Successful forest regeneration under a changing climate

Brandenburg and Latvia

Carbon Sequestration
Successful forest regeneration under a changing climate

Background
According to current climate change projections, European forests will be affected by climate change impacts to varying degrees. Temperatures will generally increase, but the precipitation regime is expected to change in different ways throughout Europe. Depending on the regional conditions, changes in the amount and distribution of precipitation may lead to increased risk of drought and/or flooding, increased frequency and intensity of extreme weather events and subsequently higher risk of fire, insect, and pest damage.

Challenges
The expected increase in damaged forest area will result in an increase of forest area to be regenerated under less favourable climatic conditions. In addition to the traditional objectives of stand productivity and quality, improving forest resilience with respect to abiotic and biotic risks thus becomes a crucial objective of forest regeneration, requiring a reassessment of current regeneration strategies and techniques. In general, decisions made during the forest regeneration phase can only be corrected later at a great cost. The careful selection of regeneration strategies, methods, and materials therefore becomes particularly important in times of increasing risk.

General options
There are two main strategies of forest regeneration:
• Natural regeneration
• Artificial regeneration

Natural regeneration
In addition to the general prerequisites of establishing forest regeneration, the use of natural regeneration requires the presence of a seed source in or near the area to be regenerated. Seed sources should be healthy mature individuals of the target tree species featuring desirable properties.

Advantages of natural regeneration
• Preservation of locally adapted populations
• Preservation of high genetic variability
• Good adaptation to micro-sites
• Undisturbed root development
• Mostly low cost
• Low investment risk
Artificial regeneration
Artificial regeneration relies on seeding, planting of seedlings, or planting of cuttings. Particular prerequisites to the successful establishment of artificial regeneration are:

- Presence of seed orchards or stands
- Presence of a seedling industry (nurseries)
- Availability of an adequate labour force
- Site preparation (in most cases)

The active introduction of seed or plant material to a forest site allows for prior selection of the reproductive material with respect to certain objectives of plant breeding or genetic improvement. The most important objectives are to improve tree growth, quality, and/or resilience to pests, disease and drought.

Disadvantages of natural regeneration
- Inability to change genetic stock
- Irregular regeneration density and tree species composition
- Dependence on fructification and seed production
- Low flexibility
- High management intensity and complexity
- Long risk period

Advantages of artificial regeneration
- Controlled plant density
- Predictable seedling production
- High flexibility
- Low management intensity
- Option of introducing improved seed or plant material
- Changing species and/or varieties

Disadvantages of artificial regeneration
- Labour-intensive
- Temporarily disturbed root development
- Less adapted to micro-sites
- Cost-intensive

Natural regeneration in pure pine stands
Case study - Brandenburg

Aiming to distribute the climate change-related risks on several tree species, it is the objective of forest management to convert the pure pine stands typically found in large parts of Brandenburg into mixed stands. In a 78 year-old pure pine stand stocking on a moderately moist and rich site, the establishment of a more or less full cover of natural regeneration of oak and beech originating from bird sowing required no silvicultural measures, but do require an increase of the game reduction targets.

Naturally regenerated oak and beech seedlings are expected to be more resilient to drought conditions than planted regeneration, as their root development is not disturbed by planting. Within only 10 days, oak seedlings can develop a 15 cm-long taproot. During the vegetation period, the taproot can increase to 50 cm length even in dense clayey soils, and can thus endure long periods of drought. Root development of planted oaks will never be similar to that of oak seedlings. While more than 75% of naturally regenerated oaks develop a taproot, most planted oaks develop a fibrous root system.

After an overstory thinning, the advance regeneration will be tended by removing damaged plants and removing harvest residues. Due to the light regime below the overstory, regeneration is expected to be of relatively high quality despite the relatively low regeneration density. Additional natural regeneration of pine will likely complement the regeneration layer following overstory thinning. In the long-term, the pure pine stand will thus be converted into a continuous-cover pine-oak-beech stand at little cost simply by reducing game density and thinning the overstory.
Artificial regeneration to improve species
Case study - Latvia

A large-scale network of seed orchards, nurseries, and trial sites has been established in Latvia since the 1960s. It is aiming for the genetic and physiological improvement of tree species such as Silver birch, Scots pine, Norway spruce, and Black alder with respect to growth, quality, and – in light of climate change – resilience to drought and/or pests. In ongoing experiments, resistance against pathogens and reaction to changes in climatic conditions of selected progenies is investigated. Results will allow for selecting seed material with high adaptive potential for establishing the next generation of seed orchards and for introduction into forest stands.

Results reveal that the use of selected (seed orchard) seed material can notably improve stand growth and quality – as demonstrated by progenies of two different birch mother trees at the same site (afforested former agricultural land) at the age of 10 years.

Experimental results on dry and sandy Scots pine sites also demonstrate that release of carbon from the soil due to seedbed preparation is compensated by regeneration within 11–15 years. Moreover, stands established using selected plant material have been shown to sequestrate more carbon in living biomass and plant litter than naturally regenerated stands established on similar sites.

Outlook
No universal recommendation can be made for the selection of a particular regeneration strategy. Rather, the choice of regeneration strategy – natural or artificial – ought to be based on the specific natural conditions of the forest stand or region, on local and regional forest management objectives, and on site-specific risks.

Artificial regeneration is essential for the (re-) introduction or changing of tree species in the course of forest conversion and diversification. In contrast, natural regeneration would be the optimal strategy for regenerating (near-) natural forest stands where highly site-adapted species with a high genetic variability need to be maintained. However, it is the combination of both regeneration strategies which will likely prove to be most effective in creating forests that are resilient to abiotic and biotic risks.

Only vital, resilient and productive forests can lock away large amounts of carbon in trees and soil and produce timber for construction and energy, thus storing carbon in wood products or replacing non-renewable energy sources. Therefore, the timely regeneration of over mature and damaged forests using an adequate strategy is crucial for ensuring forest functionality.

Further reading:
Impacts of Climate Change on European Forests and Options for Adaptation (http://ec.europa.eu/agriculture/analysis/external/euro_forests/full_report_en.pdf)