Monitoring soil-based ecosystem services in El Salvador

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Outline

- Introduction
  - Research objectives
- Methods
  - Project location and sampling
  - GIS analysis
- Preliminary Results
  - Maps of soil properties and nutrient deficiencies
- Next steps and applications
  - Translating soil properties into ecosystem services

Introduction

Agroforestry for **B**iodiversity and **E**cosystem **S**ervices (**ABES**) Project

Develop and promote management strategies to protect and/or enhance ecosystem services

- Evaluate a "slash-and-mulch" agroforestry system (SMAS)
- *Quantify current ecosystem services and assess degradation at the landscape scale*

Introduction

- *Quantify current ecosystem services (ES) and assess degradation at the landscape scale*

Measure indicators → Assess relationship with ES → Map ES → Value ES

Broad Indicators

Land use/cover

Soil quality

Erosion

Biodiversity (woody vegetation)

Biomass

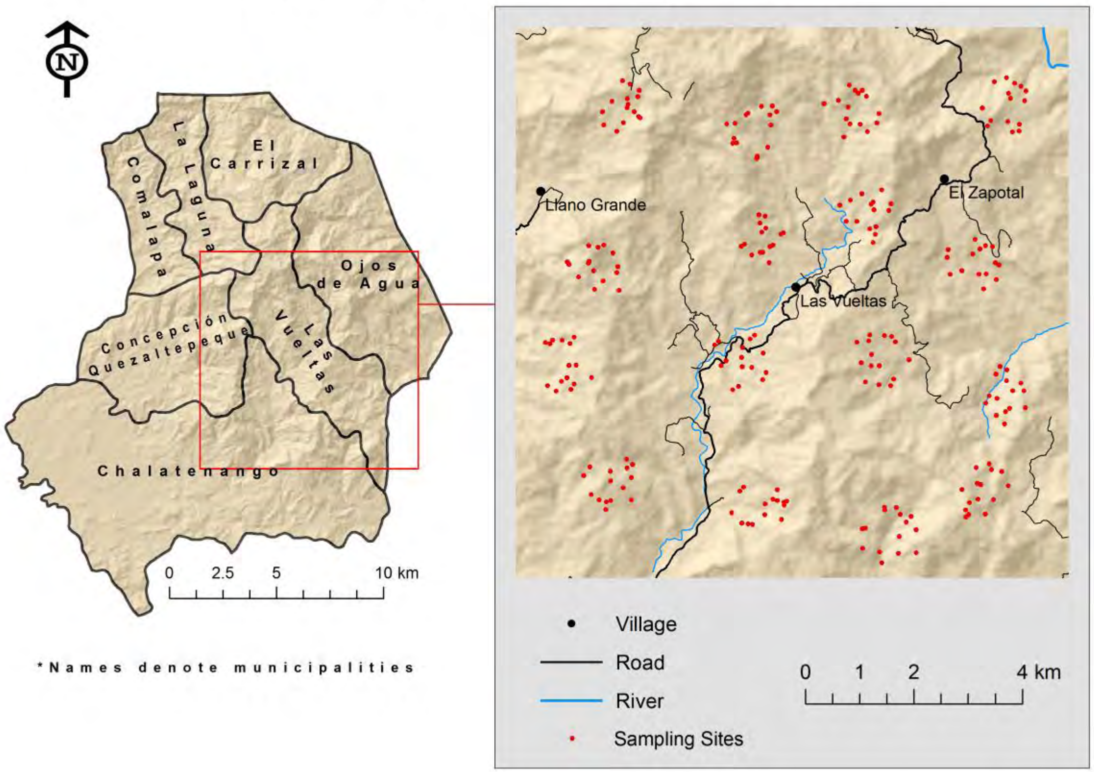
Carbon storage

Methods

Methods

Baseline Landscape Assessment (BLA)

ABES BLA Site: Las Vueltas, El Salvador



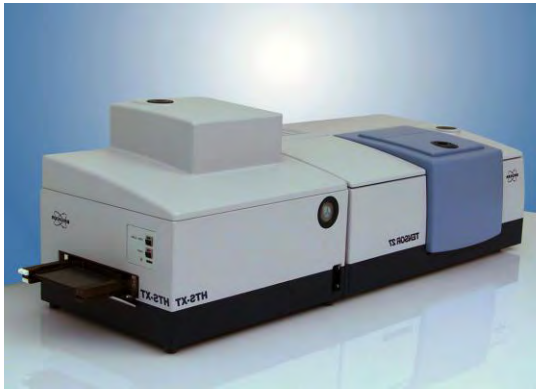
<u>Sampling (Nov-Dec 2012)</u>

- 100 km^2
- 144 sites
- Based on the **LDSF** methodology
- Hierarchical cluster sampling
  - Soils cores up to 1m
  - Infiltration rate
  - All woody vegetation
  - Canopy/ground cover
  - Observations

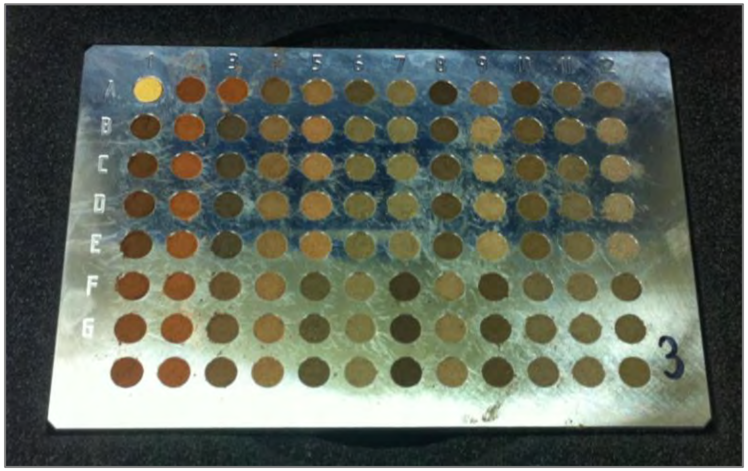
Methods

Soil analysis

	Soil Property	Analysis Method
Chemical Properties	**SOM**	FT-MIR (Walkeley-Black)
	Total C	FT-MIR
	Total N	FT-MIR (Keidel)
	P	Mehlich - 1
	K	Mehlich - 1
	exch-Ca	FT-MIR (KCl)
	exch-Mg	FT-MIR (KCl)
	Zn	Mehlich - 1
	pH	Soil:Water (1: 2.5)
Physical Properties	**Sand**	Hydrometer
	Silt	Hydrometer
	Clay	Hydrometer
	Soil Depth	Auger Restriction (up to 1m)
	Infiltration Rate	Decagon MDI



FT-IR spectrometer (Tensor 37 with HTS-XT)



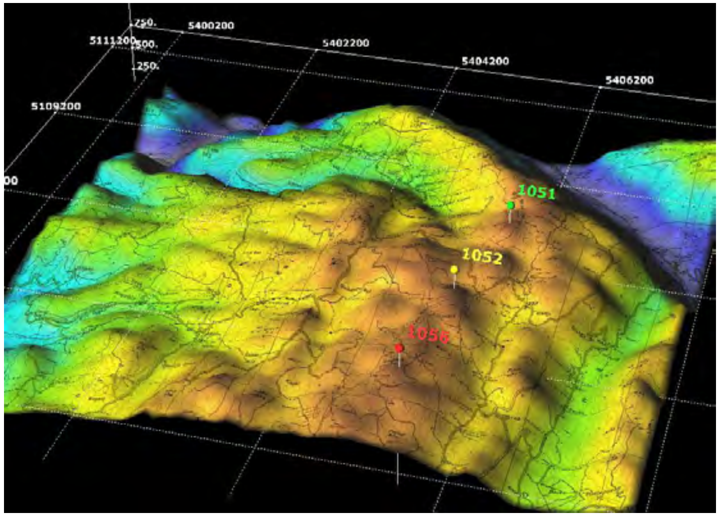
Micro-plate prepped for FT-MIR analysis

Methods

Mapping using geostatistics

Co-Kriging

- Predict values at unsampled locations
- Incorporate cross-correlation with remote sensing variables that are:
  - Higher resolution
  - Easier/cheaper to measure



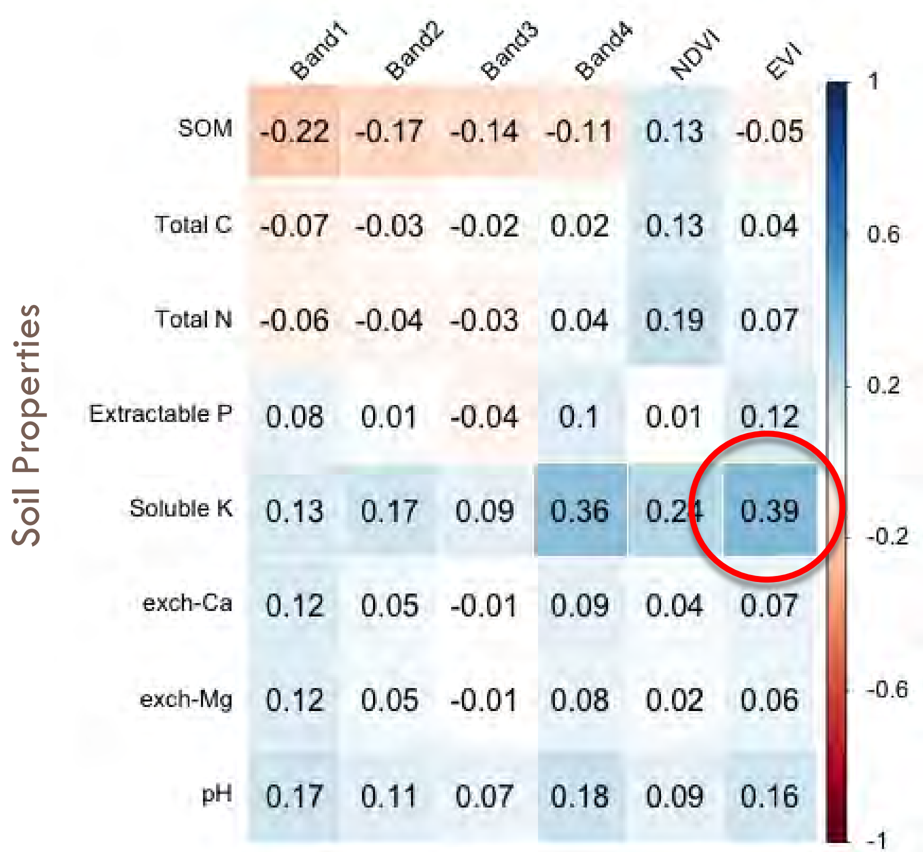
Source: sciencegl.com

Methods

Choosing co-variates

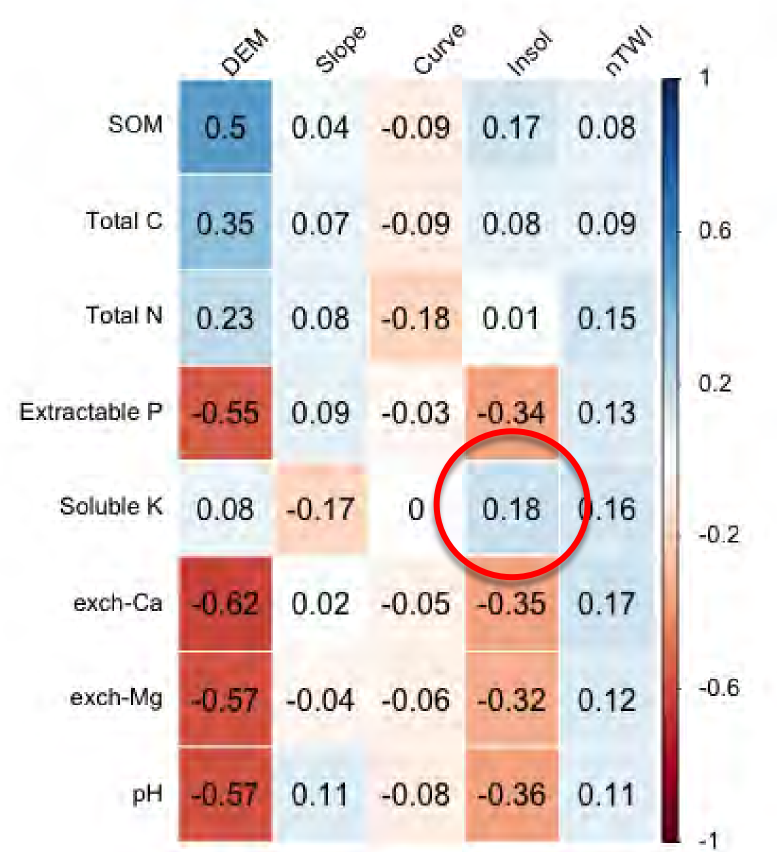
Spectral Layers (biotic)

QuickBird Imagery (2.4m)



Terrain Layers (abiotic)

ASTER DEM (30m)

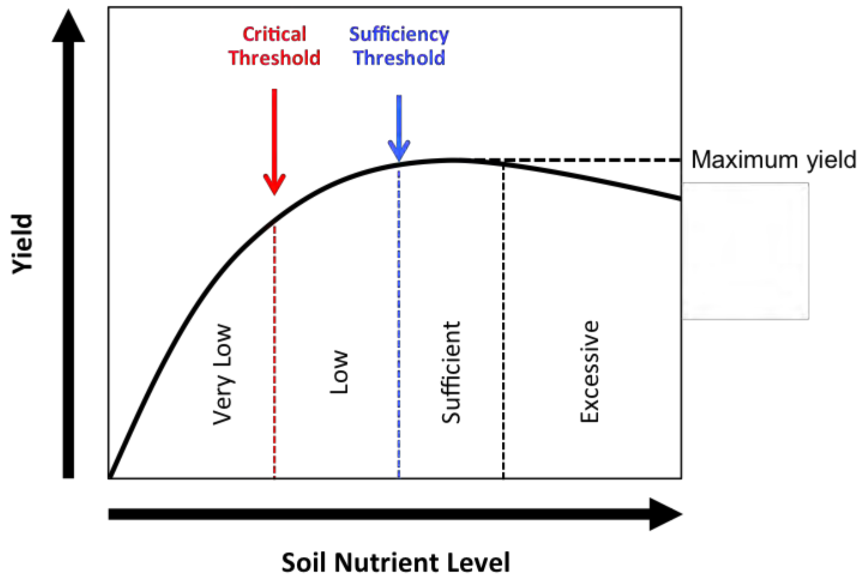


Methods

Co-Kriging Maps

Prediction Map: Predicted soil property values

Probability Maps: Probability of not exceeding recommended threshold values



Results

Results

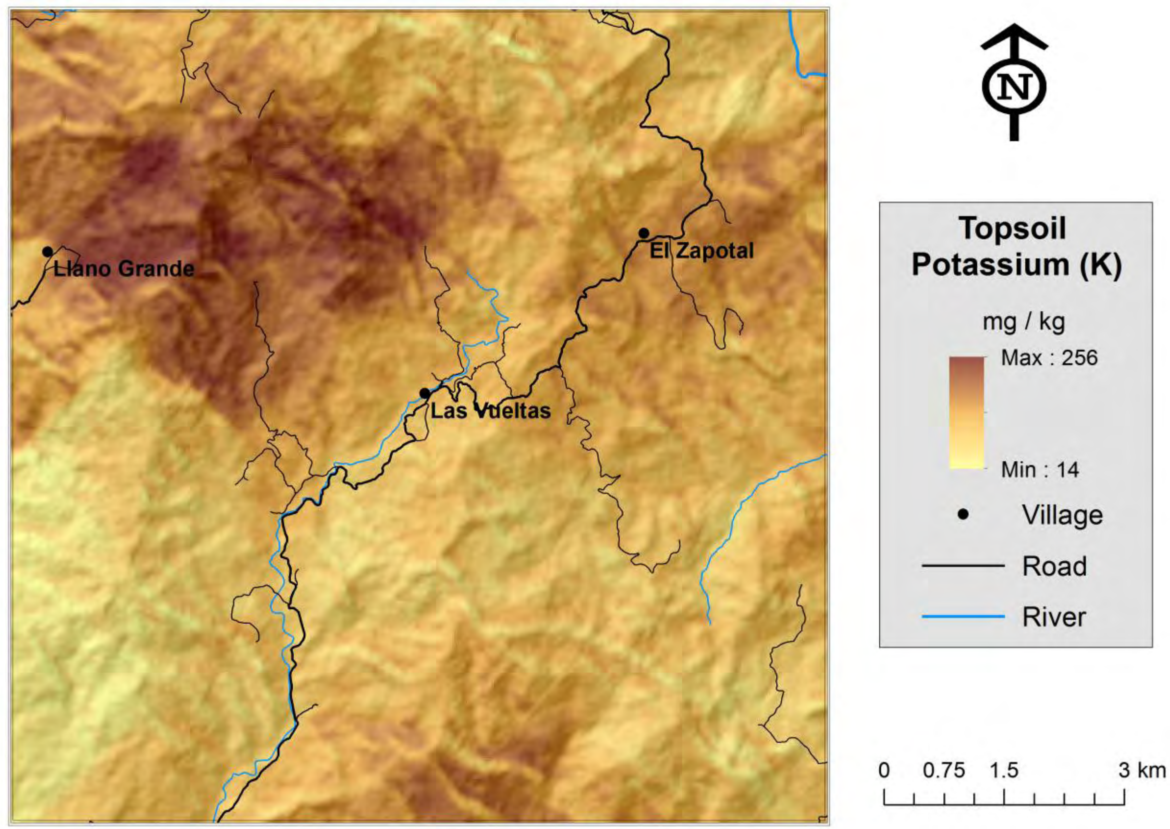
Example: Potassium

Sample Results

Topsoil K (mg kg^{-1})		
Mean (n = 143)	115	(± 65) [1]
Median	109	
Minimum	13	
Maximum	335	
Sufficiency Threshold	175	(86%) [2]
Critical Threshold	60	(26%) [2]

[1] Standard deviation
[2] Percent of sample sites below threshold

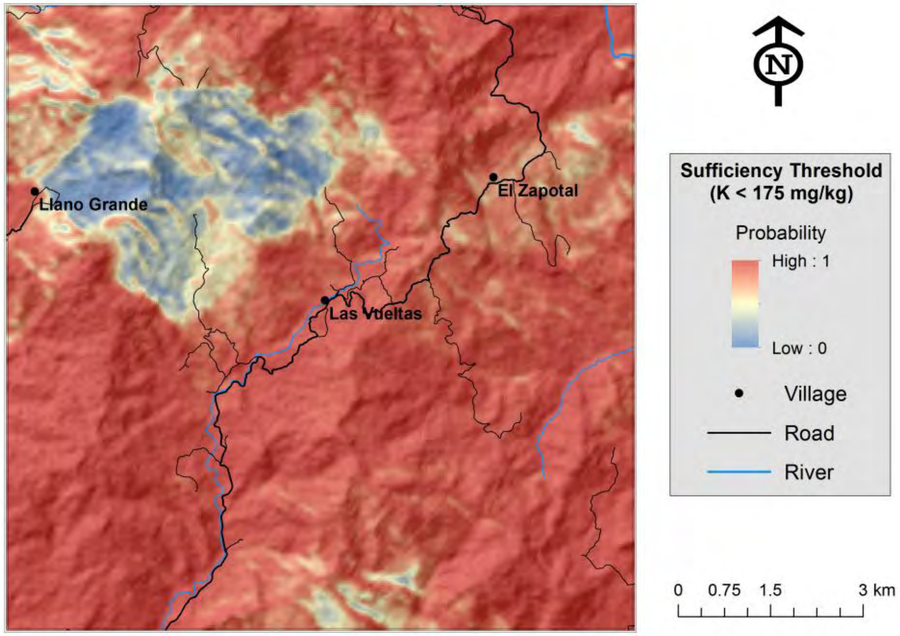
Co-Kriging Map Results



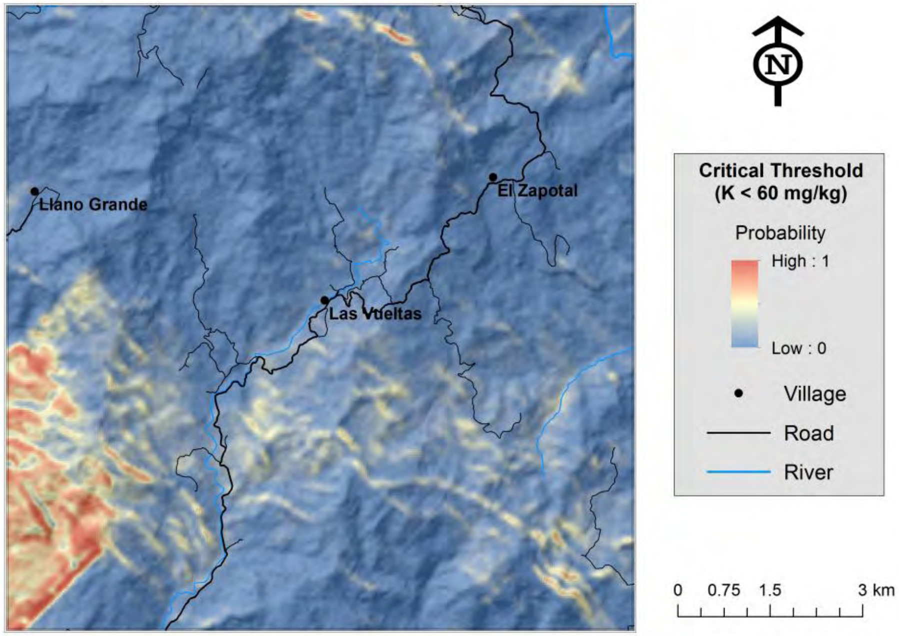
Results

Example: Potassium

Probability of Low Soil K



Probability of Critical Deficiency



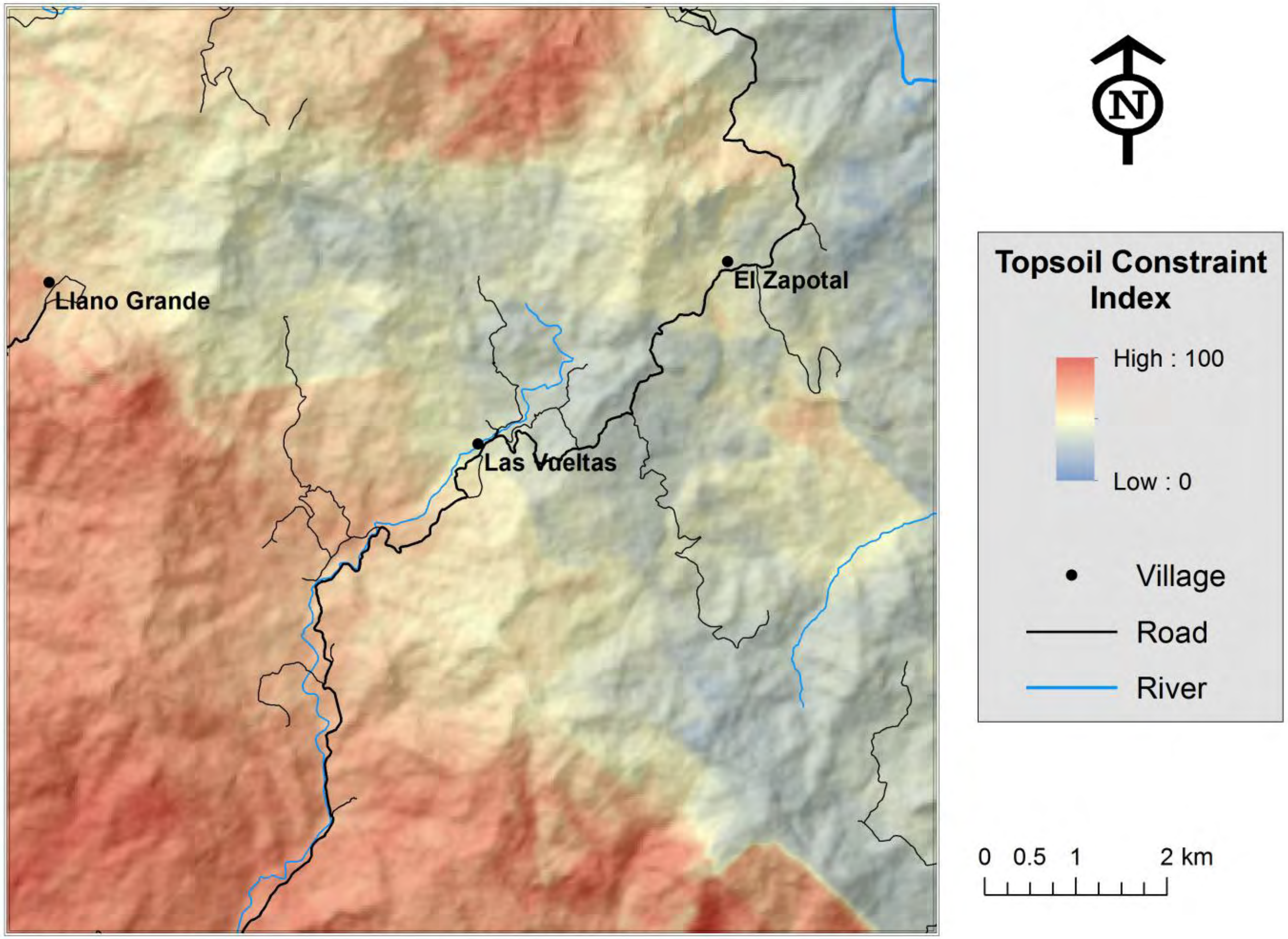
Topsoil Constraint Index (TCI)

Raster Math:

$$TCI = \frac{\left(\sum_{(P_1)^2}^{(P_n)^2} \times 100 \,/\, n\right)}{\left(\frac{P_{SOM}}{Max(P_{SOM})} + \frac{P_{Depth}}{Max(P_{Depth})}\right) / 2}$$

$P_{1 \ldots n}$ = probability of value below sufficiency threshold

n = Soil property



Next Steps and Applications

Next steps and applications

Provisioning Services

Spatially specific dataset:

Example: Potassium (K)

on: 14.(… 1

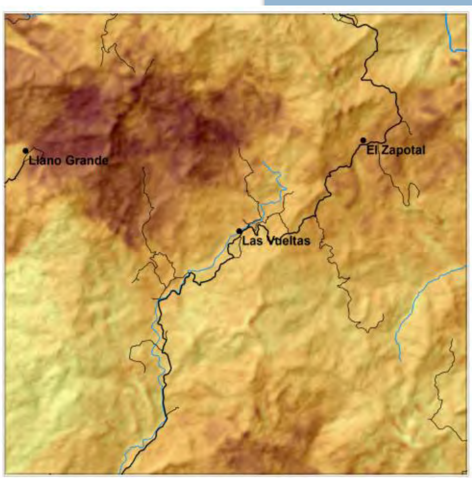
ted K: 4

dence: M

bility of … ng/kg):

mmende … kg/ha

Predicted Values



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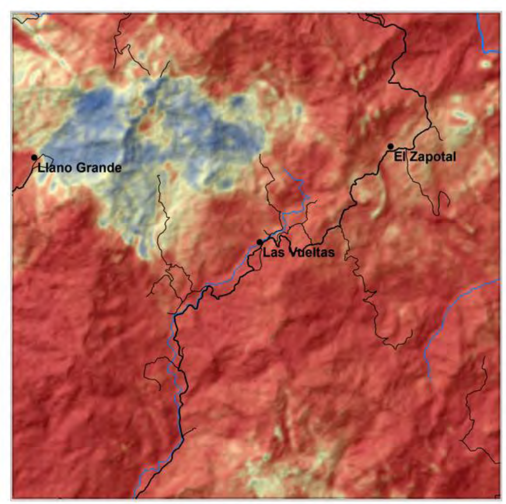
Probability of Deficiency



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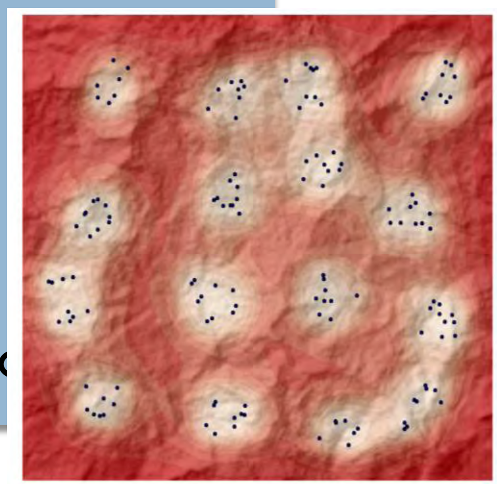
Uncertainty Estimates

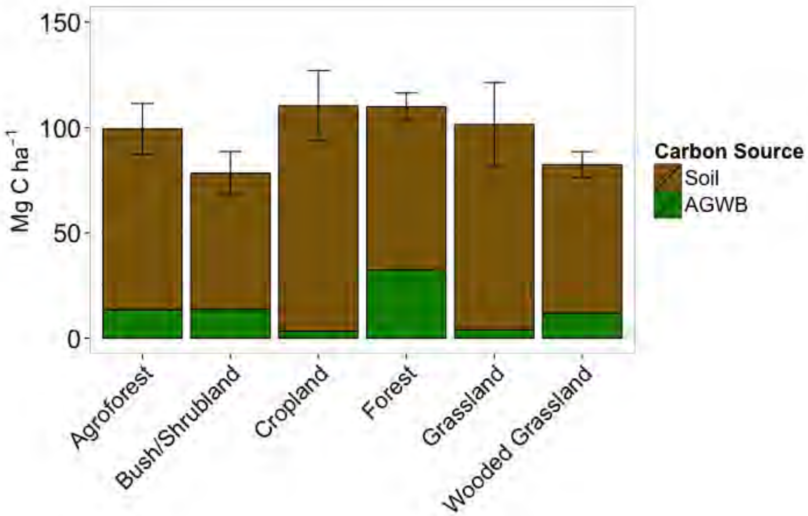


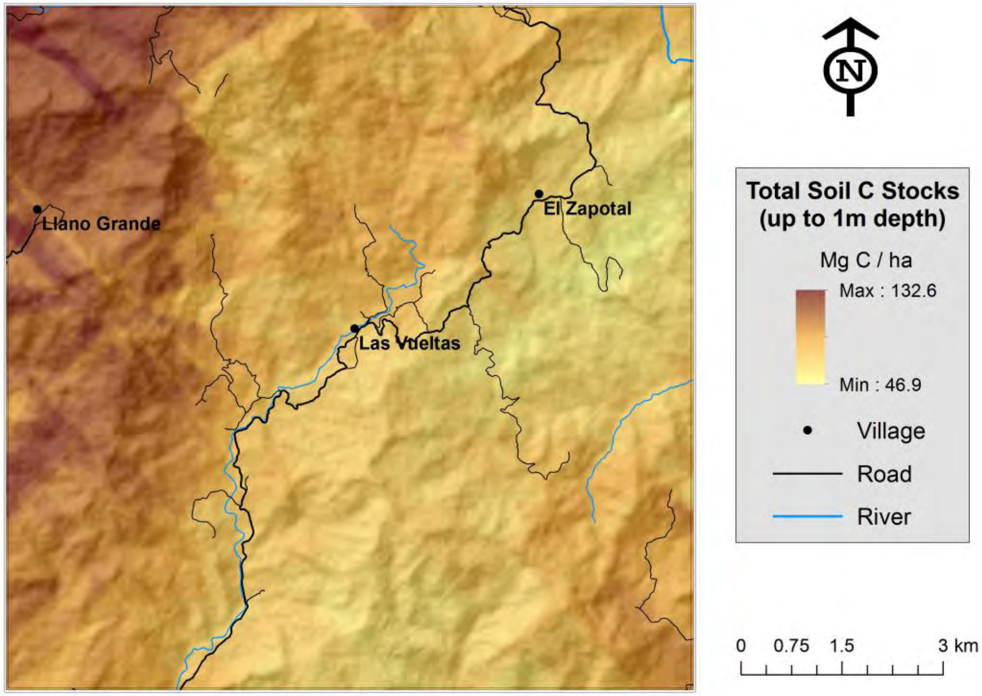
What about Liebig's <u>Law of the Minimum</u> and soil <u>interactions</u>?

Next steps and applications

Regulatory Services

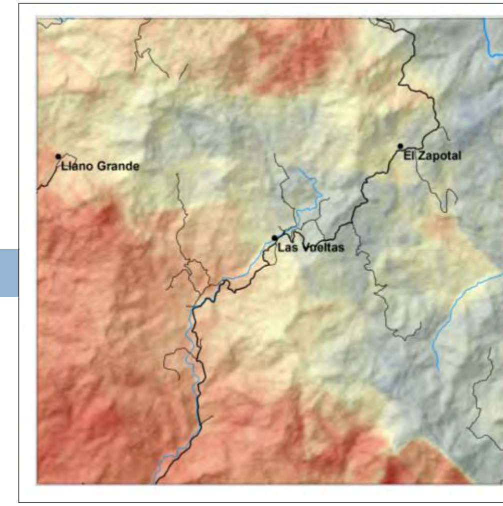
- Carbon storage
- Erosion Risk
- Biodiversity

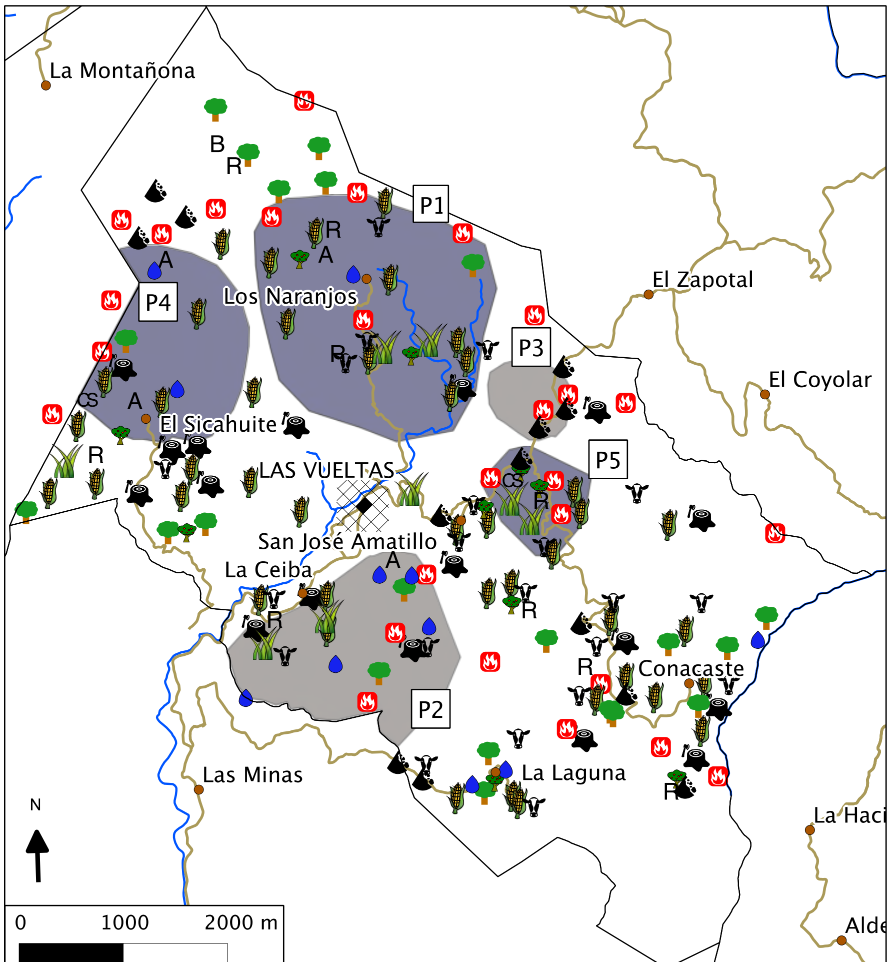




Next steps and applications

Community Perspectives





Paisajes Priorizados
P1: Los Naranjos
P2: Cerro El Picacho
P3: Cerro La Arenilla
P4: Sector Sicahuite
P5: Zona de nacimiento de agua San José Amatillo

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  - **Aracely Castro**
  - **Edwin Garcia**
- PRIMSA, El Salvador

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  - Luis, Victor, Jose, Jenny and many others!

Thank you

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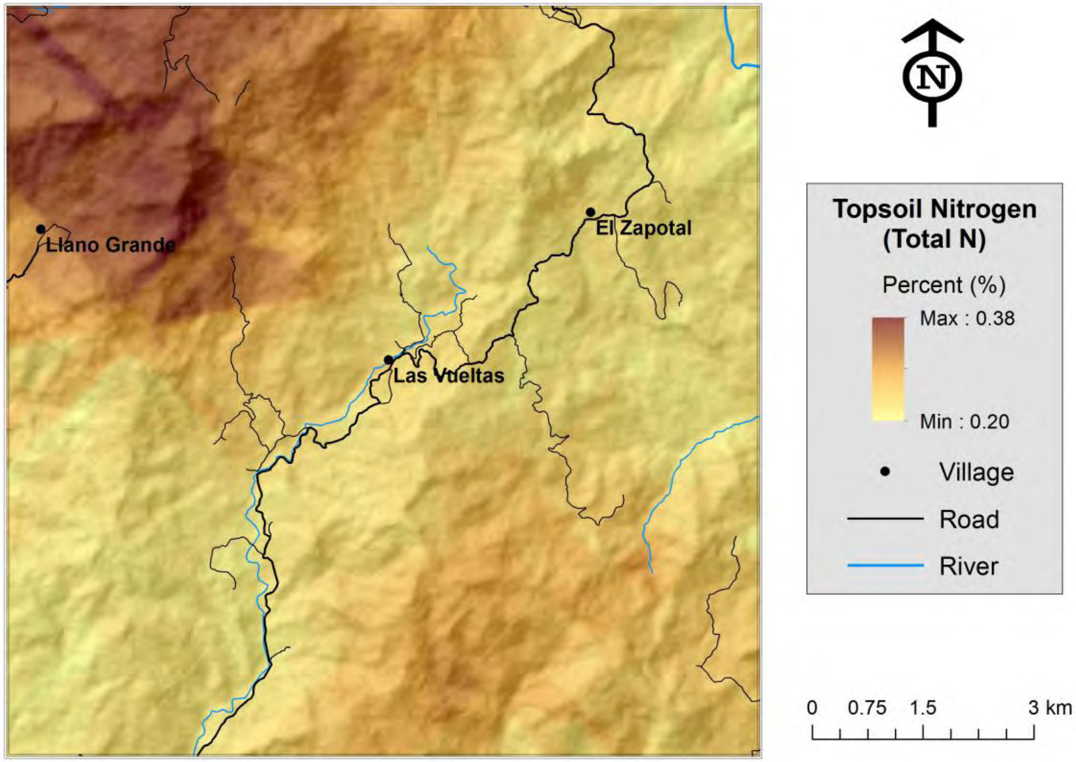
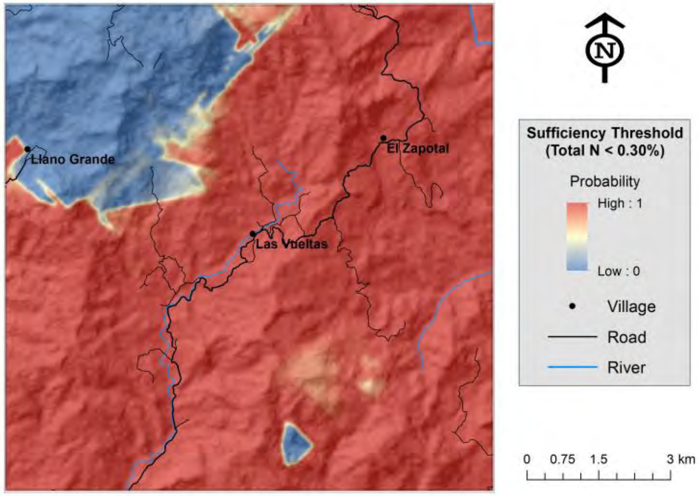
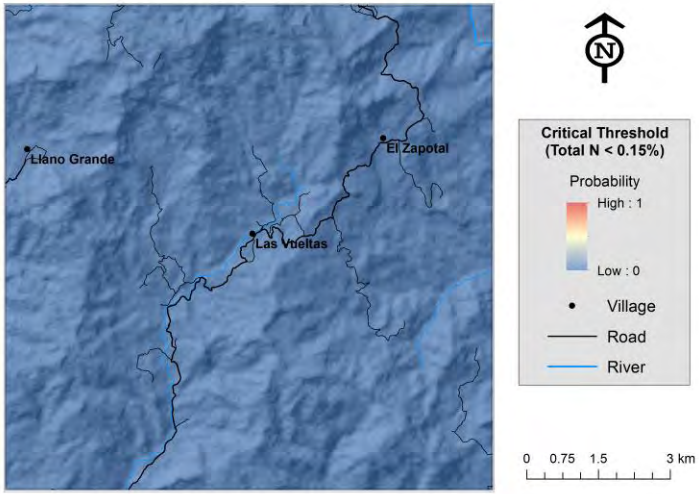
Co-Kriging Results

Nitrogen (Total N)

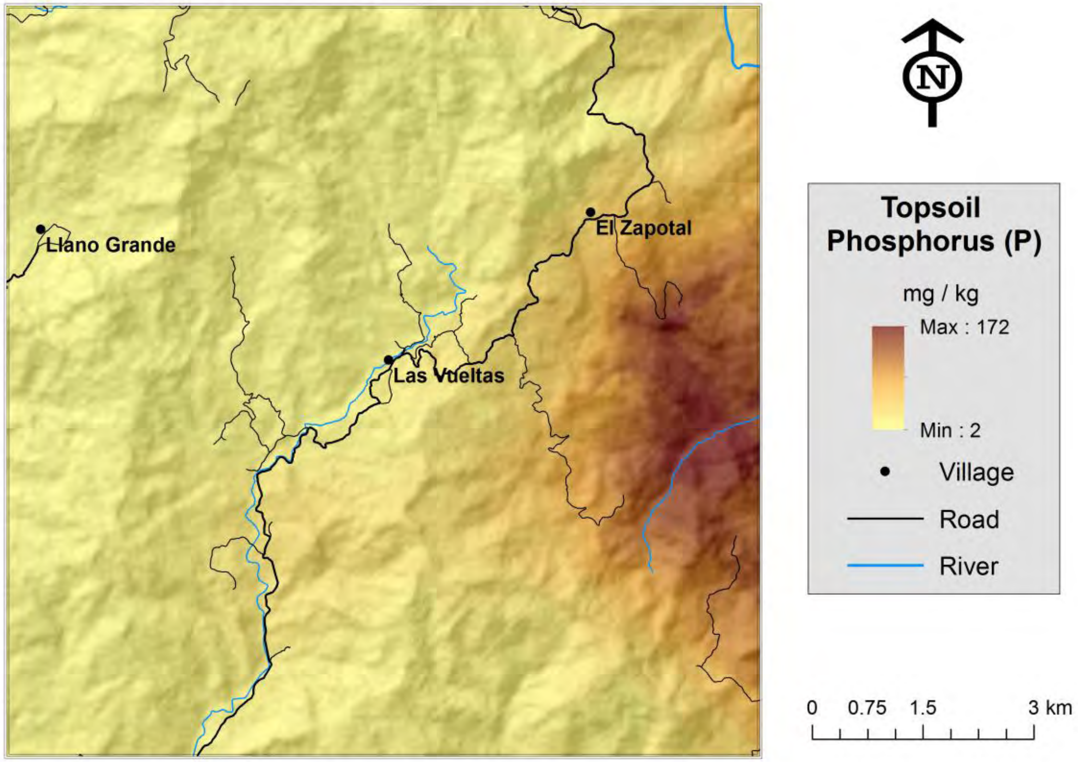


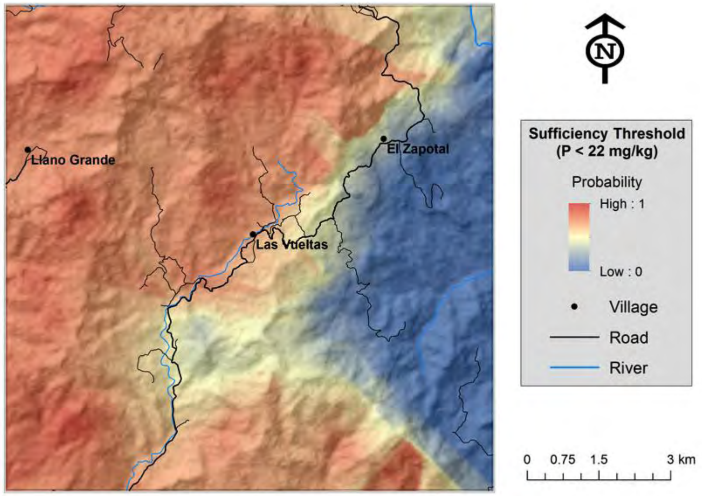


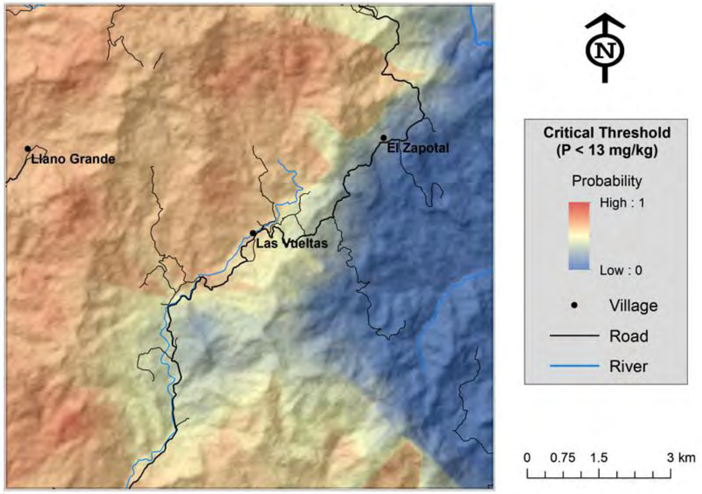


Co-Kriging Results

Phosphorus (P)

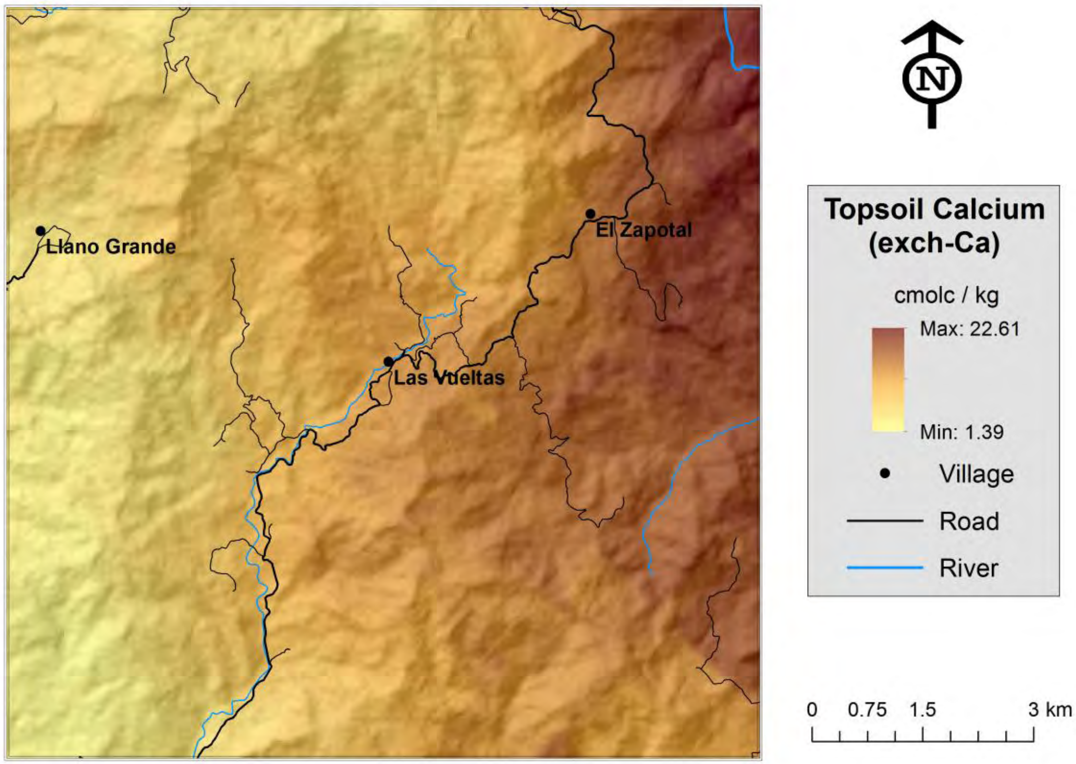


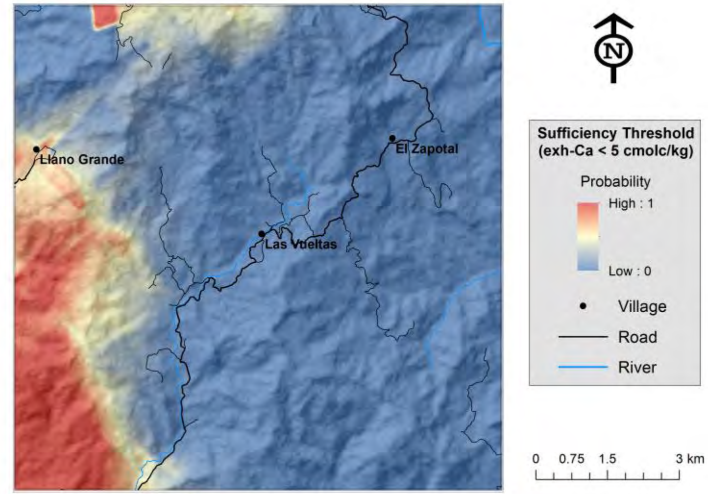


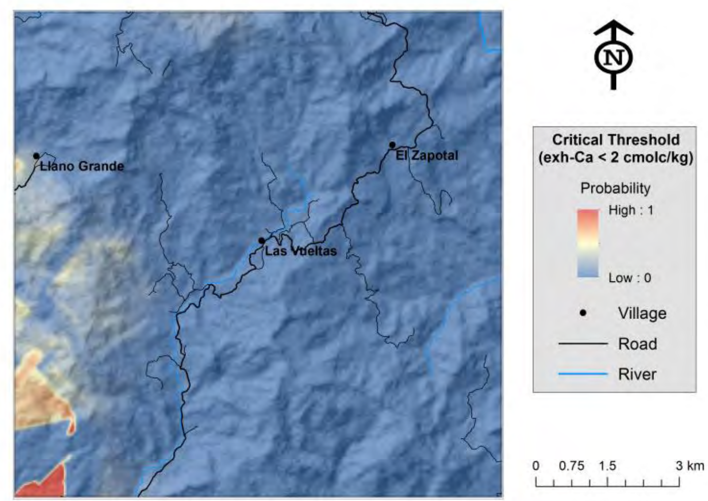


Co-Kriging Results

Calcium (exch-Ca)

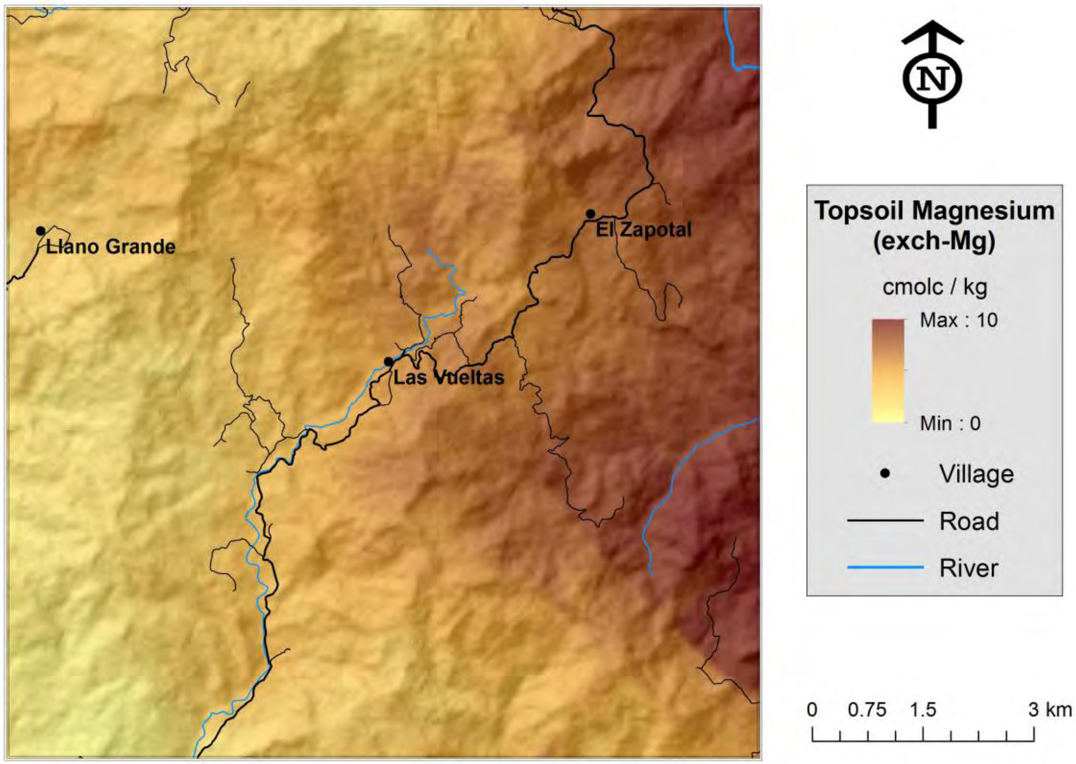


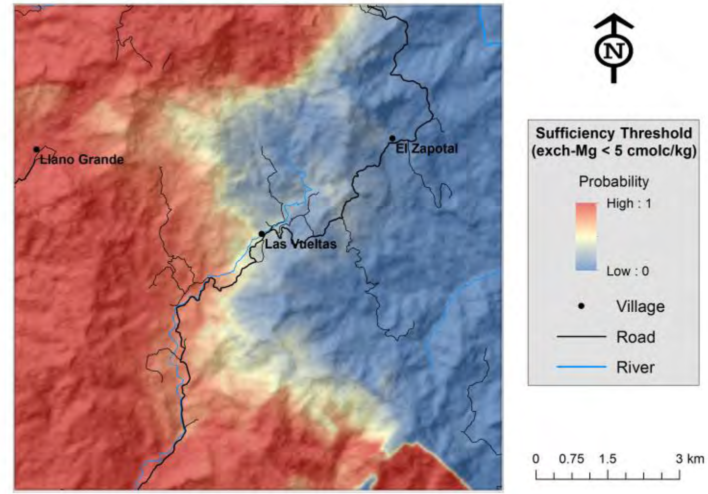


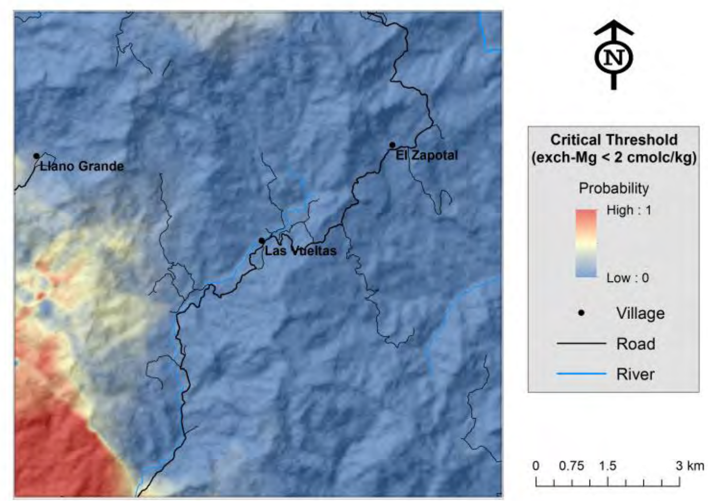


Co-Kriging Results

Magnesium (exch-Mg)

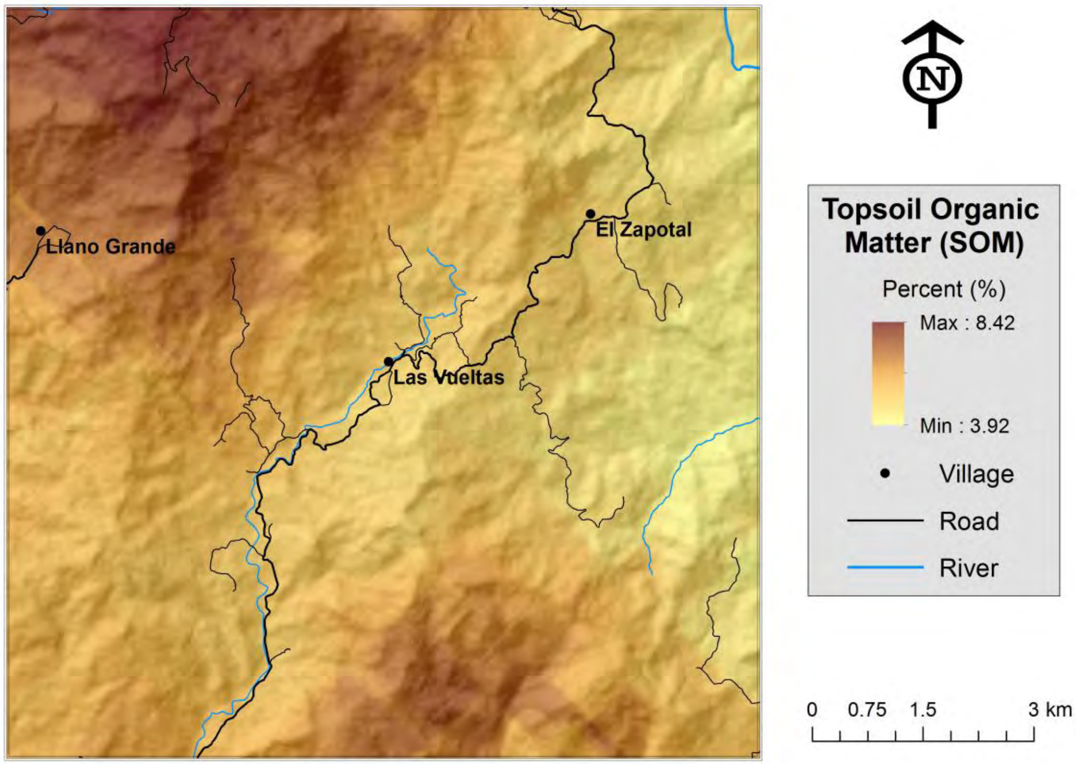


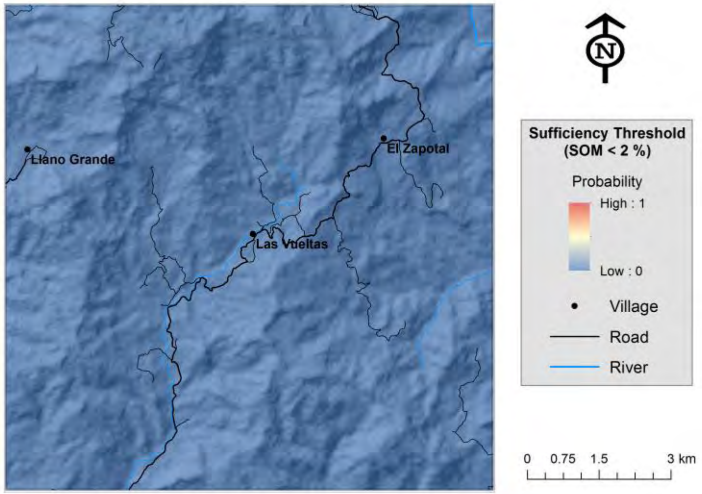




Co-Kriging Results

Soil Organic Matter (SOM)

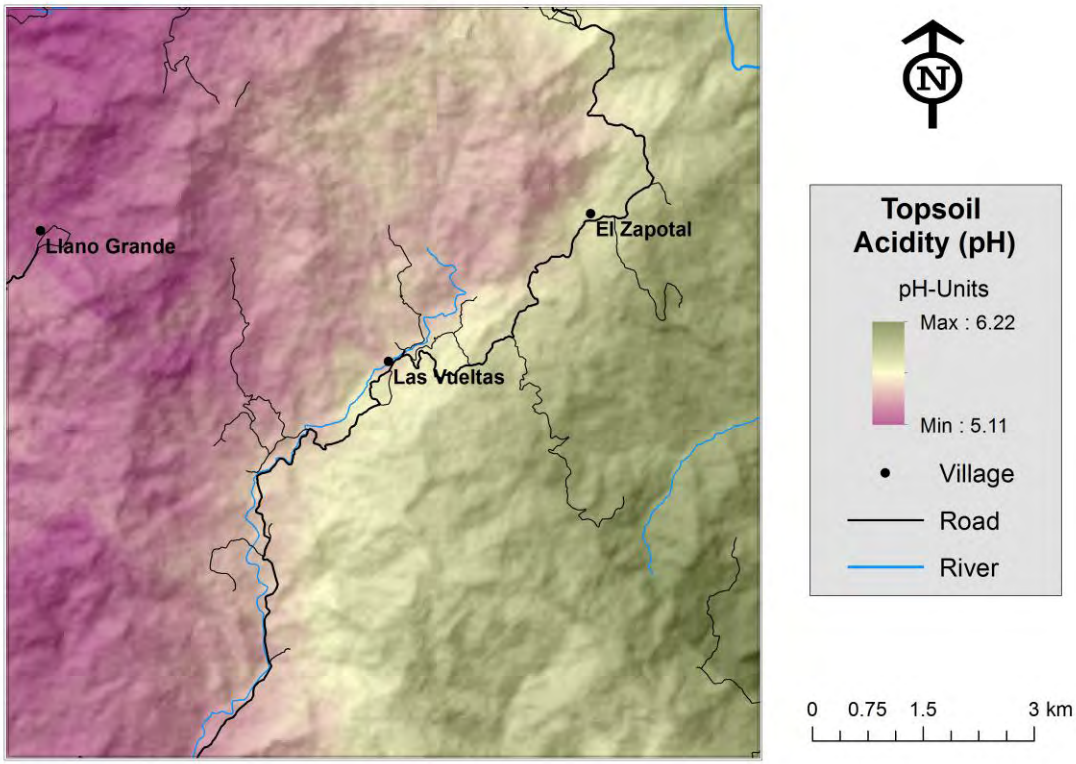


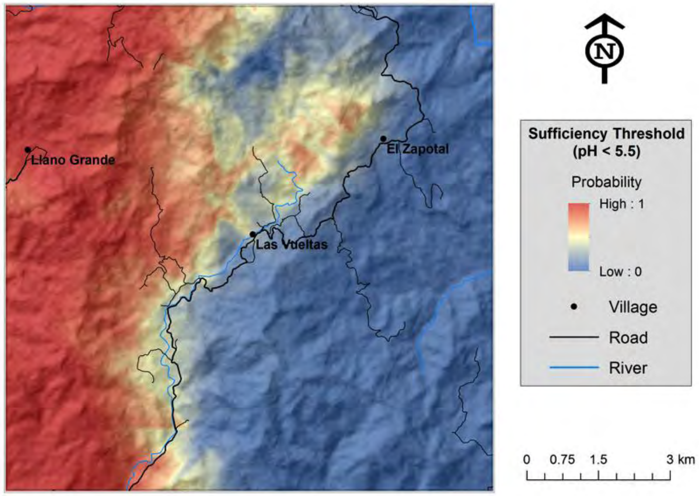


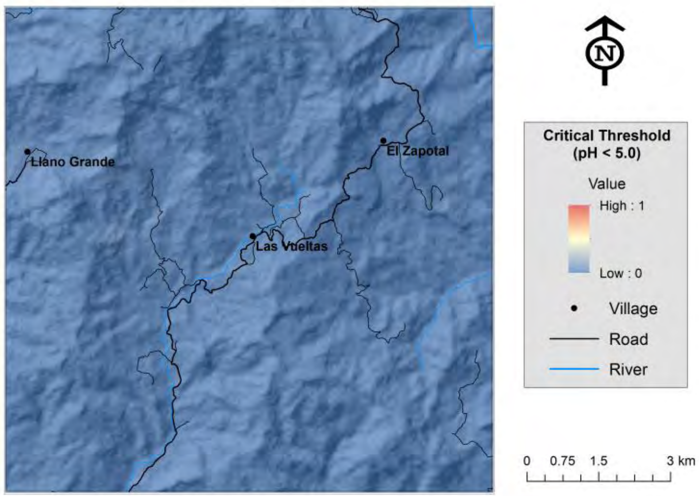
N/A

Co-Kriging Results

Acidity (pH)

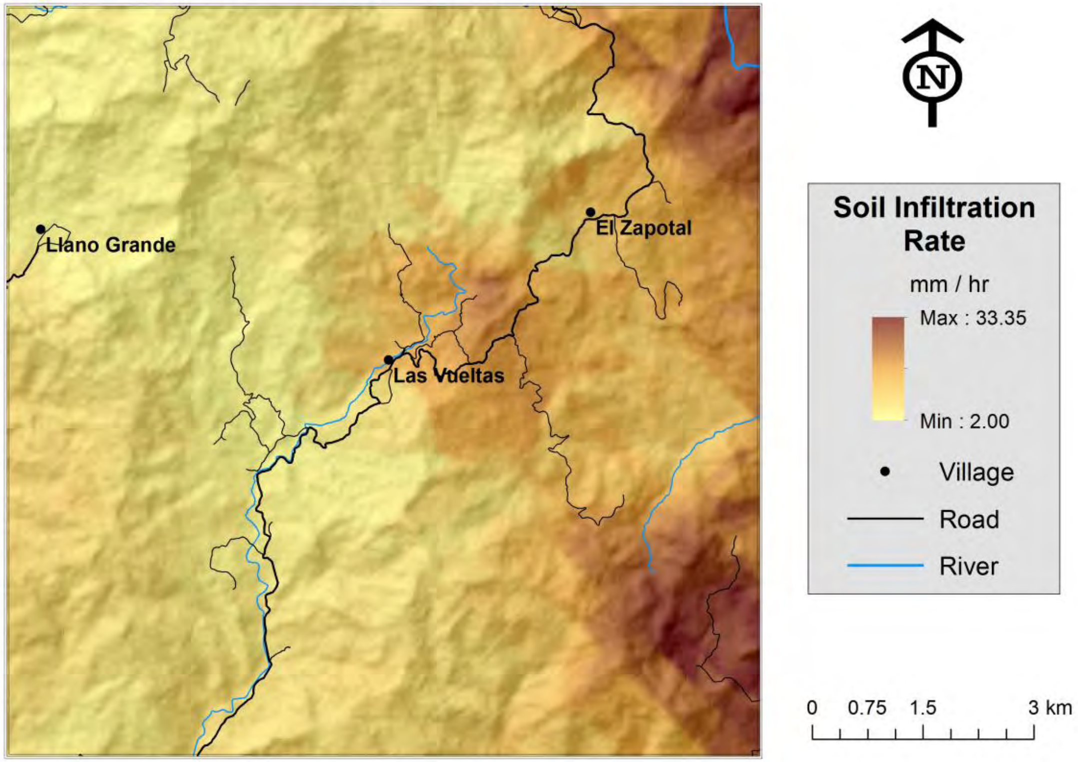


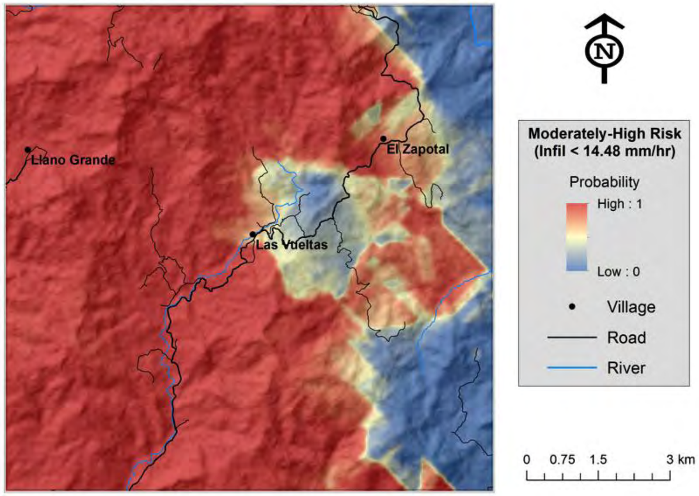


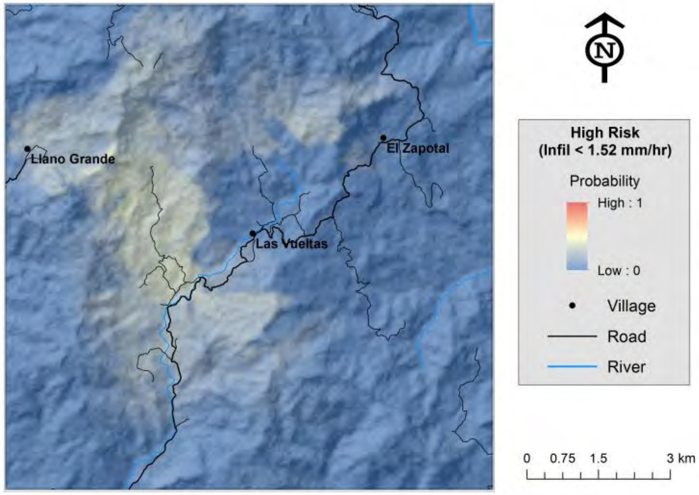


Co-Kriging Results

Infiltration Rate

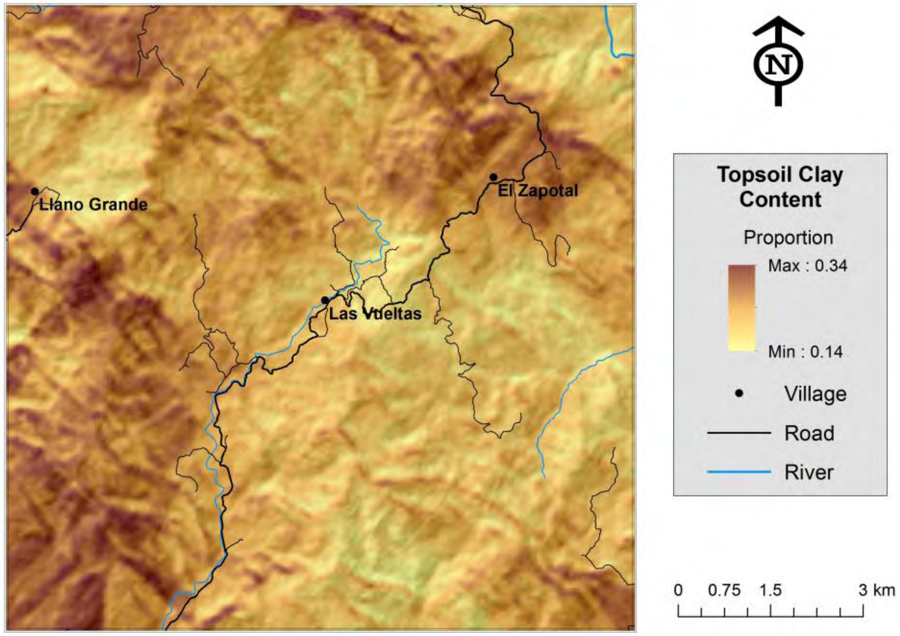


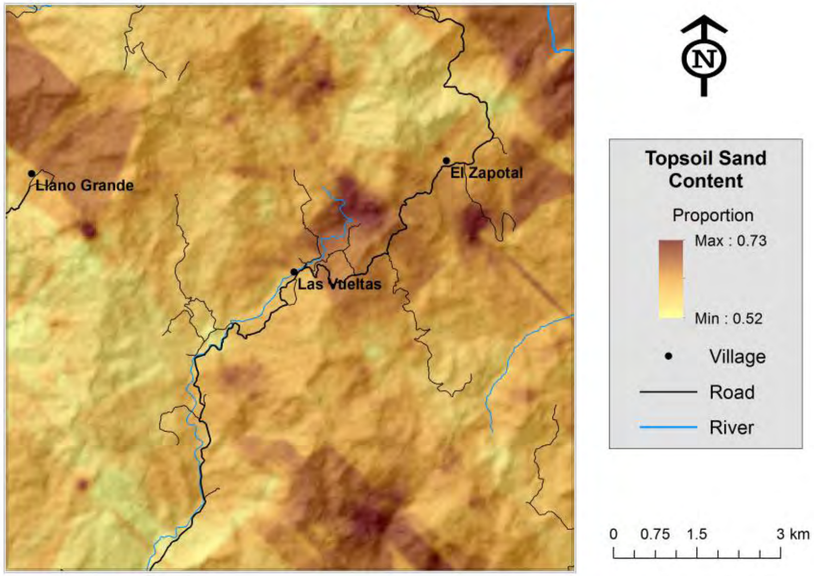


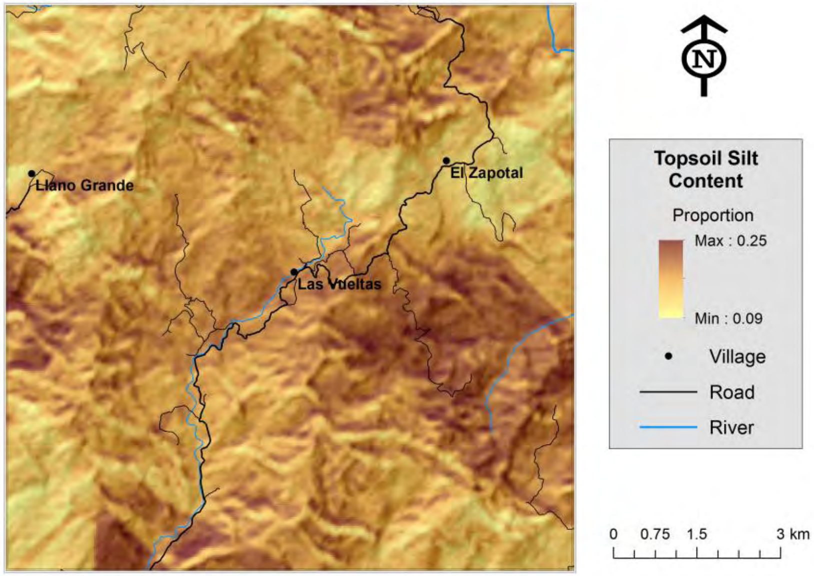


Co-Kriging Results

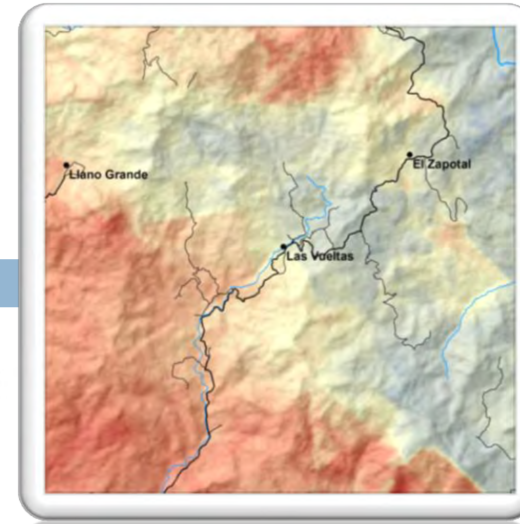
Texture

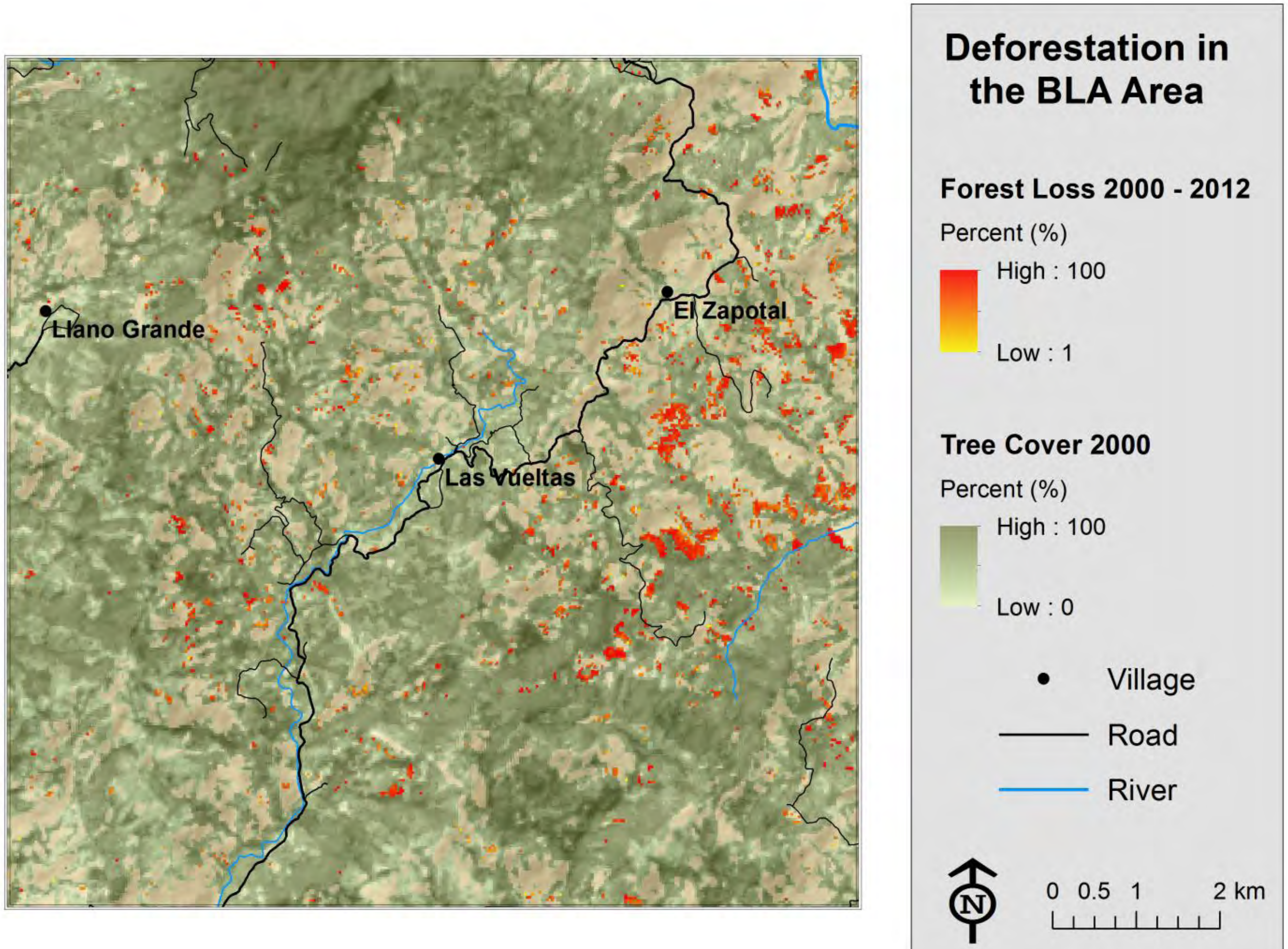






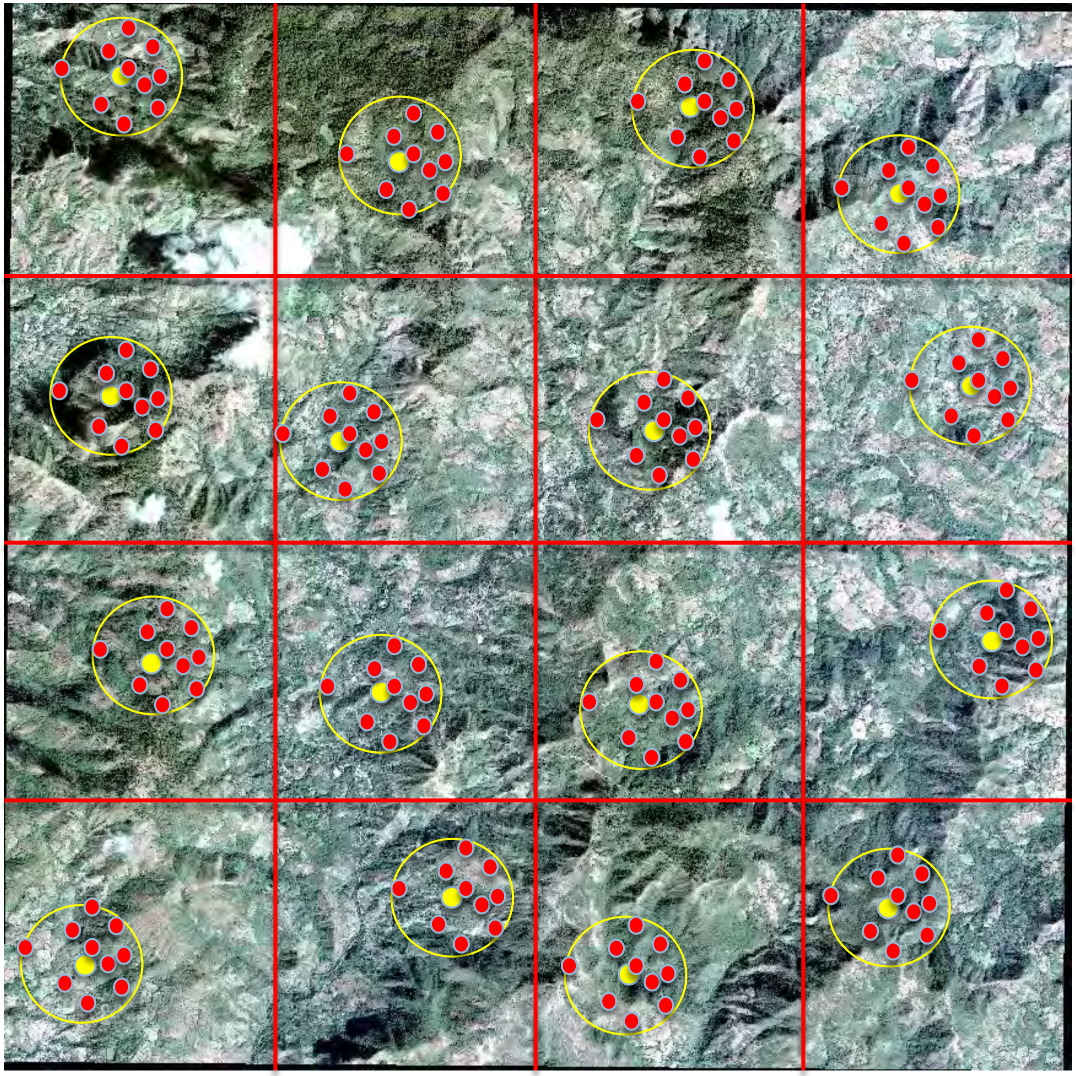
Deforestation

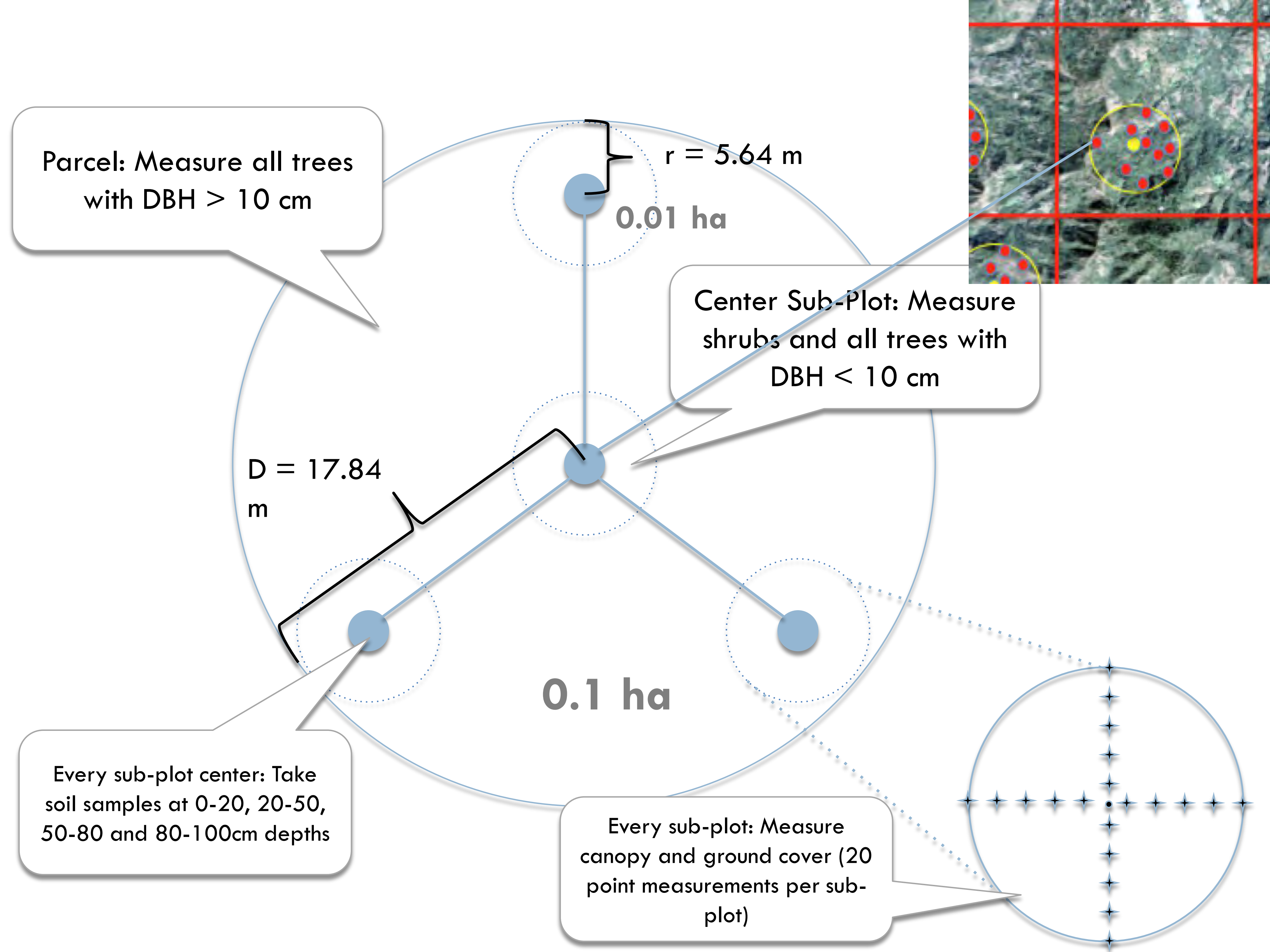




*Created using data from Hansen et al. 2013 ‘Global Forest Change 2000-2012’

Randomizing sample plots




Parcel: Measure all trees with DBH > 10 cm
r = 5.64 m
0.01 ha
Center Sub-Plot: Measure shrubs and all trees with DBH < 10 cm
D = 17.84 m
0.1 ha
Every sub-plot center: Take soil samples at 0-20, 20-50, 50-80 and 80-100cm depths
Every sub-plot: Measure canopy and ground cover (20 point measurements per sub-plot)