NATURAL REGENERATION IN WOODLAND MANAGEMENT

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Summary

The life cycle of forest trees and the recruitment process (natural regeneration) in the forest is described. The importance of natural regeneration in forest management is outlined. Insights are given on methods that can be applied for assessing the suitability of a forest stand for natural regeneration and for planning natural regeneration at a large scale. Silvicultural systems to implement natural regeneration in high forests are described; regeneration systems are described in terms of: cutting procedures, onset and establishment of natural regeneration, technical limitations and applicability, and effects on the characteristics of the renewing forest. The main factors controlling natural regeneration are analyzed: from seed availability and seed predation to factors affecting seedling growth and survival, including herbivore grazing.

1. Introduction

Natural regeneration is the process by which the forest is naturally renewed; it is based on the recruitment of young plants deriving from seeds (seedlings). Over their life cycle, forest trees encounter different phases: a seedling phase, characterized by intensive competition and high mortality; a juvenile intensive height growth phase, which determines how fast growing trees reach the overstory canopy layer; and a maturity

phase, characterized by canopy dominance and the onset of reproduction and recruitment processes.

Natural regeneration can successfully occur only if a sufficient amount of "growing space" is available for seed germination and subsequent growth of seedlings. Canopy trees strongly determine the understory light regime and tend to reduce the growing space for the recruitment of young trees into the canopy layer, thus consolidating their dominance.

In natural forests, the onset of regeneration processes depends on the creation of open patches (gaps) as a result of the death and felling of mature trees; gaps become preferential sites for natural regeneration, and the characteristics of mature forest ecosystems largely depend on gap recruitment dynamics. In managed forests, the onset of natural regeneration depends on the application of appropriate regeneration cuttings, reducing canopy cover and thus creating the necessary growing space for the recruitment of the new generation of trees. Regeneration cuttings should be intended, to some extent, as a means to reproduce patch disturbances occurring in natural forests.

2. Importance and Potential of Natural Regeneration

Natural regeneration is the main process a forester can rely on to influence the dynamics of forest stands and to preserve the genetic characteristics of local tree populations. Promoting natural regeneration of late-succession tree species is the most efficient way to move from even-aged artificial stands dominated by coniferous species into mixed stands with higher species diversity. Natural regeneration may allow improving the operational budget in commercial forests, since expensive plantation practices after logging can be avoided or at least reduced. Reliance on natural regeneration meets the need to move towards near-natural silvicultural regimes and multiple forest management objectives, which are considered important public opinion issues.

In most cases, natural regeneration proves to be superior to artificial regeneration, as seedlings derived from locally dispersed seeds are often better adapted to locally adverse environmental conditions; this is especially important at sites where trees are exposed to natural hazards over their entire life cycle, such as in the subalpine forest belt or the Mediterranean region, where harsh climatic conditions (strong winds, low winter temperatures, late freezing, or prolonged summer drought) are common events.

Natural regeneration is an important process we can rely on for restoring the forest over large areas after severe disturbance. In the tropics, there are examples of secondary rain forests derived from natural regeneration after shifting cultivation and also of intensive tree colonization of pastures following seed dispersal from the adjacent forest. Secondary succession by natural regeneration of trees on abandoned farmland or pastures is increasingly important as one of the most evident traits of global landscape change in temperate regions. Relying on natural regeneration often represents the best choice for vegetation that is recovering in burnt areas of the Mediterranean region; for instance, after extensive fires in Aleppo pine forests in southern Italy, dense seedling populations originate as large amounts of seeds (up to 500 seeds m^{-2} in the first days after fire) are rapidly dispersed from cones retained on the crown of burnt trees (crown

seed "bank"); logging operations to remove dead burnt trees immediately after the fire may have adverse affects on the recruitment of the new generation and should be discouraged.

Overall, forest practices based on natural regeneration are considered as a valuable means for moving towards forest types that are more efficient in providing valuable forest products and, at the same time, in assuring multipurpose forest functions (recreation, site protection, water conservation, and preservation of the habitats of endangered species of plants and wildlife). The elaboration of sustainable management criteria relying on natural regeneration is considered as an important effort at the international level.

3. Planning and Implementing Natural Regeneration

Planning natural regeneration requires good knowledge of ecosystem functioning and dynamics and highly experienced forest staff. Increasing research efforts are devoted to filling knowledge gaps on what ecological factors control regeneration processes, as well as to developing decision-making criteria for the selection of the best silvicultural option for stands scheduled for natural regeneration.

Objective criteria may be of help when planning natural regeneration. Regeneration indices have been proposed for evaluating the suitability of a forest stand for natural regeneration; indices are mainly based on parameters like seedling density (no. seeds per square meter), seedling height, or a combination of density and height. A forest may be considered suitable for natural regeneration if the regeneration index reaches a given "threshold," which is established on the basis of both ecological and economical considerations, at a certain stand age (for instance at the normal age for the first thinning in even-aged stands).

At a large scale, attempts to assess the suitability of natural regeneration can be made by applying methods based on the multivariate analysis of site factors, such as regional climate variables (temperature, humidity, frost, and radiation) and ground conditions (topography, soil properties, water availability, and vegetation); or by applying stochastic models conceived to predict the forest dynamics following disturbances. There are examples of appreciable results by these methods in explaining and predicting the suitability for natural regeneration of Scots pine-dominated forest stands in the boreal region and the long-term fluctuations of natural regenerations in oak stands of the temperate region. Vegetation analysis based on the attribution of ecological indicator values to understory plant species may also be useful for predicting ecologically meaningful conditions for natural regeneration; there are examples of application of this method to Scots pine stands under Mediterranean conditions. Geographic information systems (GIS) may help considerably in the production of scenario maps of natural regeneration across space and time, which are useful tools for forest management.

Foresters have to be aware of local socioeconomic conditions when planning natural regeneration. For instance, they should be aware of possible problems with shepherds in zones such as in the Mediterranean region, where open herbivore grazing is still an

important traditional activity; the temporary exclusion of grazing animals from the forest, necessary for the onset of tree recruitment process, may generate conflicts.

Implementing natural regeneration requires the application of a regeneration system. In silviculture, a regeneration system is defined as a cutting procedure that leads to the establishment of a new generation of trees and to the development of a new forest stand. There are different systems that may allow the creation of favorable conditions to initiate reproduction and natural regeneration. The choice of a given system depends on the structure of the forest and the objectives the management plan aims to achieve.

In turn, this choice will have a strong influence on the characteristics of the renewing forest, in terms of biodiversity, structure, site protection, growth rate, and timber quality. Qualitative and quantitative information on the effects of different regeneration methods and silvicultural regimes on forest characteristics are increasingly available in the scientific and technical literature; for instance, a substantial amount of information has been produced in recent years on the implications of different regeneration systems on the genetic diversity of the recruiting forest community.

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Biographical Sketches

Marco Borghetti, full professor of forest ecology and silviculture at the University of Basilicata. He has extensive experience in the ecophysiology of forest trees and forest stands: water relations, modeling gas exchanges, carbon balance and growth, effects of climate change, adaptation and acclimation processes, and natural regeneration.

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