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Concept of Forest Development Phases: Identification and Classification Issues

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Abstract: The decision making in forestry and choosing the appropriate silvicultural practices are based on the knowledge about forest development. Usually, forest development is described as a cycle or sequence of phases similar to the development cycles of organisms. The information about the development cycle of unmanaged forest ecosystems is applied and adapted to managed stands to refine the managerial approaches and decision making. Moreover, natural forests are more stable and resist pests and diseases better. Thus knowing the mechanisms that lie behind this self-sustainability could help in forest management. Assigning a patch of a stand a specific development phase makes it possible to evaluate its productivity and make decisions about necessary silvicultural operations. Yet there is no single opinion among the scientists about how many phases the forest's life cycle has, not to mention that different classifications offer different and sometimes even contradictional criteria to define the current forest development phase for a given subplot. The confusion in terminology for stand structures and stand development phases is also an issue to be considered. Several, the most popular approaches to assigning forest development phases are compared. A short overview of the algorithms used to define the forest development phases is given. There is a lack of a complex approach in the offered algorithms of assigning a subplot to a certain development phase. In particular, soil properties, as well as belowground biomass, are entirely ignored. It is necessary to develop a more comprehensive and detailed approach to defining forest development phases and arranging the diagnostic criteria in a clear and easy-to-use system that could enhance decision making in forestry. Only several studies are currently focused on soil properties and belowground biomass in temperate deciduous forests under different development phases. Although there is still little information on this issue, the data is insufficient and/or controversial. Our study offers several possible directions to make the forest development phases classifications more elaborate by considering the soil and belowground parameters. They include but are not limited to, quantity, density, humidity, and acidity of forest floor, soil respiration, and content of water-extractable organic matter in the soil.

Keywords: forest development phases; gap; forest soil; forest floor; succession

1. Introduction

The decision making in forestry, choosing the appropriate silvicultural and environmental protection measures are based on our knowledge of forest ecosystems development. Natural forests tend to have higher productivity, they resist pests and various disturbances better than managed stands [1], therefore, information about forest development patterns is necessary to build frameworks for informed decision making in silviculture. Knowing the natural development process in depth will allow choosing the optimal parameters for silvicultural stands (optimal area, stand density, stand structure, etc.) Such information may be used to make managerial decisions about operations that can affect one or more key stand variables to achieve a particular silvicultural purpose [2], for example, to estimate the optimal age for cutting trees [3]. Moreover, understanding of the forest development cycle is crucial for effective forest restoration.

Usually, the forest development cycle is described similarly to the development cycle of a living organism [4, 5, 6]. It is presented as a sequence of phases that follow each other. But there are different approaches to forest development phases identification, and every author singles out different process segments as forest development phases.

2. Discussion

The first attempt to classify the forest development phases was made by Watt [4]. His classification includes the gap phase, the Bare phase, Oxalis and Rubus. The late gap phase here also includes the regeneration, as it is not taken into other phases.

The concept of forest development phases was further developed by Leibundgut [5]. He defines the gap phase, the disintegration phase, the rejuvenation phase, the initial phase and optimal phase followed by terminal phase.

According to Oldeman [6], the life cycle of the forest consists of 7 phases, and the process begins with a zero-event, which can be, depending on the forest type and location, a windfall, fire, clearcut, etc. It is followed by the innovation phase, the early canopy closure phase, aggradation phase, early and late biostatic phases, leading to the degradation phase.

Oliver & Larson [7] offer a more generalized forest development phases classification, where stand initiation, stem exclusion, understorey reinitiation and old growth phases are defined.

As we can see, various authors go into different amount of detail describing the forest development cycle, defining different quantities of the phases in the sequence. Besides the aforementioned linear classifications, that view the forest development cycle as a sequence of phases, there are less simplified non-linear approaches [8]. While this is not an exhaustive overview of the forest development phases identification, one can see that different approaches are confusing and make it difficult to use the forest development phases for making certain decisions to achieve a particular silvicultural purpose.

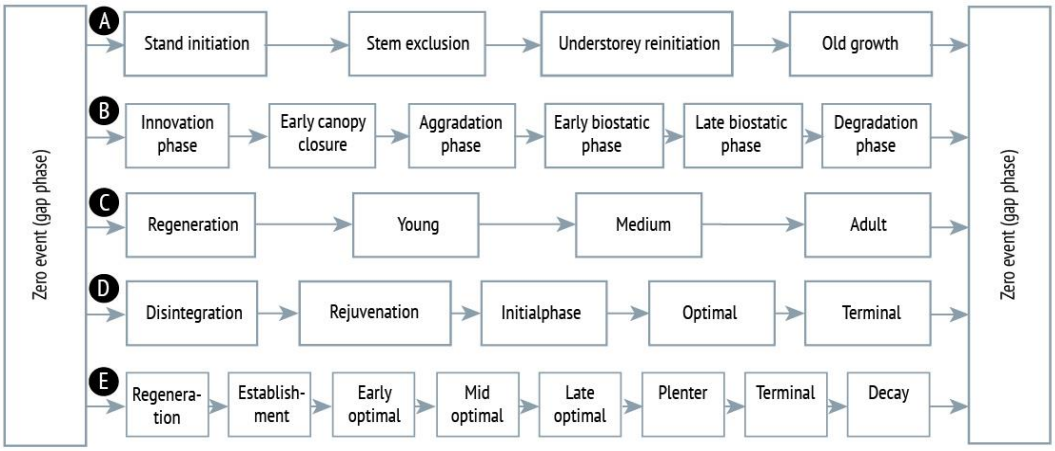

Figure 1. Figure 1. Different sequences of forest development phases depending on the classification approach: (A) Oliver & Larson [7]; (B) Oldeman [6]; (C) Duncker [2]; (D) Leibundgut [5]; (E) Tabaku et al. [9]. Not all the phases refer to the same hierarchical level.

The identification algorithms of the phases are also not unified. Different authors offer different criteria to assign the patches of the forest certain development phases.

For example, Tabaku [9] offers to take into consideration the diameter at breast height, the crown projection area, the proportion of dead trees, the proportion of stand height and the normed quartile distance. A more elaborated algorithm by Winter [10] uses these same parameters, though in a slightly different way — for instance, the definition is made for the 14 ×14 m patch of the forest.

What is common about all of these forest development phases classifications, and the algorithms used to assign a patch of the forest a certain forest development phase is that neither of them takes into consideration the soil properties.

There are several reasons why we think research on soil, forest floor and belowground biomass properties is important. First of all, it's the soil and forest floor microorganisms, fungi and invertebrates that decompose the deceased trees and bring the nutrition elements back into the system, linking the last phase of the cycle with the first phase. Another reason to study the soil properties linked to different forest development phases is to evaluate the carbon dioxide emissions for every forest development phase.

Soil, forest litter and belowground biomass properties also directly affect forest productivity, as releasing or immobilizing certain nutrition elements influences the green biomass development. Among the parameters of soil and belowground biomass that require research in terms of their relation to the forest development phases, there are for example pH level, conductivity, the total carbon content, the soil respiration. The forest floor parameters such as the quantity, density, humidity and acidity can also be characteristic to each of the forest development phases and even may be used in an express method of assigning a patch of forest a certain development phase.

Currently, we have started respective research in the Uholka-Shirokiy Luh forest. We foresee several possible directions to make the forest development phases classifications more elaborate by considering the soil and belowground parameters. They include but are not limited to, quantity, density, humidity, and acidity of forest floor, soil respiration, and content of water-extractable organic matter in the soil.

3. Conclusions

The forest development phases classifications in the current state should not be considered a comprehensive ecological and silvicultural tool, as they do not encompass the processes happening in the belowground part of the forest ecosystem.

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