Interactions between under- and over-storeys

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Consequences to design silvicultures adapted to climate changes

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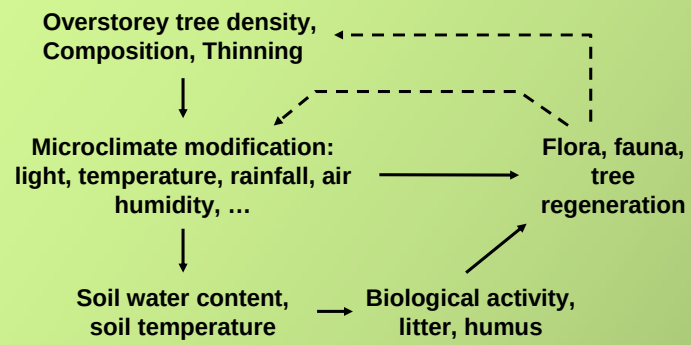
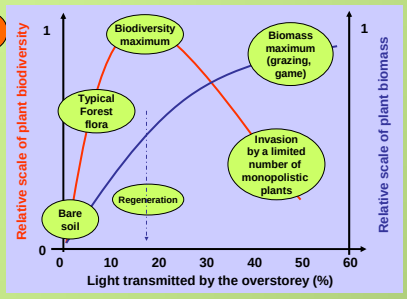
Forests comprise several interacting strata of vegetation; overstorey trees are most obvious but sub-canopy strata are typically present including herbaceous plants, shrubs, seedlings, and suppressed trees. For decades only crop trees have been considered in forests; however the understorey also plays a fundamental role in the ecosystem functioning and health. Various silvicultural systems are currently designed or experimented in relation with climate changes, and in particular **a change in crop tree species composition and a decrease of the standing tree density** to cope with a reduction of soil water availability together with an increase of scorching temperatures in many regions of the temperate area.

Modifying tree species composition or density of the overstorey changes the microclimate in the understorey, which affects the understorey composition and functioning, which in turn will create a new microclimate and will interact with the overstorey. Light is one of the main environmental factors controlling the processes; clearly, factors such as soil water availability, nutrients and temperatures are also fundamental, but these are all linked to some extent to light availability.



Long-term experiments have been designed to record microclimate, vegetation development, and tree regeneration, *in situ* and in controlled conditions, according to the structure of the overstorey.

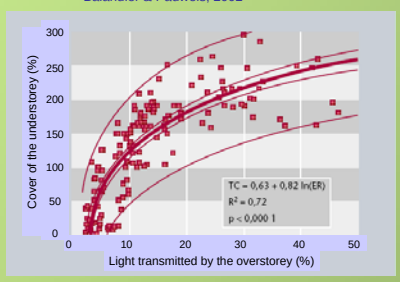
1



Balandier & Pauwels, 2002

Light availability in the understorey promotes the development of the floor vegetation (1). Globally, at the community level, there is a logarithmic increase in the vegetation cover with light availability (2). At the species level, patterns of plant cover or biomass with light availability are not simple and depend on the light requirements of species (3). Light availability modifies not only the cover of the floor vegetation but also its species composition (1). However, the response pattern of species composition with respect to light is not simple. Some studies have reported a bell-shaped curve with a maximum number of species for intermediate light levels, others a continuous increase in species richness with light. The first response is observed more frequently at a local scale, whereas the second is often recorded for larger geographical scales. The bell-shaped curve from shade to full light is explained by the progressive enrichment of a flora made up of shade-tolerant species by more and more light-requiring species as light increases up to a maximum species richness; thereafter one or more monopolistic, strongly light-requiring species colonise the whole space at the expense of all the other species (4).

2



Balandier & Pauwels, 2002

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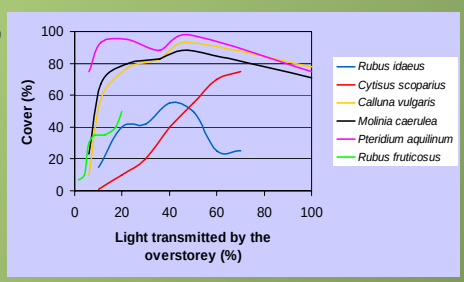


Gaudio et al., 2008, 2010 & unpublished data

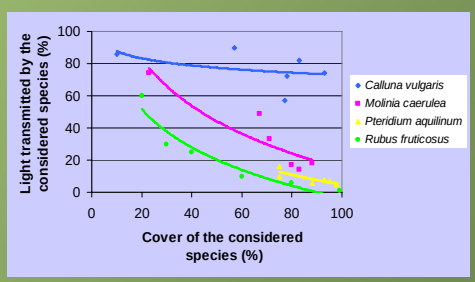
4

Strong colonisation of the understorey by *Molinia caerulea*

Depending on their development, the understorey plants can intercept a non-negligible amount of resources, e.g. light (5), water (6) or nutrients. Considering tree regeneration, those monopolistic species (e.g. *Rubus fruticosus*, *Molinia caerulea*, *Pteridium aquilinum*, ...) are highly competitive and can jeopardise tree seedling establishment and growth when they are surrounded by such a dense vegetation (7), and thus may compromise forest sustainability.

7

5



Gaudio et al., 2010 & unpublished data

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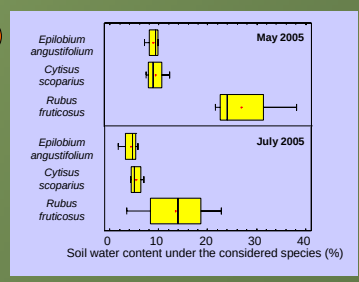

Unpublished data

Therefore the foresters have to reach a compromise for standing tree density of the overstorey that limits water consumption at the stand level whereas do not allow a too strong development of monopolistic understorey plant species.