A NEIGHBOURHOOD ANALYSIS TO CHARACTERIZE COMPETITION IN A MULTI-STRATA AGROFORESTRY SYSTEM OF TIMBER AND FRUIT TREES.

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A need to characterize competition in agroforestry systems

The Growing AgroForestry systems with Apple in Mediterranean climate (GAFAM) project looks at the growth and development of apple trees in a multi-strata agroforestry system where walnut trees planted in 1995 forms the upper stratum, four-year-old apple trees the intermediate stratum and sainfoin the herbaceous stratum (figure 1). However, analyzing multi-species, multi-strata agrosystems using a categorical variable, i.e. 'treatments', is not satisfying when looking at the heterogeneity within each 'treatment' and could possibly hide differences between treatment when using comparison of means statistical tests. Inspired by forest ecologists we developed a neighbourhood competition index (NCI) to characterize competition for each of our focal apple tree, competition for light being a key determinant of productivity here (Jucker et al., 2014).

Creating an indicator to suit our needs

Our NCI combines traditional distance-dependent crowding models (Canham et al., 2004 ; Fichtner et al., 2017 ; González de Andrés et al., 2018) in which the target tree growth and fruitng is analyzed as a function of the sizes and distances to neighbouring trees and a season-dependent canopy shading factor. For $i = 1, …, n$ neighbours within a maximum radius (r=15 meters) of the target tree the net competitive effect of the neighbours on the target tree is given by equation [1].

$$[1] \quad NCI = \frac{1}{\sum_{t0}^{t} GF} \times \sum_{i=1}^{n} \frac{CSA_i}{distance_i}$$

Where GF is the sum of the gap fraction (derived from hemispherical photography) during the focal tree growing season and CSA the cross section area at breast height of the neighbour i. The apple trees being fertilized and irrigated we hypothesized that the limiting factor would be light. Therefore, we only considered the walnut trees in the creation of our NCI.

Validation of our NCI

The apple trees are planted in three treatments, on the same row as the walnut trees (AFR), on the inter-row 6.5m away of two walnut row (AFIR) and furthest away of the walnut trees considered as our agricultural control (AC) establishing a gradient of competition with the walnut trees. We correlated the trunk diameter of the target trees with the NCI (figure 2a). The NCI we calculated explained 59% of the variation of the target trees trunk diameter diameter and 49% of the number of flower clusters on 45 apple trees (figure 2b).

Take home message

✓ When working in complex agroforestry systems using a continuous indicator based on a focal tree can complement analysis using only treatments.
✓ Improving distance-dependent competition models by using a gap fraction based NCI proves to be relevant to model tree architectural features.

References

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Figure 1: A view of the plot with sainfoin at the bottom, apple trees in the middle and hybrid walnut at the top.

a) $y = 16.872x^{-0.139}$
$R^2 = 0.5885$

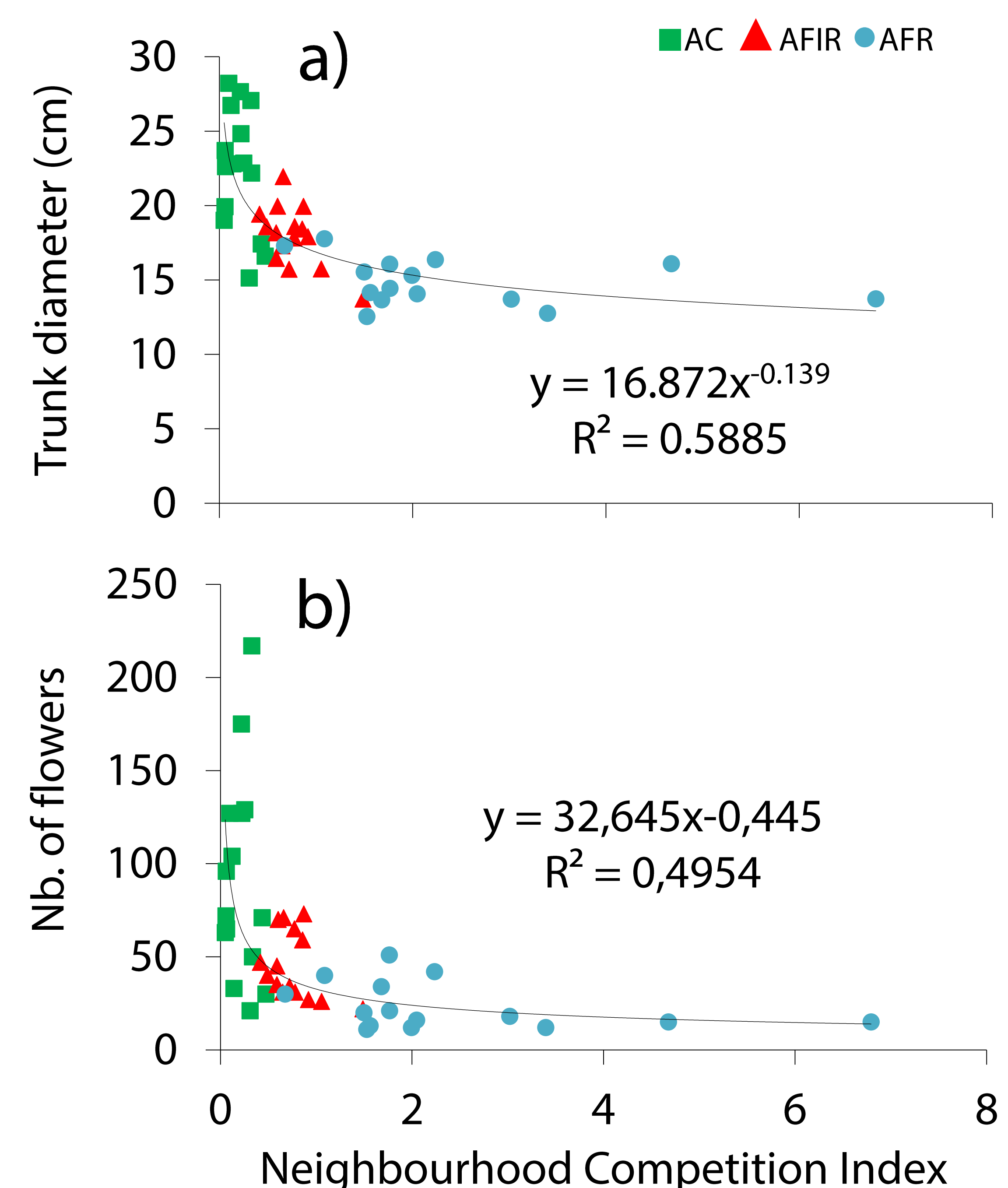b) $y = 32,645x^{-0,445}$
$R^2 = 0,4954$

Figure 2: a) Correlation between the trunk diameter and our NCI for 45 3-year-old apple trees along a gradient of competition for light. b) One example of data analysis using the NCI. Here we correlated the number of flowers per tree for 45 apple trees with the NCI (AC: Agricultural Control, AFIR: AgroForestry Inter-Row, AFR: AgroForestry Row). NB: increasing NCI values means increasing competition.