

Spectral methods for monitoring soil carbon in landscapes

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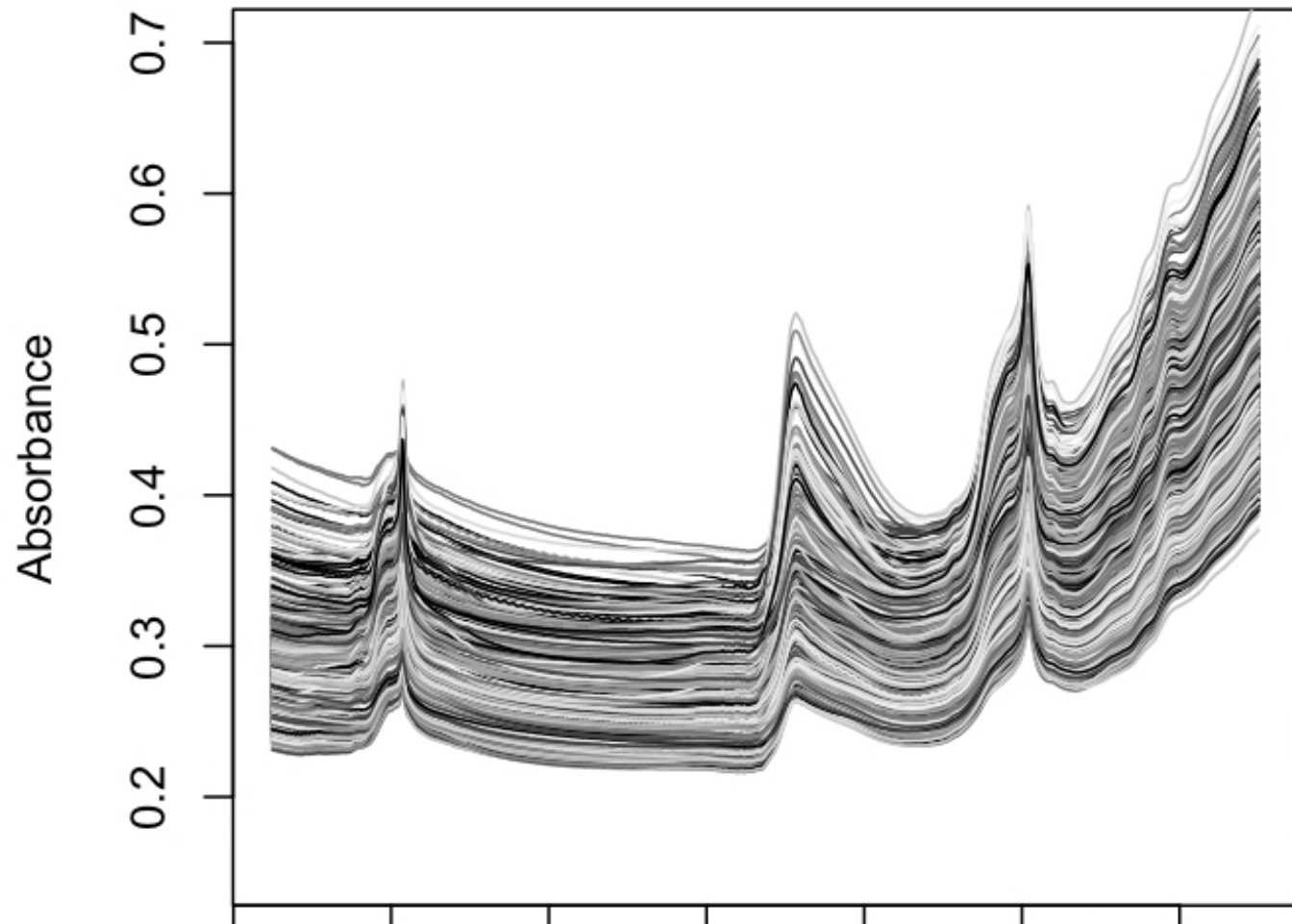
Concerns about monitoring soil carbon in landscapes

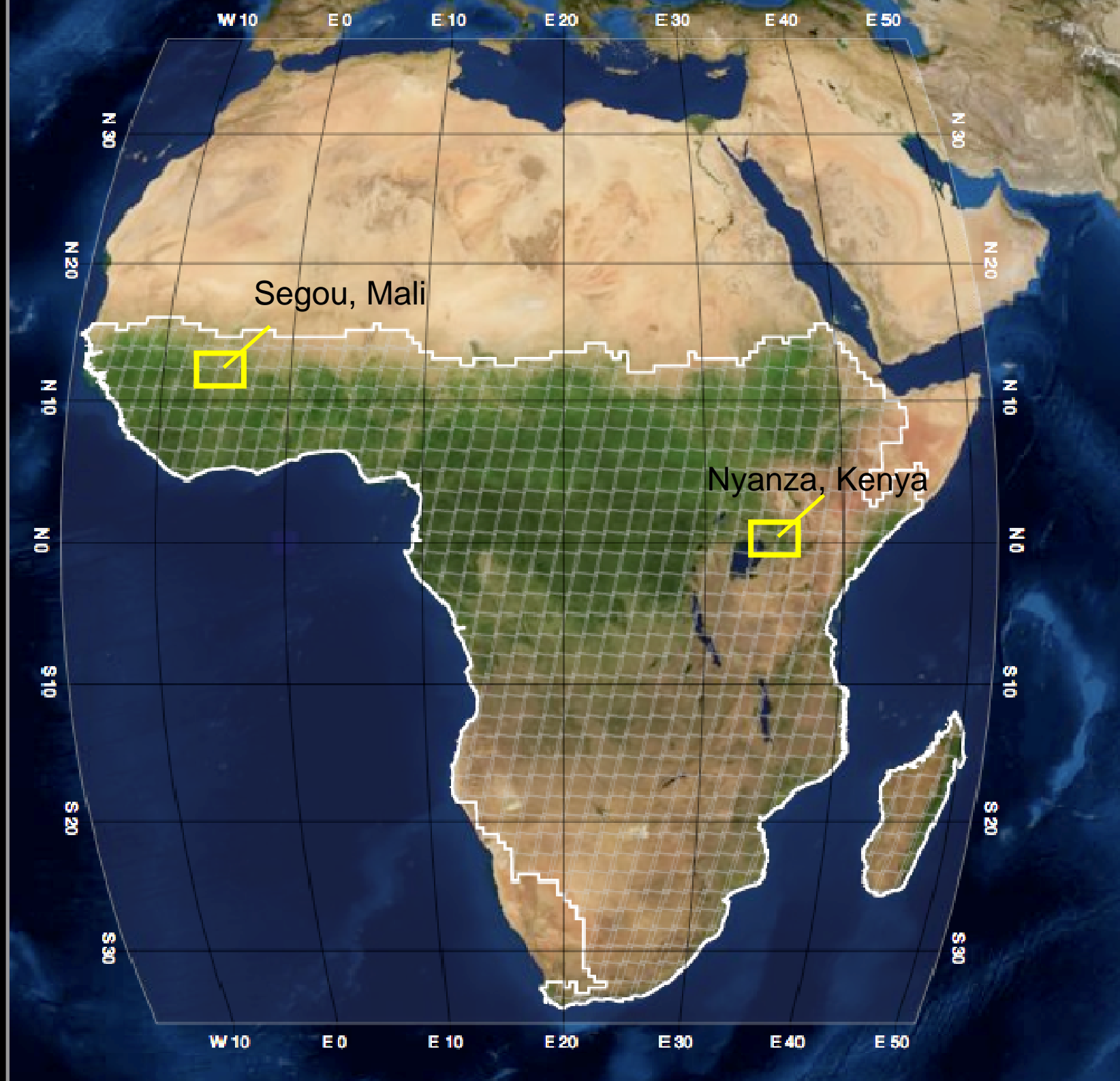
(most of these issues apply to other soil properties as well)

- **High measurement costs**
 - fixed costs (8-15 U\$ per sample)
 - variable costs (2-8 U\$ per profile / sampling location, in Africa)
 - so ... min. cost of profile sampled in 20 cm increments to 1 m depth ~42 U\$
- **Variable process rates**
 - fast changes in bulk density (of surface layers)
 - slow changes in SOC concentrations.
- **High spatial heterogeneity**
 - Variation with depth or cumulative soil mass + x,y
 - Statistical procedures for 3-D integration still not widely followed
- **Low measurement repeatability**
 - small sample volumes (mg extrapolated to tons)
 - lab. methods (dry combustion, wet oxidation, loss on ignition ...)
 - variations within & between labs



- Minimal sample preparation
- Predicts wide range of soil properties
- 300 - 500 samples per day (NIR)
- up to 3000 per day (MIR)
- 5 AfSIS NIR labs (Kenya, Tanzania, Mali, Malawi, Mozambique)
- MIR in Nairobi





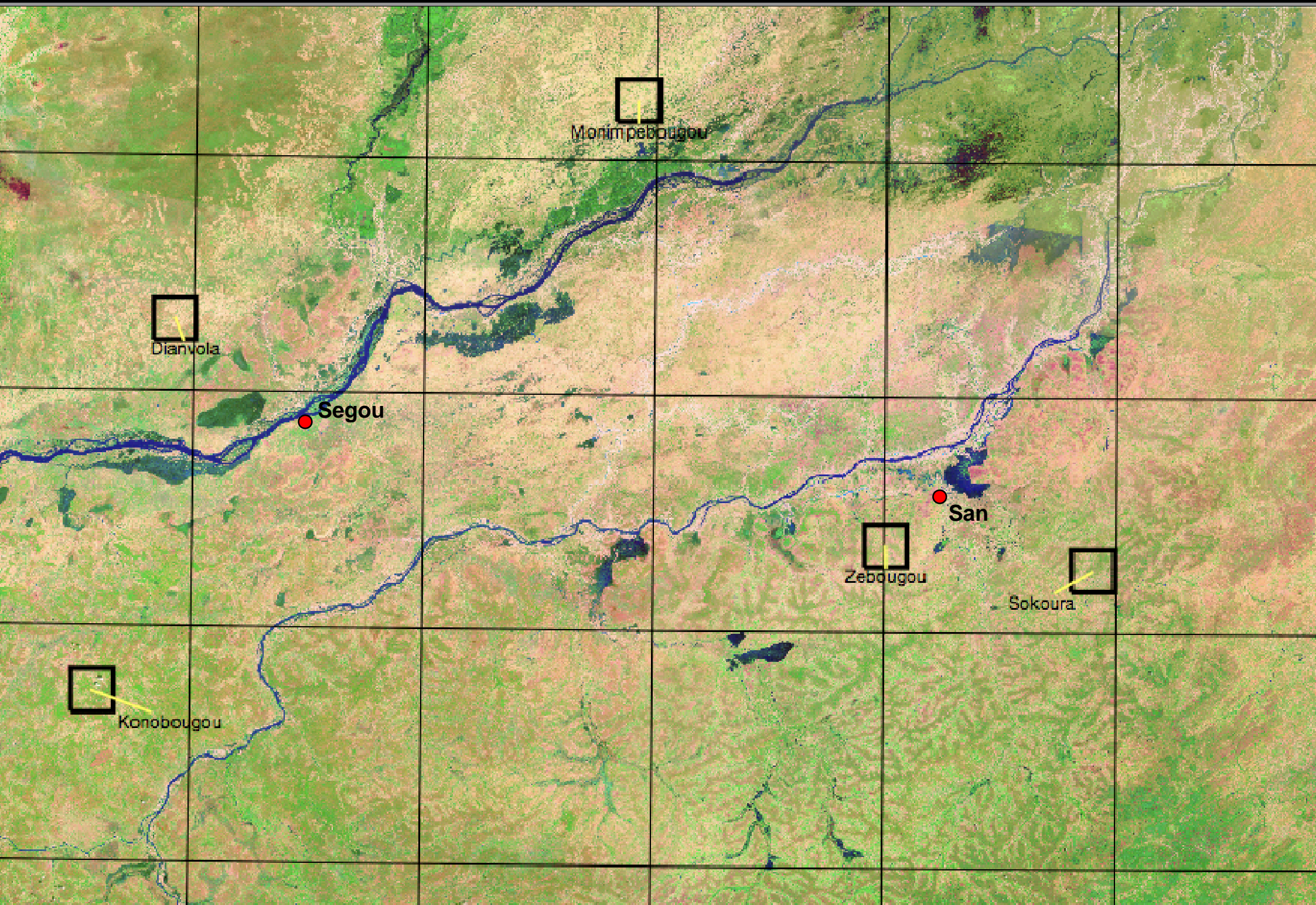
W6 30'

W6

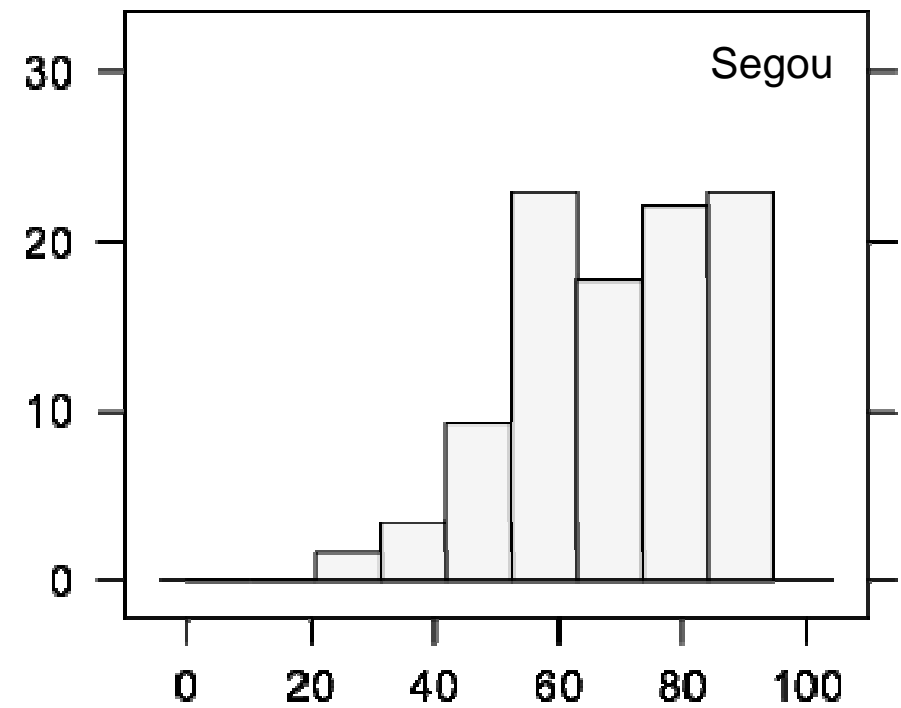
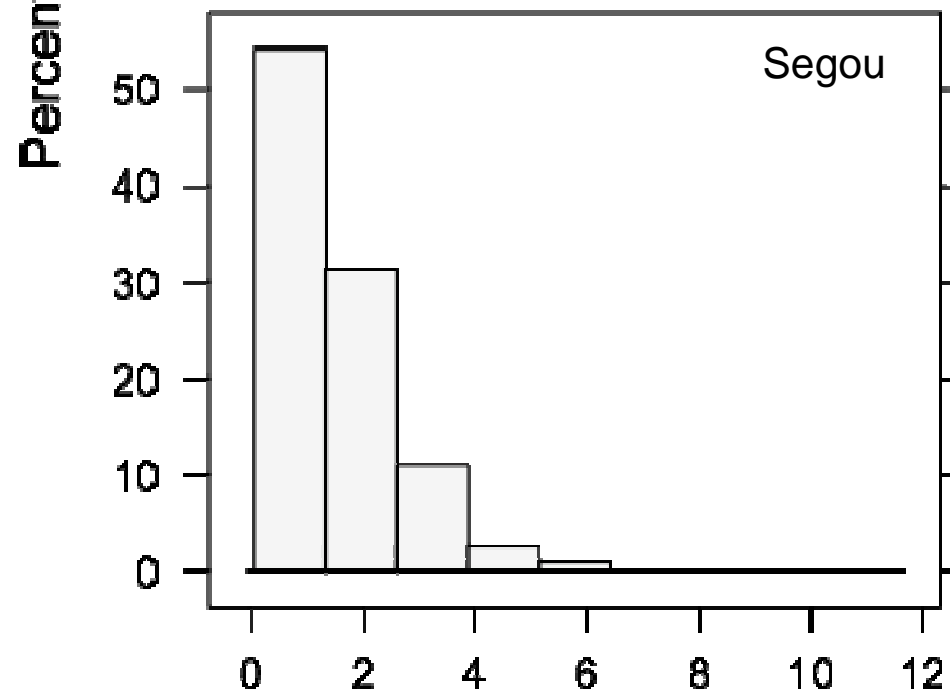
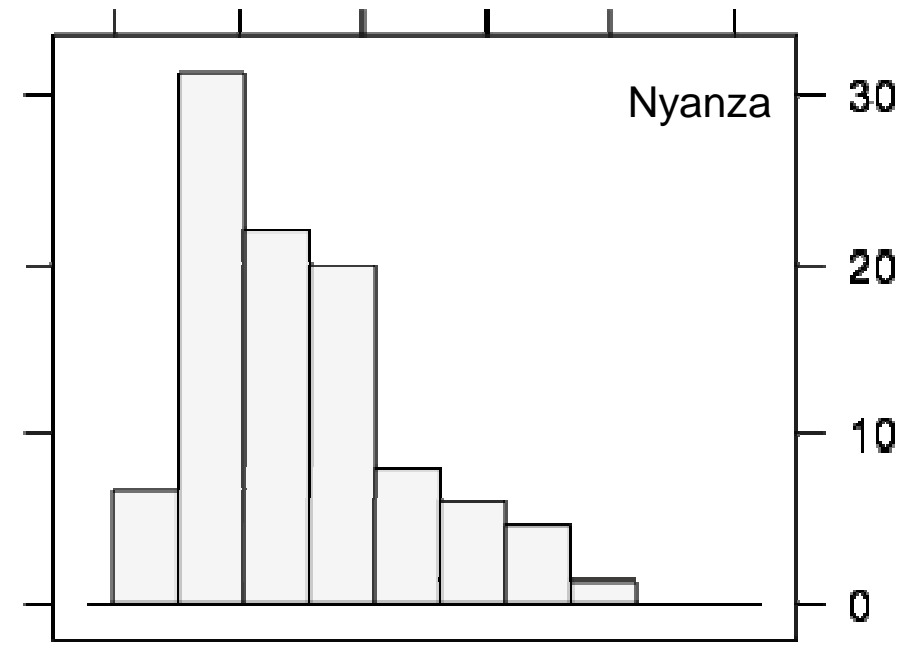
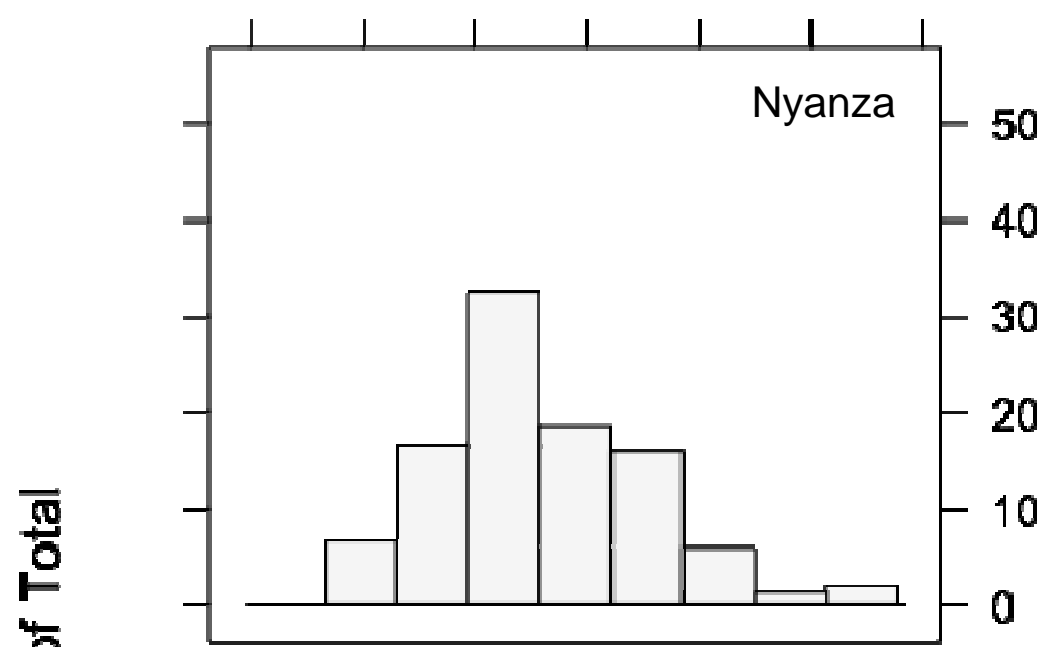
W5 30'

W5

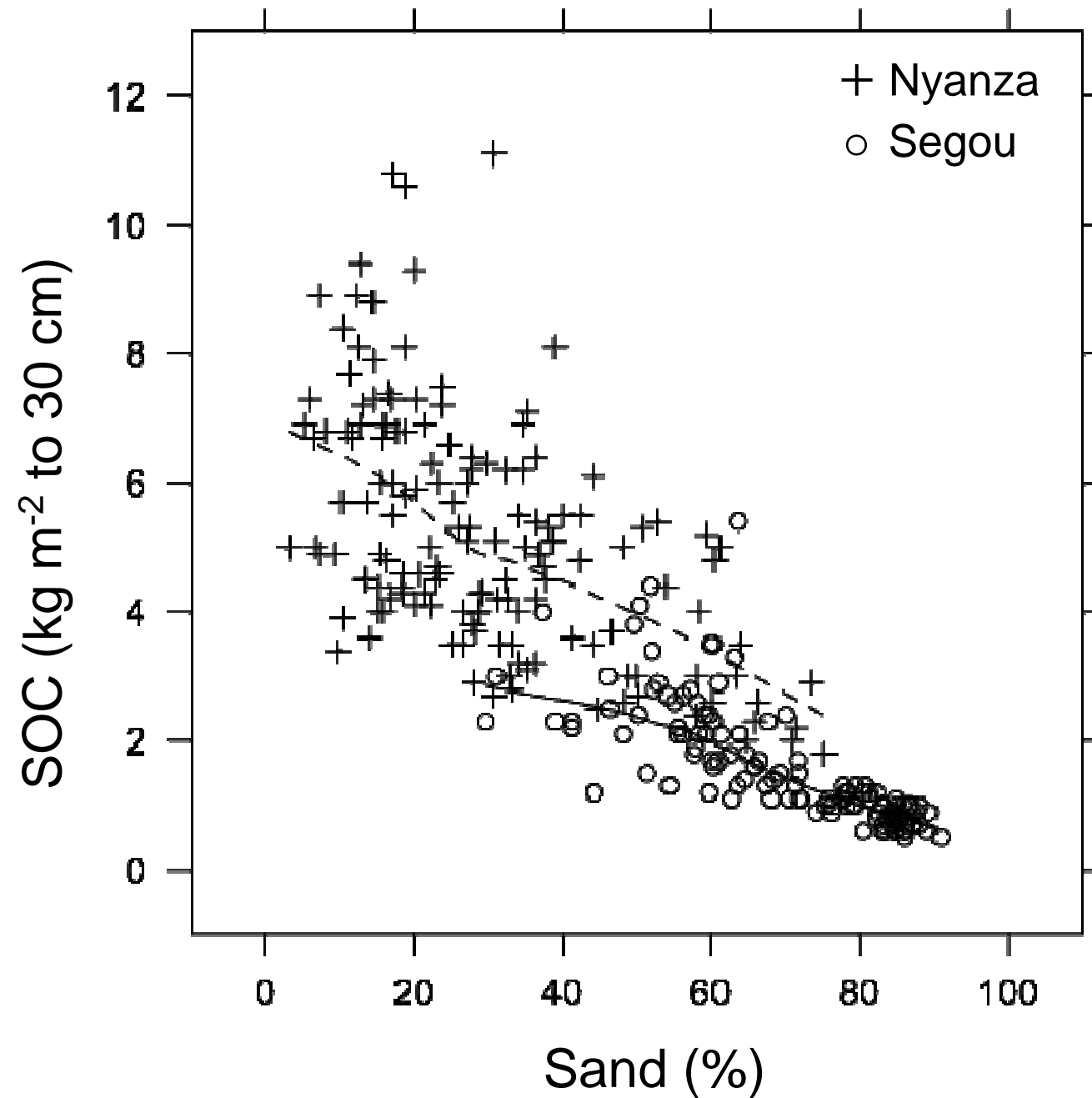
W4 30'



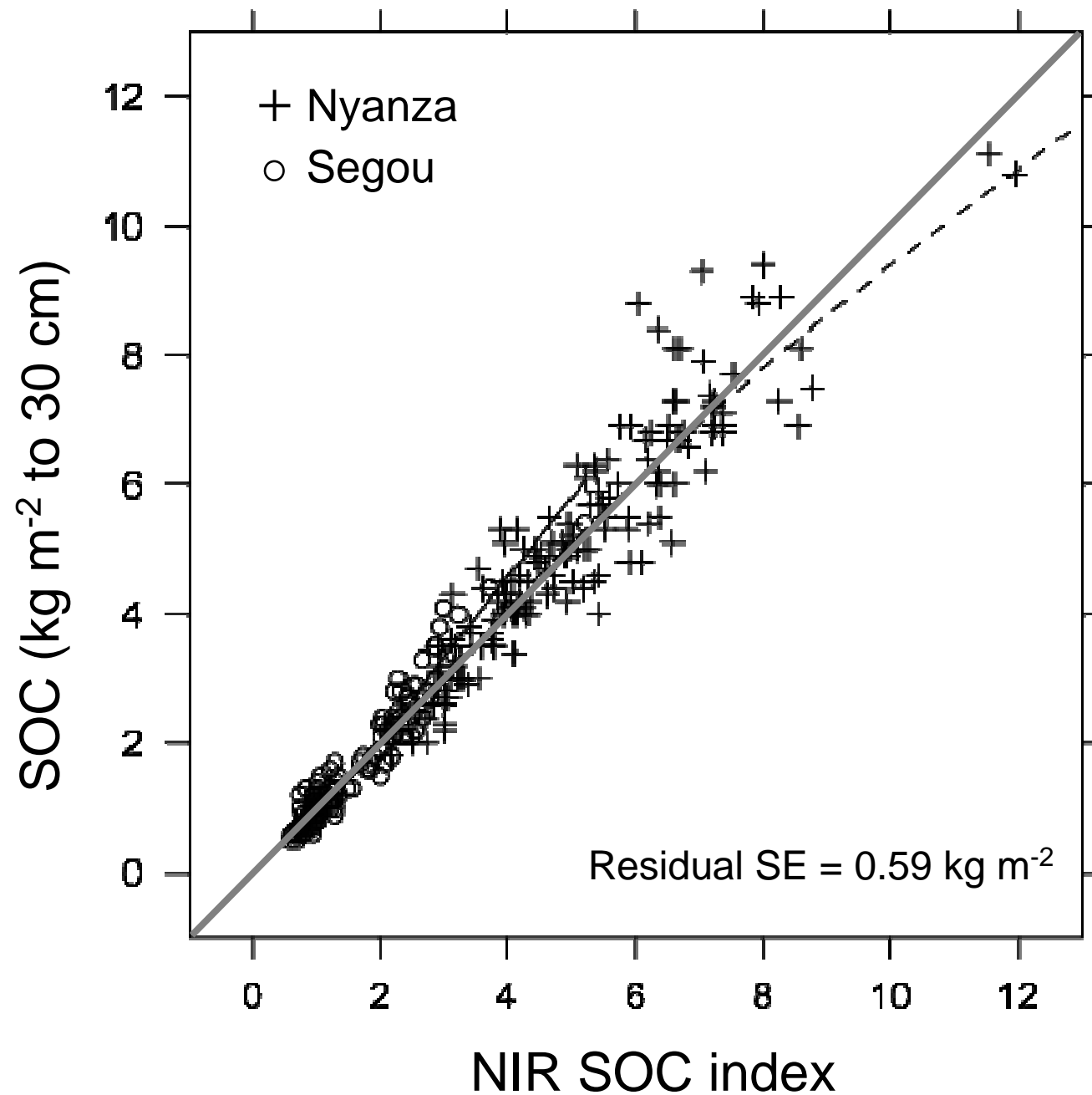
between Nyanza, Kenya and Segou, Mali



in Nyanza, Kenya & Segou, Mali



Nyanza, Kenya & Segou, Mali



Recommendations on how to use

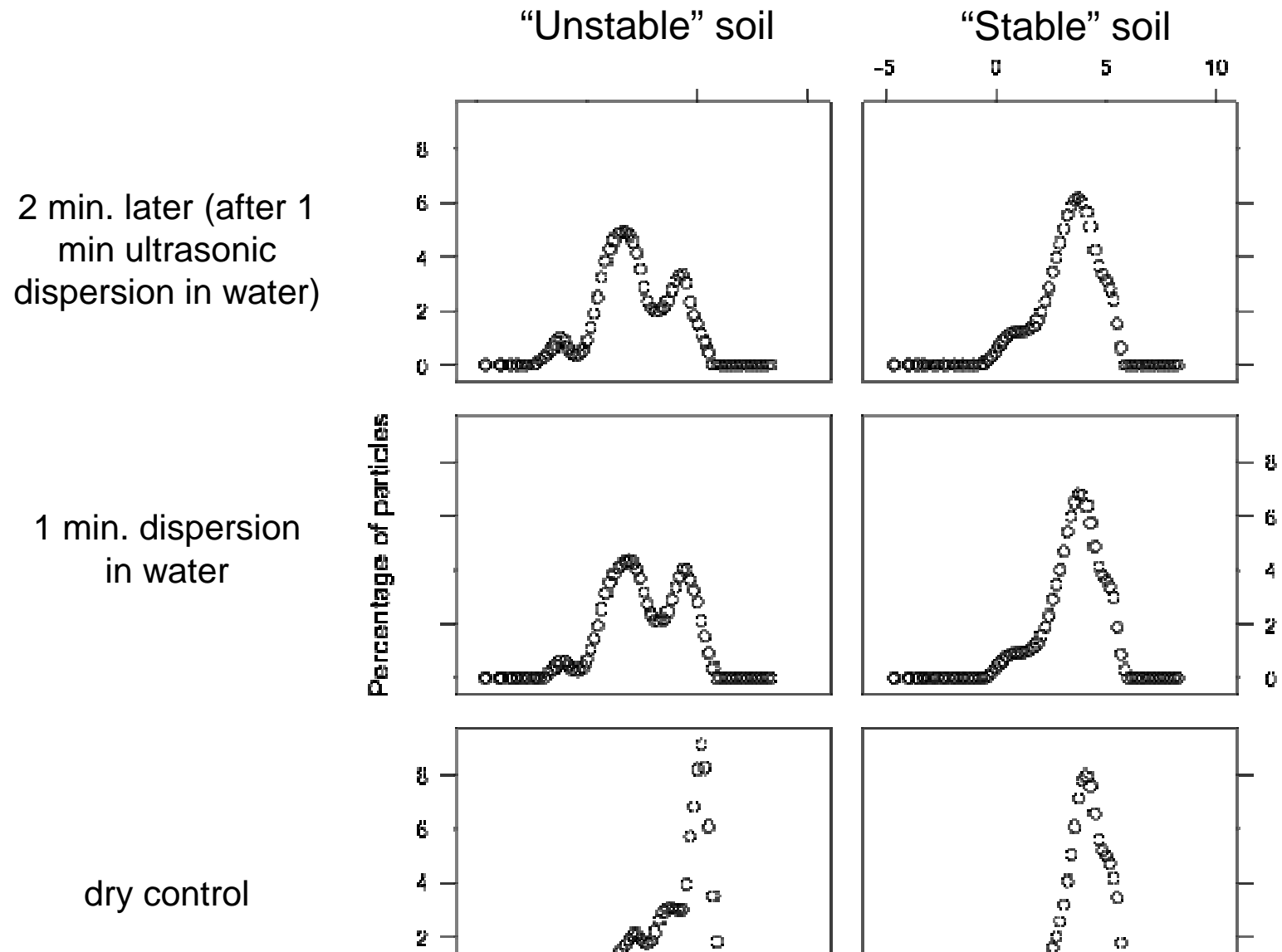
$$\hat{c} = \bar{c}_i + b (\bar{s}_j + \bar{s}_i)$$

- Use double sampling approach
 - decreases variance of the mean estimate over an area
 - can be cost optimized at given levels of needed precision
 - easily extendable to observations over time.
- Use other covariates
 - e.g. remote sensing & terrain data

Laser Diffraction Spectroscopy



- Full particle size distribution
- Dry powder or suspensions
- Can do aggregate stability!
- ~300 samples per day





- Solids, powders, liquids, suspensions
- Fast and simple sample preparation
- Multi-element analysis without external calibration (Na to U)
- 100 samples per day

Period	1 IA 1A	2 IIA 2A											13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1	1 <u>H</u> 1.008	2 <u>He</u> 4.003																
2	3 <u>Li</u> 6.941	4 <u>Be</u> 9.012											5 <u>B</u> 10.81	6 <u>C</u> 12.01	7 <u>N</u> 14.01	8 <u>O</u> 16.00	9 <u>F</u> 19.00	10 <u>Ne</u> 20.18
3	11 <u>Na</u> 22.99	12 <u>Mg</u> 24.31	13 <u>Al</u> 26.98	14 <u>Si</u> 28.09	15 <u>P</u> 30.97	16 <u>S</u> 32.07	17 <u>Cl</u> 35.45	18 <u>Ar</u> 39.95										
4	19 <u>K</u> 39.10	20 <u>Ca</u> 40.08	21 <u>Sc</u> 44.96	22 <u>Ti</u> 47.88	23 <u>V</u> 50.94	24 <u>Cr</u> 52.00	25 <u>Mn</u> 54.94	26 <u>Fe</u> 55.85	27 <u>Co</u> 58.93	28 <u>Ni</u> 58.69	29 <u>Cu</u> 63.55	30 <u>Zn</u> 65.39	31 <u>Ga</u> 69.72	32 <u>Ge</u> 72.59	33 <u>As</u> 74.92	34 <u>Se</u> 78.96	35 <u>Br</u> 79.90	36 <u>Kr</u> 83.80
5	37 <u>Rb</u> 85.47	38 <u>Sr</u> 87.62	39 <u>Y</u> 88.91	40 <u>Zr</u> 91.22	41 <u>Nb</u> 92.91	42 <u>Mo</u> 95.94	43 <u>Tc</u> (98)	44 <u>Ru</u> 101.1	45 <u>Rh</u> 102.9	46 <u>Pd</u> 106.4	47 <u>Ag</u> 107.9	48 <u>Cd</u> 112.4	49 <u>In</u> 114.8	50 <u>Sn</u> 118.7	51 <u>Sb</u> 121.8	52 <u>Te</u> 127.6	53 <u>I</u> 126.9	54 <u>Xe</u> 131.3
6	55 <u>Cs</u> 132.9	56 <u>Ba</u> 137.3	57 <u>La</u> 138.9	72 <u>Hf</u> 178.5	73 <u>Ta</u> 180.9	74 <u>W</u> 183.9	75 <u>Re</u> 186.2	76 <u>Os</u> 190.2	77 <u>Ir</u> 192.2	78 <u>Pt</u> 195.1	79 <u>Au</u> 197.0	80 <u>Hg</u> 200.5	81 <u>Tl</u> 204.4	82 <u>Pb</u> 207.2	83 <u>Bi</u> 209.0	84 <u>Po</u> (210)	85 <u>At</u> (210)	86 <u>Rn</u> (222)
7	87 <u>Fr</u> (223)	88 <u>Ra</u> (226)	89 <u>Ac</u> (227)	104 <u>Rf</u> (257)	105 <u>Db</u> (260)	106 <u>Sg</u> (263)	107 <u>Bh</u> (262)	108 <u>Hs</u> (265)	109 <u>Mt</u> (266)	110 <u>Ds</u> (271)	111 <u>Uuu</u> (272)	112 <u>Uub</u> (277)	114 <u>Uuq</u> (296)	116 <u>Uuh</u> (298)	118 <u>Uuo</u> (?)			
Lanthanide Series*			58 <u>Ce</u> 140.1	59 <u>Pr</u> 140.9	60 <u>Nd</u> 144.2	61 <u>Pm</u> (147)	62 <u>Sm</u> 150.4	63 <u>Eu</u> 152.0	64 <u>Gd</u> 157.3	65 <u>Tb</u> 158.9	66 <u>Dy</u> 162.5	67 <u>Ho</u> 164.9	68 <u>Er</u> 167.3	69 <u>Tm</u> 168.9	70 <u>Yb</u> 173.0	71 <u>Lu</u> 175.0		
Actinide Series~			90 <u>Th</u> 232.0	91 <u>Pa</u> (231)	92 <u>U</u> (238)	93 <u>Np</u> (237)	94 <u>Pu</u> (242)	95 <u>Am</u> (243)	96 <u>Cm</u> (247)	97 <u>Bk</u> (247)	98 <u>Cf</u> (249)	99 <u>Es</u> (254)	100 <u>Fm</u> (253)	101 <u>Md</u> (256)	102 <u>No</u> (254)	103 <u>Lr</u> (257)		

Bottom-line messages

- Major cost savings
 - up to 80% of fixed costs (for e.g. IPCC Tier 3) SOC inventories
 - the higher the variability, the greater the proportional savings
- Multiple soil properties predicted
 - general fertility indicators, micro-nutrients, physical properties, mineralogy
 - little known about biological indicators?
 - also plant & water testing with same instruments (TXRF, MIR, NIR)
- Performance
 - higher precision and accuracy for soil monitoring of landscapes
 - may result in better prices for SOC sequestration + other benefits ???

For new developments watch: GlobalSoilMap.net &
www.africasoils.net