Modelling the spatial structure of heterogeneous stands.
Example of Oak - Scots pine mixed stands of the Orleans forest (France)

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Introduction

Since a few years there has been a growing interest for uneven-aged or mixed forest stands. This interest is the result of both changing in demands from the society and also changing in forestry practices. Thus, single-species forest management, widely used in France and in several temperate countries, has been put into question.

Unfortunately, due to their high complexity, the dynamics of uneven-aged or mixed forest stands are more difficult to understand than pure and even-aged stands, which rises new research questions in terms of stand description, stand dynamics and growth modelling. Existing management tools, such as stand level models, are not relevant for this kind of stands.

To model the growth of heterogeneous stands, the use of individual-based models seems more appropriate, because of the individual variability within such heterogeneous stands. Such models simulate the evolution of each individual tree according to its particular characteristics and its local environment. There are many models of this type in literature, with a great diversity of competition index.

However, forest managers cannot easily use this kind of models, because they require an initial state with the description and the location of each tree in order to run simulations. Typically, these data are not commonly available. It is however possible to use our knowledge on stand-level characteristics of a forest stand as rules to build a virtual stand, which will be close to the real stand, and which could be used as initial state for an individual-based model. This approach corresponds to the development of a model of spatial structure.

Our aim is to explain and to illustrate the principle of the development of such a spatial structure model. We focused on mixed stands of sessile oak and Scots pine in the Orleans forest in France.The first step toward modelling spatial structure of mixed or uneven-aged stands is to describe precisely their spatial structure. We used the classical $L(r)$ functions (Ripley 1977) to characterise the specific spatial structure of each population, and the $L_{12}(r)$ intertype functions (Lotwick and Silverman, 1982) to characterise the structure of the interactions between populations. The Ripley function characterise the specific spatial structure of a population and allow to distinguish 3 types of spatial structure: aggregated, random or regular. The $L_{12}(r)$ intertype function characterize the interactions between populations and allow to distinguish 3 types of intertype structure: attraction, independence or repulsion between 2 populations.

We applied these spatial structure analysis on 26 sessile oak - Scots pine 1ha plots. We used the results of canopy and understorey spatial structure to build a typology of these stands. We will present the main spatial types identified.

In a second part we will specify how to use adapted statistical tools - point processes - to

build virtual stands, with the spatial characteristics of identified types. This step that consist in building virtual stands from real type of stand is the construction of a model of spatial structure.

Such a model of structure would help simulating realistic initial states, which would facilitate the use of individual based growth model. Indeed, our typology of oak-pine mixed stands identifies the main spatial characteristics of the stands in terms of spatial types. Further more, for each type we can measure many stand level characteristics (rate of mixing in the canopy, tree density in the canopy and in the understorey, presence or absence of species in the understorey, basal area, diameter classes, and possibly few inter-tree distances). For a given real stand whose spatial pattern has not been mapped, we could easily measure the stand level characteristics and the resulting variables could be used to identify its corresponding type in our typology. Then, the main spatial characteristics of the identified type could be used to simulate a realistic stand, using specific point processes. The simulated realistic virtual stand will then be used as initial state for the corresponding individual-tree-based growth model.