Describing spatial process and prediction of soil aggregate stability at different scales in a teak (Tectonia grandis) plantation in a Nigerian Savanna

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Motivation

Soil aggregate stability is key to ecosystem functioning as retention and flow of water and gases, along with the biota are controlled and modulated by it. Understanding and predicting aggregate stability across spatial scale requires clarification of the scales of the spatial process. This study hypothesized that prediction of soil aggregate stability and its associated soil parameters at coarse sampling scale will affect quality of estimation quality and resolution.

Our objectives include:

- **to develop and compare multiple regression and state-space models to study relationships between mean weight diameter (MWD) and soil attributes.**
- **Determine estimation quality at coarse resolution for MWD and associated soil attributes.**

Study Area

- **Site: Teak plantation at Nimbia Forest Reserve in northern Nigeria; coordinate 09º 29' - 09º 31'N , 08º 30' - 08º'35'E, 600 m asl.**
- **Climate: Long-term mean annual rainfall of 1260 mm, mean annual air temperature of 22ºC.**
- **Soils: classified as Dystric Cambisols (FAO-UNESCO) and Typic Dystrustepts (USDA).**

Materials and Methods

- **Surface soil (0-15 cm) samples were taken along a spatial transect of 100 points at 3 m intervals with GPS used to identify sampling locations.**
- **Mean weight diameter (MWD), bulk density, soil aggregate carbon , total phosphorus and soil water content were analysed.**
- **Using softwares GS+ and ASTSA (Applied Statistical Time Series Analysis) auto- and cross- correlation functions and first order autoregression respectively. Autoregressive process was later carried out with omission scenarios; we mimicked 6-m sampling interval (51 observations), 9-m (34 observations) and 12-m intervals (26 observations).**

Results

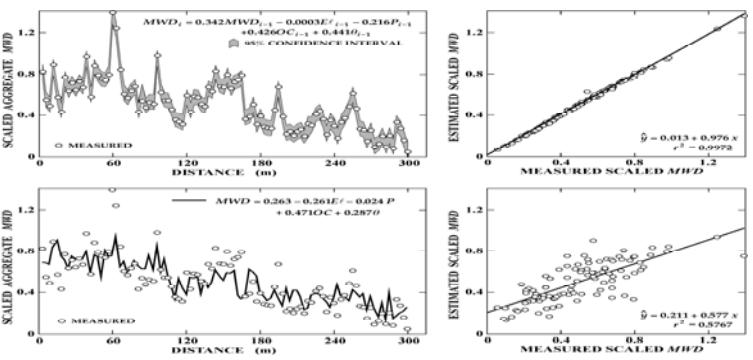

Fig 1. Estimates of *MWD* from state-space analysis and multiple regression analysis using 100 observations of Mean Weight Diameter (*MWD*), Elevation (*El*), Total P (*P*), Organic Carbon OCa in large aggregates (*OC*) and soil water content (*θ*).

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Results Cont'D

- **State-space analysis estimated spatial distribution of 100 MWD values nearly perfectly than the Multiple regression estimates (58% of total variation about the mean of MWD explained).**
- **AS number of ignored measured values (or Sampling intervals) increases in Fig. 2, r^2 decreased monotonically, from 0.83 to 0.53 to 0.5, relative to r^2 in Fig.1.**
- **Fig. 3 showed that coefficient of determination was highest and number of measured values not captured within the 95% confidence interval lowest with 9-m sampling interval (34 observations).**

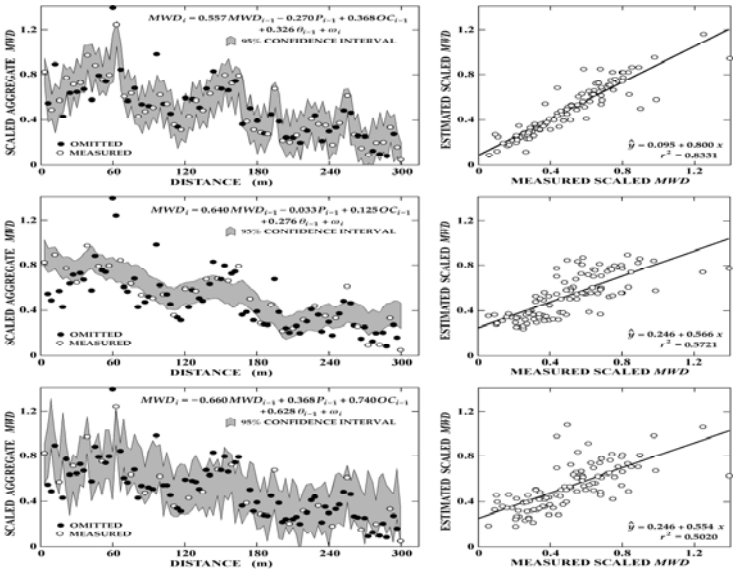

Fig 2. Estimates of *MWD* from state-space analysis using 51, 34 or 26 observations of *MWD* coupled with 100 observations of each variable *P*, *OC* and *θ*.

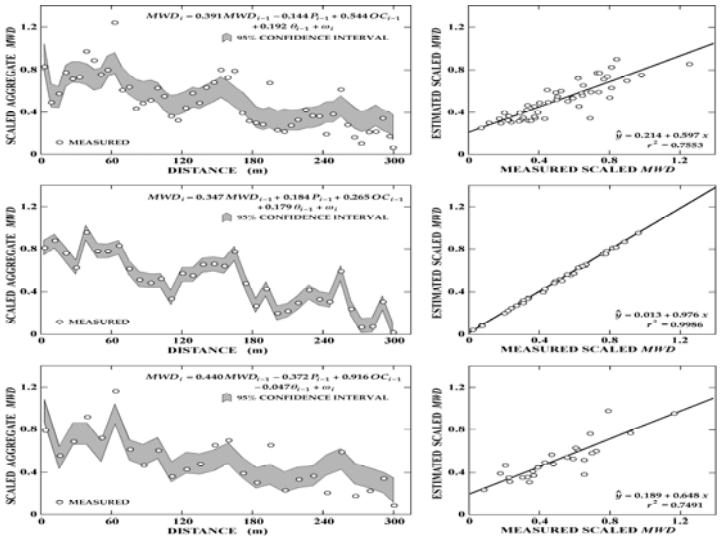

Fig 3. Estimates of *MWD* from state-space analysis using 51, 34 and 26 observations of each variable *MWD, P*, *OC* and *θ* along the 300-m transect

Conclusion

- **Autoregressive state-space analysis performed better than the multiple regression analysis as it accounts for llocal neighbourhood information when analysing and addressing a spatial soil process.**
- **Scale dependent relationships exist between MWD and the other soil parameters and estimations were reliable at fine scale (>10 m).**
- **The notable changes in the magnitude of the shaded 95% confidence interval with sampling scales and those of measured values not captured in the confidence interval are indications that other means of comparing reliability of estimates beyond the r^2 are possible and need to be explored.**