

Ecophysiology of Northern Spruce Species: The Performance of Planted Seedlings

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Tree physiology research has contributed greatly to our understanding of forest ecosystems and their management. Much of this research has been aimed at questions concerning nursery culture and silvicultural activities associated with artificial regeneration. This book combines a review and synthesis of such work on northern spruce species with general information on the seedling environment, seedling physiology, and their interaction. The result is a unique, much needed forestry text on applied ecophysiology. This subject matter is focused at the whole plant level, with an emphasis on artificial regeneration of clearcut sites with northern spruce species, i.e., white, black, red, Engelmann, Sitka, and Norway spruce. The primary objective of the book is to provide foresters and resource managers with information needed to develop an understanding of the importance of ecophysiology to forest regeneration programs. However, it is organized and cross-referenced to meet the informational needs of a varied audience.

The first of the book's five chapters defines and describes the major components of the abiotic environment of tree seedlings. Discussion of the primary physical and biological processes associated with seedling energy balance, the hydrologic cycle, and nutrient cycling is greatly enhanced by liberal use of tables, graphs, and illustrations from the scientific literature and unpublished work of the author. The influence of the forest canopy on the seedling environment is emphasized throughout this section to discriminate between the undisturbed forest understory and clearcut reforestation sites.

The second chapter of the book focuses on seedling physiology and morphology as they relate to forest regeneration. The primary physiological processes covered are plant water relations, leaf gas exchange, plant nutrition, freezing tolerance, and dormancy. The section on plant water relations introduces the concept of water potential and describes water movement through the plant using the soil-plant-atmospheric continuum model. Discussion of leaf gas exchange is divided into stomatal function, photosynthesis, transpiration, respiration, and water-use efficiency. The section on seedling nutrition centers on soil and plant factors influencing nutrient uptake and the general physiological role of mineral elements. It also includes a useful table synthesizing our current knowledge of nutrient requirements and deficiency symptoms of spruce seedlings. The section on seedling physiology concludes with a discussion of the environmental cues and physiological changes associated with seasonal variation in freezing tolerance and dormancy. The remainder of the chapter is concerned with the growth and development of spruce seedlings. The influence of environmental factors on the growth and form of shoots and root systems is discussed, as well as morphological effects on the uptake of CO₂, water, and nutrients by spruce seedlings. Morphological features of container-grown planting stock are compared with those of naturally regenerated

seedlings to illustrate potential differences in field performance between artificially and naturally regenerated forest stands.

The third chapter builds on previous material to address the interactions between tree seedlings and their environment. The influence of temporal variation in the atmospheric and soil environment on gas exchange, water relations, and growth of planted spruce seedlings is discussed, as well as the effects of the belowground environment on nutrient uptake and utilization. This is followed by information on the influence of mineral nutrition, primarily N and P, on gas exchange, drought tolerance, freezing tolerance, and seedling growth. Freezing tolerance and dormancy of spruce seedlings receive a more detailed coverage than in the previous chapter, and includes a discussion of growing season frosts and winter desiccation. The chapter ends with a discussion of the dynamic nature of the seedling environment and the integrated physiological response of spruce seedlings to multiple environmental factors/stresses.

The shortest chapter in this book is also one of the best, as it presents much recent information on the physiological genetics of spruce. Background information on forest genetics is followed by discussion of genetic variation in spruce species at the population, family, and clonal level. The research of the author and others is used to provide numerous examples of how the wide genetic variation in physiology and morphology of northern spruce species can be used to produce planting stock with site-adapted physiological and morphological features.

The final and longest chapter of this book nicely brings together previous material to illustrate the role of ecophysiology in regeneration silviculture. The topics are organized in an operational sequence beginning with nursery and preplanting silvicultural activities, which includes nursery culture, stock quality assessment, overwintering, container stock characteristics, and stock handling practices. This is followed by a fairly comprehensive discussion of the ecophysiological response to silvicultural activities associated with planting, early establishment, and vegetation management. The chapter concludes with a brief treatment of partial harvest silvicultural systems that are increasingly used as alternatives to large clearcuts. The environment and physiology of spruce seedlings under partial forest canopies (e.g., shelterwoods) and in comparatively small clearcuts of different shape (e.g., strip clearcut) are discussed.

The author is well known for his research in ecophysiology and regeneration silviculture of northern conifer species. In this book, he has successfully merged information from both disciplines to produce a treatise on applied ecophysiology that will be invaluable to foresters, resource managers, and members of the research community alike. This book will likely be

most useful to undergraduate forestry students, as well as foresters and resource managers charged with the regeneration of northern latitude forests. Members of the forest research community and foresters working with regeneration of northern forest species will undoubtedly also find the book to be a use-

ful reference for its comprehensive review and synthesis of more than 1200 research reports on this subject.

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