Traits influence the role of trees on ecosystem services: phytostabilization of trace elements and carbon sequestration

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Introduction

Functional traits of trees affect soil functions and ecosystem services in different ways.

We studied a restored land affected by a mine-spill in SW Spain (Domínguez et al. 2008).

We analysed morphological and chemical traits of leaves and roots, for seven afforested tree species with contrasted leaf habit.

We evaluated two ecosystem services: 1) The regulation of soil quality by immobilization of trace elements (phytostabilization), and 2) the mitigation of climate change by carbon sequestration in soils.

Methods

We sampled leaves and roots of five replicates of each tree species and the soil underneath, including adjacent open soils as reference (Figure 1).

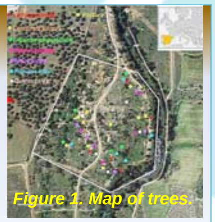

Figure 1. Map of trees.

Six functional traits were analysed by PCA: Leaf SLA, C/N_{Leaf} and Cd_{Leaf} concentration, and Root SRL, C/N_{Root} and Cd_{Root}.

Plant traits, soil C density and Cd concentration were compared among tree species by ANOVA test.

Results

Functional traits

The main trend of variation in functional traits (PCA factor 1) separated the three deciduous species (left side) from the four evergreens (right side) (Figure 2). The main factors were SLA and SRL versus C:N in leaves.

The second trend separated *Populus* with higher Cd in leaves, and *Quercus* and *Pinus* with higher C:N in roots.

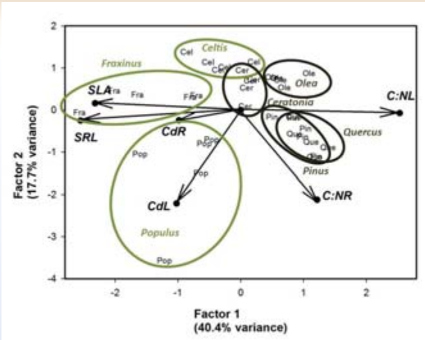

Figure 2. PCA results.

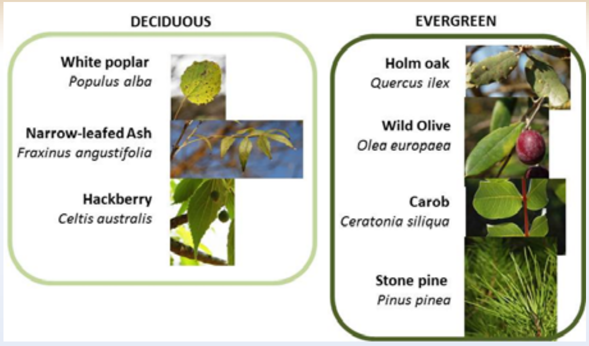

Figure 3. Studied tree species with contrasted leaf habit.

Phytostabilization of soil trace elements

Phytostabilization is the use of higher plants and associated microorganisms to immobilize contaminants in soil.

We present here results for Cd, a trace element of potential toxicity.

There were significant differences among tree species for the accumulation of Cd in leaves (maximum in *Populus*) and roots (higher values in *Pinus* and *Fraxinus*) (Figure 4).

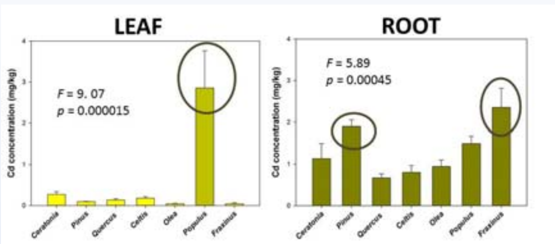

Figure 4. Cadmium in leaves and roots.

There were marginally significant differences among tree species for soil Cd (Figure 5).

Maximum loss of soil Cd was under *Pinus*.

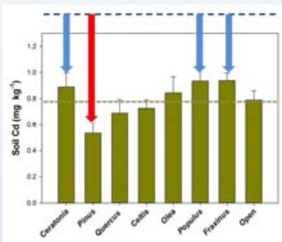

Figure 5. Soil Cadmium.

Soil carbon sequestration

Ecosystems mitigate climate change by storing and sequestering greenhouse gases.

Litter quality affects soil carbon. There were differences among species in the C:N ratio of forest floor (Figure 6), with *Pinus* having the highest value.

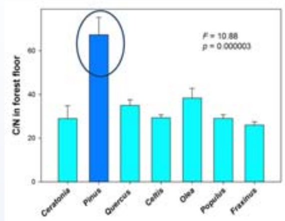

Figure 6. C:N ratio of forest floor.

There was a trend of soil under *Fraxinus* and *Populus* to have higher C density than in open. On the contrary, soil under *Pinus* and *Celtis* tended to have lower C density (Figure 7).

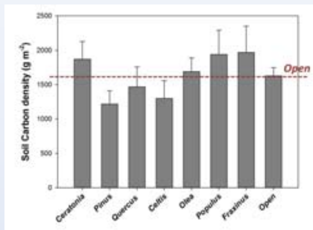

Figure 7. Soil Carbon density.

Discussion

The functional traits of planted trees affected the soil underneath and the provision of ecosystem services (Marañón et al. 2015).
The retention of trace elements by the roots of *Fraxinus* could favour the phytostabilization process, while the high transfer of Cd to *Populus* leaves would favour mobilization and risk for herbivores.
Pine trees had higher C:N ratio in litter, and lower efficiency in soil carbon sequestration. In contrast, *Ceratonia, Fraxinus* and *Populus* tended to have higher soil C density underneath.
Tree-soil interactions contribute to remediate degraded lands and provide multiple ecosystem services (Schwilch et al., 2016).

References

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