# Understory Evolution Related to Organic Fertilization in a Silvopastoral System Established under *Pinus Radiata* D. Don. In an Acidic Soil

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**Abstract**

Mixed pasture establishment is considered as a key point to increase livestock production due to the higher quality it has compared with unmanaged shrubby species. They also provide a set of ecosystem services such as carbon sequestration and higher biodiversity. Moreover, herbaceous pasture establishment effectively contributes to biomass production while replacing shrubs therefore reducing forest fire risk. Two of the main factors promoting the establishment of the herbaceous pasture are sowing and fertilisation. This study evaluates the understory composition evolution of a silvopastoral system established with cocksfoot and clover in an acidic forest soil under *Pinus radiata* D. Don with four treatments that consist of no fertilization, fertilization with mineral fertilizers (500 kg of mineral 8:24:16) and fertilization with three doses of sewage sludge (160, 320 and 480 kg N $ha^{-1}$), in Galicia (NW Spain). Botanical composition data were analysed through species abundance diagrams in a time window of 20 years. Results showed a clear evolution in understory composition from the initial situation. Organic fertilization was found to ease sown-mixture persistence on time as well as avoiding shrub colonisation with regard to mineral and no fertilization treatments. Nutritional and sun light high-demanding species were mostly replaced in favour of autochthonous ones after sewage sludge fertilization stopped and tree canopy intercepted light that reached the understory.

**Keywords:** Agroforestry, sewage sludge, biodiversity, pasture

## 1. Introduction

In the silvopastoral systems in which woody vegetation is combined with forage and animal production, the mixed pasture establishment is considered as a key point to provide high quality feed for the animals thus increasing livestock production. The evaluation of the mixed pasture establishment in this type of agroforestry systems becomes essential since it provides a set of ecosystem services (carbon sequestration, higher biodiversity) at the same time that the forest fire risk is reduced because shrubs are replaced by herbaceous species, being Galicia one of the most fire-prone areas of Europe (Ferreiro-Domínguez et al., 2014). One of the main factors promoting the establishment of the herbaceous pasture is fertilisation. Moreover, this management activity can modify the botanical composition of the pasture. This study evaluates the understory composition evolution of a silvopastoral system established with cocksfoot and clover in an acidic forest soil under *Pinus radiata* D. Don and fertilised with different doses of sewage sludge (160, 320 and 480 kg N $ha^{-1}$)

## 2. Material and Methods

The study was conducted in Galicia (NW Spain) in a *Pinus radiata* D. Don plantation established in 1993 (1667 trees $ha^{-1}$). In 1997, an experiment with a randomised block design was carried out in 27 experimental plots (9 treatments x 3 replicates). Each plot was sown with a mixture of *Lolium perenne* L., *Dactylis glomerata* L. and *Trifolium repens* L. The established treatments were three sewage sludge doses (160 (L1), 320 (L2) and 480 (L3) kg total N $ha^{-1}$) with or without liming. A no fertilization (NF) treatment was established in the limed and unlimed plots and a mineral treatment (MIN) in the unlimed plots. In order to determine the botanical composition of the understory, four random pasture samples were collected in each plot all the studied years from 1998 to 2017. Annual abundance diagrams, omitting the percentage of the senescent material and pine needles (Magurran, 1988), were completed

## 3. Results And Discussion

Results show a clear evolution in understory composition from the initial situation. Organic fertilization facilitated the persistence in time of the sowing species which implied a reduction of the proportion of shrubs in the understory compared with mineral and no fertilization treatments. Nutritional and sun light high-demanding species, as *Lolium perenne* L. and *Trifolium repens* L., were mostly replaced in favor of autochthonous ones as sewage sludge fertilization stopped and tree mass

evolution in time promoted light interception reaching understory. *Dactylis glomerata* L. gradually decreased but without disappearing as the other sown species since it is better adapted to shade and drought conditions, which makes it very suitable for sowing in silvopastoral systems (Mosquera- Losada et al., 2001).

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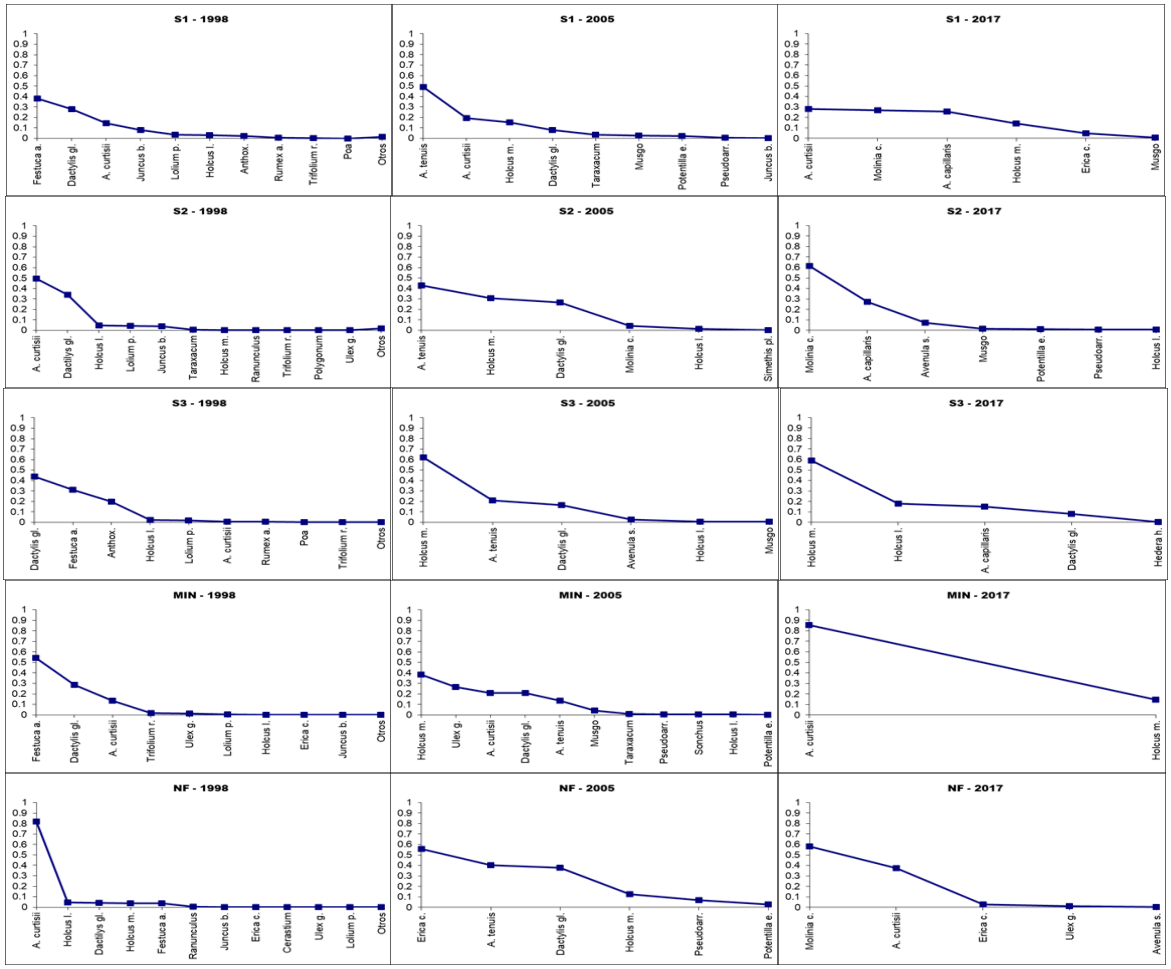


**Figure 1.** Species abundance diagrams for the fertilisation treatments (S1: 160 kg N $ha^{-1}$, S2: 320 kg N $ha^{-1}$, S3: 480 kg N $ha^{-1}$, MIN: mineral fertilisation) applied in 1998, 2005 and 2017 and the no fertilization (NF) treatment. A. capillaris: *Agrostis capillaris* L., A. curtisii: *Agrostis curtisii Kerguélen*, A. tenuis: *Agrostis capillaris* L., Anthox.: *Anthoxanthum odoratum* L., Avenula s.: *Avenula sulcata Gay ex Boiss.*, Cerastium: *Cerastium glomeratum Thuill*, Dactylis gl: *Dactylis glomerata* L., Erica c.: *Erica cinereal* L., Festuca a.: *Festuca arundinacea Schreb.*, Hedera h: *Hedera helix* L., Holcus l.: *Holcus lanatus* L., Holcus m.: *Holcus mollis* L., Juncus b.: *Juncus bufonius* L., Lolium p.: *Lolium perenne* L., Molinia c.: *Molinia caerulea* (L.) *Moench*, Otros: other species, Poa: *Poa pratensis* L., Polygonum: *Polygonum aviculare* L., Potentilla e.: *Potentilla erecta* L., Pseudoarr.: *Pseudarrhenatherum longifolium* (Thore) Rouy, Rumex a.: *Rumex acetosa* L., Ranunculus: *Ranunculus repens* L., Simethis pl.: *Simethis planifolia* (L.) Gren. et Godr., Sonchus: *Sonchus oleraceus* L., Taraxacum: *Taraxacum officinale* Weber, Trifolium r.: *Trifolium repens* L., Ulex g.: *Ulex galli*