MANUAL FOR SEED HANDLING

MANUAL OF ESSENTIAL FOREST SEED MANAGEMENT PRACTICES

SUPERB
Upscaling Forest Restoration

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EXECUTIVE SUMMARY

Successful forest restoration and regeneration depend on the quality of forest seeds and seedlings. This document provides a practical overview of the essential steps in forest seed management—offering guidance that supports forest managers, nursery staff, and restoration practitioners in making informed decisions. It explains why proper seed harvest timing, dormancy-breaking methods, seed preprocessing, pest and disease control, and nursery cultivation are fundamental to producing healthy, resilient planting stock.

Readers will gain insight into how each step—from collecting mature seeds, to applying after-ripening techniques, to protecting seeds from pests—improves germination success and reduces losses in nurseries. The document also highlights the importance of species-specific approaches and introduces an accompanying Excel tool that summarizes key seed quality parameters for 37 valuable tree species.

By applying the practices described here, users can enhance seed viability and improve the survival and growth of young trees in the nurseries. These insights are especially relevant in today's context of climate change, biodiversity decline, and increasing demand for effective forest restoration. Overall, this manual offers a concise, user-friendly foundation for anyone involved in producing high-quality seedlings for sustainable forestry and forest ecosystem recovery.

INTRODUCTION

Effective forest regeneration — whether through reforestation, afforestation, or assisted natural regeneration — depends heavily on the quality of forest reproductive material. When establishing new forest or in the process of forest restoration, it is essential to follow fundamental silvicultural principles for handling forest reproductive material (FRM). Among the key determinants of seed quality are the timing of seed harvest, the degree of after-ripening required, appropriate seed preprocessing, and effective pest and disease control. Additionally, the time required in the nursery phase significantly influences seedling vitality, survival potential, and the overall success of forest management programs. Understanding these parameters is essential not only for maintaining genetic diversity and adaptability of tree populations but also for ensuring high germination rates, robust seedling growth, and resilience of forest stands. In forest nurseries, small deviations in seed handling practices can lead to substantial losses in seed viability or seedling performance. Therefore, applying scientifically grounded principles and guidelines in forest seed technology is a fundamental aspect of modern silviculture. To support this, we prepared an Excel table that lists the key determinants of seed quality for 37 valuable tree species. In the following sections of this document, you will find a concise description of each seed quality determinant.

KEY DETERMINANTS OF SEED QUALITY

Harvest Time

Determining the optimal harvest time represents one of the most critical phases in forest seed management. Seeds collected too early are often immature, with insufficient nutrient reserves, poorly developed embryos, and low moisture reduction tolerance. Conversely, seeds harvested too late may already have dispersed naturally, suffered from predation, or damaged due to environmental exposure.

For most forest tree species, seed maturity is assessed through indicators such as cone or fruit colour change, seed coat hardening, moisture content reduction, and embryo development. In conifers, for example, cone browning and partial scale opening are widely used signals of physiological maturity. Broadleaf species often require monitoring of fruit softening or colour transition.

Another key indicator is seed moisture content, which typically declines as maturity approaches. Mature orthodox seeds usually reach moisture levels at which they can be safely processed and stored. Forestry operations often rely on predictive models that incorporate climatic data, phenology, and species-specific development timelines to optimize harvest scheduling.
Precise timing is essential because harvesting at peak physiological maturity maximizes viability, genetic quality, and storability.

After-ripening

After-ripening refers to physiological or biochemical changes that occur in seeds after they have been dispersed or harvested, enabling them to overcome primary dormancy. Many temperate forest species possess innate dormancy mechanisms that prevent immediate germination, ensuring that germination occurs under favourable environmental conditions.

In species with embryo dormancy, such as many oaks and pines, after-ripening is required to complete embryo development or to break physiological barriers. For some species, after-ripening occurs during dry storage; for others, it requires moist – cold stratification that mimics winter conditions.

This process is crucial for synchronizing germination with ecological conditions that support seedling survival. In forest nurseries, artificial after-ripening treatments are used to accelerate dormancy release and improve germination uniformity. These may include:

- Dry after-ripening at controlled temperatures,
- Cold stratification for species requiring chilling periods,
- Warm – cold cycles for species with complex dormancy patterns.

Proper management of after-ripening reduces seed losses, shortens nursery cycles, and enhances seedling uniformity — an important factor for mechanized nursery operations.

Seed Preprocessing

Seed preprocessing encompasses a range of operations designed to prepare seeds for storage, sowing, or further treatment. Typical steps include extraction, cleaning, drying, grading, and sometimes priming.

<u>Extraction and Cleaning</u>

Conifer seeds are commonly extracted through controlled drying of cones, while broadleaf fruits may require maceration or depulping. Cleaning removes inert material, improves seed handling efficiency, and reduces the risk of pathogen contamination.

<u>Drying</u>

Proper drying is critical for maintaining viability, especially of orthodox seeds, which require reduced moisture content for safe storage. Controlled drying prevents mechanical cracking and physiological damage.

Grading

Seeds may be separated by size, density, or shape. Grading enhances germination uniformity because larger, denser seeds often have better-developed embryos and nutrient reserves. Air-screen machines, flotation methods, and optical sorters are commonly used.

Priming

Seed priming, which involves hydrating seeds under controlled conditions to initiate early metabolic processes without radicle emergence, can significantly reduce germination time. This method is increasingly used in forest nurseries for species with slow or erratic germination.

Effective preprocessing increases seed-lot purity, boosts germination rates, and provides more consistent seedling performance — key outcomes in large-scale forest regeneration programs.

Pest and Disease Control

Forest seeds, both during development and after harvest, are susceptible to various pests and pathogens such as insects, fungi, and seed-borne bacteria. Infestations can drastically reduce viability, introduce pathogens into nursery systems, and distort regeneration outcomes.

Insect Pests

Cone and seed insects, such as weevils, moth larvae, and seed bugs, can damage seeds during development. Monitoring systems, pheromone traps, and silvicultural practices (e.g., timing of harvest and cone collection from non-infested stands) are commonly used to minimize damage.

Pathogens

Fungal pathogens pose significant risks during storage and stratification. To mitigate these risks, seed lots may undergo:

- Surface sterilization,
- Fungicidal treatments,
- Storage under low humidity and low temperature,
- Regular inspection and sanitation of storage facilities.

Implementing integrated pest management (IPM) strategies helps maintain seed quality and prevents the introduction of harmful organisms into nursery environments.

Time Needed in Nursery

The period that seedlings spend in the nursery largely depends on species biology, seed pretreatment quality, and desired planting stock characteristics. Species with deep dormancy, slow germination, or slow early growth require extended time in nursery conditions.

For many conifers, nursery residence may range from one to two growing seasons, whereas broadleaf species with rapid juvenile growth may require shorter periods. Factors influencing nursery duration include:

- Dormancy status at sowing,
- Seed pretreatment effectiveness,
- Seedling growth rate under controlled water, temperature, and nutrient conditions,
- Target seedling morphology (e.g., root collar diameter, height, root mass).

Nursery time is closely linked to operational costs and the quality of seedlings delivered for planting. Shortening nursery residence — without compromising seedling vigor — is a major goal of modern forest seed and nursery management.

KEY FINDINGS

Key finding #1

Scientifically informed seed management practices — covering harvest timing, after-ripening, preprocessing, pest and disease control, and nursery residence — are critical for ensuring seed viability, uniform germination, and robust seedling performance, which collectively determine the success of forest restoration.

Key finding #2

In the face of climate change, biodiversity conservation needs, and growing demands for sustainable forestry, optimizing these parameters is essential. High-quality seeds and seedlings not only enhance forest productivity but also strengthen ecosystem resilience and long-term ecological stability.

RECOMMENDATIONS

Takeaway #1

Forest managers should apply scientifically informed practices across all stages of seed management — harvest timing, after-ripening, preprocessing, pest and disease control, and nursery residence — to maximize seed viability, ensure uniform germination, and produce robust seedlings for successful forest restoration.

Takeaway #2

In the context of climate change and biodiversity conservation, it is essential to optimize these parameters to deliver high-quality seeds and seedlings that strengthen forest productivity, ecosystem resilience, and long-term ecological stability.

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(FOR EXCEL TABLE)

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