

Tree Regeneration by Seeds in Natural Forests

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Seed quality and production are major factors governing the regeneration, structure, and succession of trees in natural forests [1,2]. The beginnings of the lives of future trees and forests are hidden in the forest's seeds, i.e., in cones, fruits (e.g., nuts) and seeds. Seed production plays a major role in forest ecosystem dynamics, directly affecting the possibility of seeds spreading in the landscape and their survival in time by contributing to the soil seed bank [3].

The resulting quality of the seeds depends on the seed production, the methods of harvesting and storage and, above all, the treatment before sowing. Forest seeds are stored so that sufficient quantities are available even when the trees produce less of it than normal. Conversely, each tree may also have exceptionally good years of seed production. Pre-sowing treatment usually means dormancy breaking (e.g., hard seed coats [4]) or various surface treatments of seeds (e.g., antifungal spray or coating [5]), which can both take place in different ways. Then, the seeds may be sown directly in the prepared soil in the forest, or they may be sown in forest nurseries, which are plots with equipment used for the production of planting material. The use of preprepared seeds or young seedlings are common methods in conventional forestry practice.

In addition to conventional methods, there is also a natural regeneration of the forest from seeds. This is achieved by flying the seeds on the adjacent empty gaps or by dropping the seeds directly under the mother tree. The seeds need favorable conditions for their germination and subsequent growth of the seedlings [6]. Excess seeds will cover losses caused by falling in the wrong place or by being eaten by animals. The principle of regeneration then depends on the selection of the strongest tree seedlings, which can either occur naturally or can be purposefully influenced by humans. Due to the high number of new individuals per unit area, the resulting forest stands, with subsequent suitable management, can be significantly better than commercial seedling stands.

The advantages and disadvantages of natural reforestation are still a topic of debate. However, with climate change, the cost-effective use of spontaneous recovery for carbon sequestration and to improve the microclimate in the area is rapidly gaining popularity [7–9]. The obvious disadvantage is the longer time required than conventional forest establishment. Forest regeneration by seeds is a natural dynamic process that is self-regulating and may lead to landscape formation. Therefore, compared to conventional forests, natural forests more accurately represent the landscape's wealth and heritage.

This Special Issue aims to explore challenges and opportunities within forest seeding, focusing above all on natural forest regeneration. This work generated interesting information related to the problematic nature of the possible natural regeneration of selected trees (Brazil nut, common ash, Norway spruce, pedunculate oak, Scots pine, *Quercus chungii*, and wild cherry) from various part of the world.

The scientific team of Przybylski et al. [10] addressed the potential regenerative capacity of Scots pine (*Pinus sylvestris*) in Central and Eastern Europe. They found that Scots pine trees retained the ability to produce healthy and germinating seeds into old age. The number of cones was the main element determining the regeneration potential of the stands, but it did not influence the occurrence of natural regeneration. It was found that the regeneration potential of Scots pine stands depends mainly on the habitat and the



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competitive pressure. In addition, the genetic diversity of naturally germinating seedlings was analysed.

Controlled experiments at three forest nurseries with different climate conditions tested the possibility of using the so-called minimal seedbed tillage system (scarifying followed by rototilling) in comparison with traditional ones (plowing, disk harrowing and cultivating) [11]. Some morphometric parameters were investigated in young trees of four forest tree species: pedunculate oak (*Quercus robur*), common ash (*Fraxinus excelsior*), wild cherry (*Prunus avium*), and Norway spruce (*Picea excelsa*). The results indicate highly significant gains in growth of the root collar diameter and shoot height in all tested trees, and root volume growth on pedunculate oak under minimal seedbed tillage system. The description of the minimal seedbed tillage system is part of the methodology of this paper.

High seed production does not guarantee successful regeneration. Orlović et al. [12] observed different storage regimes for pedunculate oak acorns depending on the occurrence of internal mycobiota and seed germination. The study confirmed the efficiency of thermotherapy in the eradication of a proportion of acorn internal mycobiota, but also its effect on the proliferation of fast-colonizing fungi during storage. Different efficacies have been discussed, especially with regard to the following fungi: *Fusarium solani*, *Alternaria alternata*, *Tubakia dryina*, and *Penicillium glandicola*.

An important ecological adaptation is seed dormancy, which allows dispersal in time and space and which prevents the simultaneous germination of all new produced seeds [13]. Sun et al. [14] examined both seed morphology and germination in *Quercus chungii* (syn. *Cyclobalanopsis chungii*) and they aimed to describe seed dormancy. Epicotyl physiological dormancy was documented in *Q. chungii* (formula: Cnd(root)—Cp'' 2b(shoot)) and much information was given about its early growth. Such a type of seed dormancy has never been previously reported in *Quercus*, section *Cyclobalanopsis*. This documentation of seed germination will provide guidance for the conservation and restoration of *Q. chungii* from acorns. *Q. chungii* is mainly distributed in the montane lowland forests of East and South China.

The team of Scolforo et al. [15] searched for a growth model of Brazil nut (*Bertholletia excelsa*) in two Brazilian Amazon forests, comparing the secondary forest with the old growth terra firme forest. The growth models were fitted at the species level to predict the diameter growth rate. The age at which the Brazil nut tree in each forest environment reaches the minimum diameter for seed production was calculated by integrating the growth models. According to their conclusion, the secondary forest seems a favourable forest environment for the growth of this tree species, which may be an indicator of the potential for secondary forest environments to produce Brazil nut seeds in the future.

Seed surface disinfection has traditionally been one of the most important topics in seed science. The aim of the study by Świecimska et al. [16] was to describe the effect of nonthermal plasma treatment (nine different exposure times were used, including the control) for the disinfection of Scots pine (*Pinus sylvestris*) seed surfaces artificially infected with *Fusarium oxysporum* spores. The optimal time for nonthermal plasma treatment of Scots pine was 3 s, because such treatment inhibited fungal growth, and additionally increased the seed germination. Pines are production forest trees, so the use of nonthermal plasma to disinfect the surface of their seeds and stimulate germination seems to be an important direction for current research [16,17].

The growth of trees from seeds is an important factor in plant evolution and in the development of an optimal state of vegetation, communities, and ecosystems. Knowledge of the natural regeneration of forests is important for developing scientific models, techniques and new guidelines to conserve dwindling natural forest areas. The articles presented in this Special Issue are a small contribution to the broad issues contained within this topic.

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