Trees, Forests and People 14 (2023) 100448

Contents lists available at ScienceDirect

Trees, Forests and People

journal homepage: www.sciencedirect.com/journal/trees-forests-and-people

Continuous cover forestry: Opportunities for changing forests☆

ARTICLE INFO

Keywords
Climate change
Biodiversity
Conservation
Recreation
Sampling
Training
Selection forest
Deadwood
Peatland
Regeneration
Carbon sequestration
Funding

From a modern perspective, the invention of forest management for sustainable timber resources in the 18th century was an urgently needed response to a long history of irresponsible, large-scale forest exploitation and devastation in Europe. “They went into the hills and mountains to fell trees like others ladle water from a stream” was a famous expression in the Swiss canton Neuchâtel to describe the reckless timber-mining attitude towards forests at the time. G. F. Morosov pointed out that silviculture, a field concerned with the design, maintenance and regeneration of forests, bizarrely enough owed its existence to large-scale forest degradation and a painful lack of timber resources. Without this cataclysmic forest degradation and timber shortage, which came to the Europeans as a shock, there would not have been a need to consider silviculture and to embrace sustainability.

What followed was often the hasty introduction of systematic and rigid approaches to sustainable forest management that were – in the absence of better knowledge – largely borrowed from agriculture. Even today we can still recognise the legacy of the key components of these methods in the landscapes of many countries around the world: even-aged forests, monospecies stands, geometric thinnings, large-scale clearfelling and a forest planning system based on the “normal forest”. Given the moderate technical advance at the time, these basic building blocks allowed a fast restoration of timber resources in many parts of Europe which was largely successful and solved pressing problems. Eventually these methods paved the way towards a highly industrialised silviculture largely ignoring the existence and principles of forest ecosystems and the interrelationships that govern them including the fundamental roles of soils, plant physiology and biodiversity.

This development of industrialised forestry called for resistance and it promptly came, partly led by forest owners and forest managers, such as Wallmo, Gurnaud and Biolley, partly by forestry professors such as Gayer, Möller, Engler, Morosov, Troup and Anderson to name but a few. These individuals promoted a holistic forest management that is closer to the principles of forest ecosystems and natural forests whilst delivering timber sustainability at the same time. The subsequent debates marked the beginning of continuous cover forestry (CCF) and soon many semi-synonyms were coined such as Dauerwald, close-to-nature forestry, nature-based forest management, retention forestry, systemic silviculture, ecological silviculture and the Lübeck model among the most prominent ones. The specific definitions and objectives of these semi-synonyms can differ but all variants of CCF described by these labels share a rather high degree of similarity.

Through the decades the perception and popularity of CCF saw many ups and downs and the concept regained momentum in the aftermath of the forest decline and certification debates. Recently CCF has been revisited for its potential to mitigate climate change, to maintain biodiversity in forest ecosystems, to provide valuable techniques for forest conservation and to enhance the appeal of woodlands used for recreation. An important driver of this renewed interest in CCF are the people, i.e. the societies in the countries around the world who increasingly feel threatened by global environmental calamities and demand

☆ This article is part of a special issue entitled: “Continuous Cover Forestry: Opportunities for Changing Forests” published at the journal Trees, Forests and People.

https://doi.org/10.1016/j.tfp.2023.100448

Available online 27 September 2023

environmentally-friendly approaches to forest management. In addition, the EU forest strategy for 2030 urges an increased use of CCF. The timely special issue of *Trees, Forests* and *People* offers a unique cross section of important research topics associated with CCF and demonstrates the high diversity of intriguing scientific questions.

Across the world, selection or *plenter* forest systems usually are rare silvicultural systems, since they are on the most complex and extreme side of CCF. In Bosnia-Herzegovina, however, this silvicultural system is apparently applied in more than 90 % of all high forests of the country. As part of this CCF special issue, Čilaš et al. (2023) successfully adapted the Austrian Moses tree growth model for simulating management scenarios within Bosnian mixed-species selection forests. The simulations confirmed that regular harvesting interventions are required for maintaining the structure of these selection forests.

With ongoing transformation of plantation forests to CCF spatial forest structure usually increases. As a result more canopy layers, more species and greater size diversity emerge than there were before transformation. Some trees now occur in clusters others have rather large distances to their nearest neighbours. This typically requires changes in sampling and forest inventory. Leiter and Hasenauer (2023) have studied this problem in selection forests, a variant of CCF with high structural diversity. The authors found that relascope sampling using a basal-area factor of 4 m^2/ha or circular plots with fixed areas between 300 and 500 m^2, but also combinations of relascope sampling and fixed-area plots are the most suitable methods for estimating growth, volume and basal area.

Following widespread public concern about industrialised plantation management, CCF has recently been considered for introduction in Sweden. Kruse et al. (2023) described a strategy of how national requirements for CCF training can be derived from experiments involving marteloscopes, where test persons walk through the forest whilst recording their decisions concerning trees to remain and trees to be removed as part of CCF management. They compared the results of a marteloscope experiment in Northern Sweden with those of 14 comparable marteloscope sites in the UK. The Swedish results were partly similar to the British results and partly adhered even more to theoretical expectations, but they also revealed that more CCF training is required.

Olofsson et al. (2023) studied rare examples of selection or *plenter* forests in Central Sweden. This extreme type of CCF has no practical tradition in a country where plantation management has prevailed for decades. The two forest stands studied largely included only the species *P. abies* and small target diameters were applied, whilst traditional selection forests usually include at least three species and large target diameters. Applying dynamic demographic models the authors demonstrated that despite the differences to traditional selection forests both stands have well advanced towards the structure of a single-tree selection system.

Transformation of plantations to some form of CCF is an important silvicultural task in the context of this special issue. Neumann et al. (2023) studied changes in live and deadwood pools in forests of *P. abies, A. alba* and *F. sylvatica* six decades after transformation to a single-tree selection (*plenter*) system commenced. The authors found that selection forests do not tend to have more deadwood than comparable forests before transformation but a more diverse range of deadwood components thus potentially providing more habitats for plant and animal species that depend on deadwood.

The fate of boreal peatlands that in the past were drained and planted up with trees is hotly debated in Scandinavia and elsewhere. Laudon and Maher Hasselquist (2023) reviewed the role CCF can play in brokering a compromise between continued forestry use and peatland restoration. CCF is increasingly argued to provide alternatives to traditional clearfelling on peatlands and thus to improve water quality and quantity, biodiversity and carbon sequestration. The authors concluded that the use of CCF should be expanded on productive drained peatlands, since CCF can balance the groundwater level, reduce soil disturbance and reduce costs otherwise spent on ditch cleaning. Peatland restoration should, however, be a priority where tree growth has not responded well to past draining efforts.

Suitable techniques of transforming plantations to CCF depend on many factor, not least on the environmental conditions of given forest site and on past management. Shell et al. (2022) studied the growth response of residual *P. elliottii* in various silvicultural systems and their variants in the Southeastern US. Tree growth was significantly affected by harvest treatment, dominance, gap size and distance of the gap boundary. The authors found that group systems with canopy gaps of at least 0.2 ha are needed for the successful regeneration of *P. elliottii* in Florida.

Promoting carbon sequestration in trees and forest soils is another important theme of CCF, which – with ongoing climate change – has recently raised increased interest in this management type. Li et al. (2022) reviewed China's key forest ecology projects in terms of achieving carbon neutrality. Since forestry and particularly CCF achieve a high reduction of greenhouse gas emissions at low costs, the authors concluded that Chinese forestry may be able to attract government funds and even to mobilise private-sector funding in the future.

This special issue has illustrated many global challenges forestry is currently facing. CCF as an environmentally friendly form of forestry can clearly help in these situations and accordingly research support for CCF should have a high priority for any government. Ironically the core fields of silviculture and forest management responsible for the implementation of CCF have, however, suffered a steady decrease of research funds for quite some time now. Hardly any national research council is prepared to fund the development of methods in forest management and the associated scientific experiments whilst forest industries often do not have sufficient means to invest in research. As a result, this situation leads to a continued loss of key silvicultural research staff at universities which bizarrely comes at a time when the knowledge in this field is more needed than ever. As a consequence many silvicultural research groups and institutions have been dissolved and closed. Experience tells us that discontinuing research is easy but reinstating something that has been lost is much more difficult. May this special issue of *Trees, Forests and People* raise awareness of an urgent need to rethink.

Acknowledgements

I acknowledge the unwavering support of Dan Binkley, Todd Fredericksen, Alrun Albrecht, the firm dedication of all authors who kindly contributed their papers and – most importantly – the enormous and much appreciated commitment of 13 reviewers.

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