close up of text on a white background

Description automatically generated

# Figure 2

**A close up of a map

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# Figure 3

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# Figure 4

**A screenshot of a cell phone

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# Figure 5

# Table S2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Response | Term | Variance explained | | |
| (a) *S*QDS | (Residuals) | 0.72 |  | - |
| *R*2adj. = 0.27 | MAP | 0.13 |  | \*\*\* |
|  | Elevation | 0.06 |  | \*\*\* |
|  | NDVI | 0.03 |  | \*\*\* |
|  | PDQ × Region | 0.02 |  | \*\*\* |
|  | region | 0.02 |  | \*\*\* |
|  | NDVI × Region | 0.01 |  | \*\*\* |
|  | Clay | 0.01 |  | \*\* |
|  | pH | 0.01 |  | \*\* |
|  | CEC | 0.01 |  | \* |
|  | pH × Region | 0.01 |  | \* |
|  | PDQ | < 0.01 |  |  |
|  | MAP × Region | < 0.01 |  |  |
| (b) *S*HDS | (Residuals) | 0.54 |  | - |
| *R*2adj. = 0.43 | MAP | 0.21 |  | \*\*\* |
|  | Elevation | 0.1 |  | \*\*\* |
|  | pH × Region | 0.04 |  | \*\*\* |
|  | NDVI | 0.02 |  | \*\* |
|  | MAP × Region | 0.02 |  | \*\* |
|  | pH | 0.02 |  | \* |
|  | Clay | 0.02 |  | \* |
|  | PDQ | 0.02 |  | \* |
|  | Surface T × Region | 0.01 |  | \* |
|  | Surface T | 0.01 |  |  |
|  | Soil C: × Region | < 0.01 |  |  |
|  | region | < 0.01 |  |  |
|  | Soil C | < 0.01 |  |  |
| (c) *S*DS | NDVI | 0.17 |  | \*\*\* |
| *R*2adj. = 0.85 | Elevation | 0.15 |  | \*\*\* |
|  | PDQ | 0.14 |  | \*\*\* |
|  | pH × Region | 0.11 |  | \*\*\* |
|  | Clay | 0.07 |  | \*\*\* |
|  | (Residuals) | 0.07 |  | - |
|  | NDVI × Region | 0.06 |  | \*\* |
|  | Clay × Region | 0.06 |  | \*\* |
|  | Soil C × Region | 0.04 |  | \*\* |
|  | Surface T | 0.04 |  | \*\* |
|  | CEC | 0.03 |  | \* |
|  | Soil C | 0.02 |  | . |
|  | Elevation × Region | 0.02 |  | . |
|  | PDQ × Region | 0.01 |  |  |
|  | pH | 0.01 |  |  |
|  | Surface T × Region | < 0.01 |  |  |
|  | region | < 0.01 |  |  |
|  | CEC × Region | < 0.01 |  |  |

# Table S3 […] All pairs of GCFR and SWAFR *SD*-values differed significantly (*P* < 0.01; two-sided *F*-tests).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | *SD* of model residuals | | | | |
|  |  |  | Including hotspots | |  | Excluding hotspots | |
| Scale | Region |  | PC1 | MV |  | PC1 | MV |
| (a) QDS | GCFR |  | 343.46 | 312.89 |  | 234.93 | 217.56 |
|  | SWAFR |  | 245.77 | 223.05 |  | 203.91 | 174.97 |
| (b) HDS | GCFR |  | 638.62 | 519.19 |  | 460.39 | 360.47 |
|  | SWAFR |  | 334.15 | 290.90 |  | 326.06 | 273.31 |
| (c) DS | GCFR |  | 811.89 | 6.22 |  | 588.58 | *NA* |
|  | SWAFR |  | 311.80 | 226.50 |  | 297.22 | *NA* |

A close up of a device

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# Figure S1



# Figure S2

A close up of a keyboard

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# Figure S3

# A close up of a map Description automatically generatedFigure S4 […] Environmental heterogeneity variables’ loadings are labelled as follows: 1, elevation; 2, MAP; 3, PDQ; 4, surface T; 5, NDVI; 6, CEC; 7, clay; 8, soil C; 9, pH.



# Figure S5 […] PC1-outliers

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# Figure S6 […] MV-outliers



# Figure S7

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# Figure S8

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# Figure S9–S10