Sonja Kuster 01/10/2024
Unit Code: H/602/3963
UNIT GUIDE 2023-24

3. Understand the principles of common silvicultural systems of tree management.

3.1. Describe two common silvicultural systems

Silviculture encompasses both the art and science of managing the establishment, growth, composition, health, and quality of forests and woodlands to fulfil the varied needs and values of landowners and society sustainably (Adams et al. 1994). It is frequently characterized as the care of forests or the cultivation of trees. At its core, silviculture is a field dedicated to addressing human requirements through the manipulation of forest environments. Given that forests generally require extended periods to mature, silviculture typically depends on the management of ecosystems that closely resemble natural conditions. Consequently, silviculture is often regarded as a practical application of forest ecology.

Silvicultural systems are forest management methods or approaches that aim to achieve certain objectives while considering the ecological and economic elements of forest ecosystems. There are several primary silvicultural systems, each with unique traits and applications. They are used individually in high forests (which are defined by the presence of fully formed, mature trees that form a continuous, closed canopy) and in other types of silviculture, such as coppice or agroforestry systems.

A *forest stand* refers to a specific area of woodland characterized by a relatively uniform group of trees, which share similarities in species composition, spatial distribution, age class distribution, and size class distribution (Jenkins et al. 2012). The site is expected to exhibit uniform quality, and the overall characteristics of the stand will be noticeably different from those of neighbouring communities. This concept is frequently regarded as the fundamental unit of management within silviculture, with a forest being an aggregation of multiple stands across a wooded landscape. In the context of plantation forests, the terms compartment and sub-compartment are often employed to identify related areas that are managed independently.

Key considerations for selecting a silvicultural system:
Site Conditions: The choice of silvicultural system is determined by elements such as soil type, climate, and tree species.
Management objectives: Different systems are appropriate for a variety of purposes, including timber production, biodiversity conservation, and enjoyment.
Environmental impact: Each system's potential ecological repercussions should be thoroughly assessed.
Additional notes:
Hybrid systems contain characteristics of both even-aged and uneven-aged management.
Sustainable forestry: Effective silvicultural practices aim to strike a balance between economic, environmental, and social goals.
Adaptive management requires a flexible approach that allows for adjustments depending on monitoring and evaluation to ensure long-term forest health.
Forest managers can make more informed judgements about forest management by understanding the characteristics and implications of various silvicultural systems.

Silviculture interventions need to be well thought out and require a thorough understanding of the site, historical management practices, the dynamics of forest stands, and an assessment of the current state of the stands. Using this data, the silviculturist creates stand-level plans, also known as *stand prescriptions*, which specify the short- and long-term steps needed to achieve certain stand management goals. Plans for the overall management of the forest compile prescriptions for each stand. Typically, these are created and updated every five years according to a planning cycle.

They can be broadly categorized based on the regeneration pattern and canopy removal techniques:

Even Age: All trees belong to the same age group, resulting in a single cohort.
Two Age: This system features two separate age classes of trees, comprising one older and one younger cohort.
Uneven Age: In this scenario, there are three or more distinct age classes of trees, indicating the presence of at least three cohorts.

Management activities, or *treatments*, that collectively form a silvicultural system can be classified into several distinct categories. These include *regeneration treatments*, *stand establishment treatments* and *intermediate treatments*.

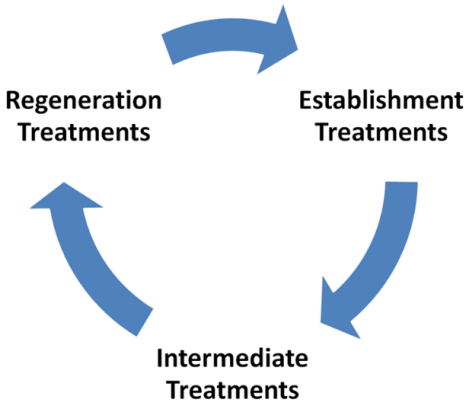


Figure 1.2.1. The three phases of a silvicultural system.

https://www.sfasilviculture.com/index.php/textbook/1-2-introduction-silvicultural-systems

Regeneration treatments refer to harvesting techniques that conclude one growth cycle and facilitate the initiation of a new one. A new growth cycle commences when the entire forest stand is populated with one or more new cohorts. Consequently, these practices are *fundamentally harvesting techniques*. They are termed regeneration treatments because the main goal of the silviculturist during the harvesting process is to effectively establish the subsequent growth cycle, thereby revitalizing the forest. Additionally, regeneration methods are classified according to the age class structure of the newly formed forest. There are eight specific regeneration treatments.

Even aged:
Clear-cutting
Seed-tree method
Shelterwood system
Two-aged management:
With reserves
Plus deferment
Uneven-aged:
Patch selection
Group selection
Single tree selection

Various regeneration treatments establish distinct age class structures and supply varying levels of light, water, and nutrients to emerging cohorts, in alignment with their respective silvicultural systems.

Even-Aged Stand: The objective is to create a forest stand where the trees are of similar age, which can facilitate easier management and harvesting processes.
Clearcutting: This method involves the complete removal of all trees within a designated area, resulting in an entirely open landscape.
Exposed Microclimate: The clearcut area receives full sunlight, which may be advantageous for certain species while posing challenges for others.
Regeneration Options: Clear-cutting allows for multiple approaches to regenerate the area, such as natural seeding, planting new seedlings, or leveraging existing trees within the stand (advance reproduction).
Management Unit: Each clearcut region is treated as a separate management unit, concentrating on the regeneration, growth, and productivity of the newly established stand.

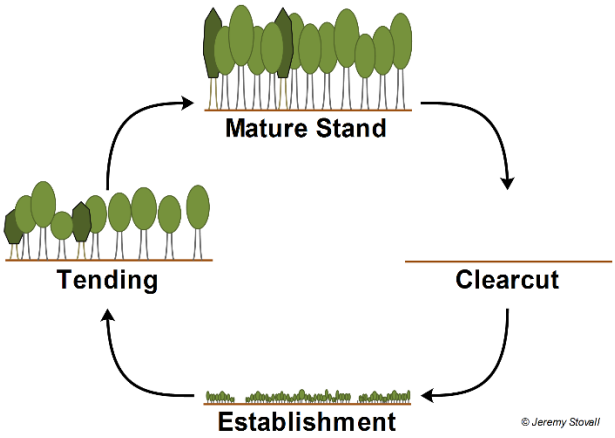
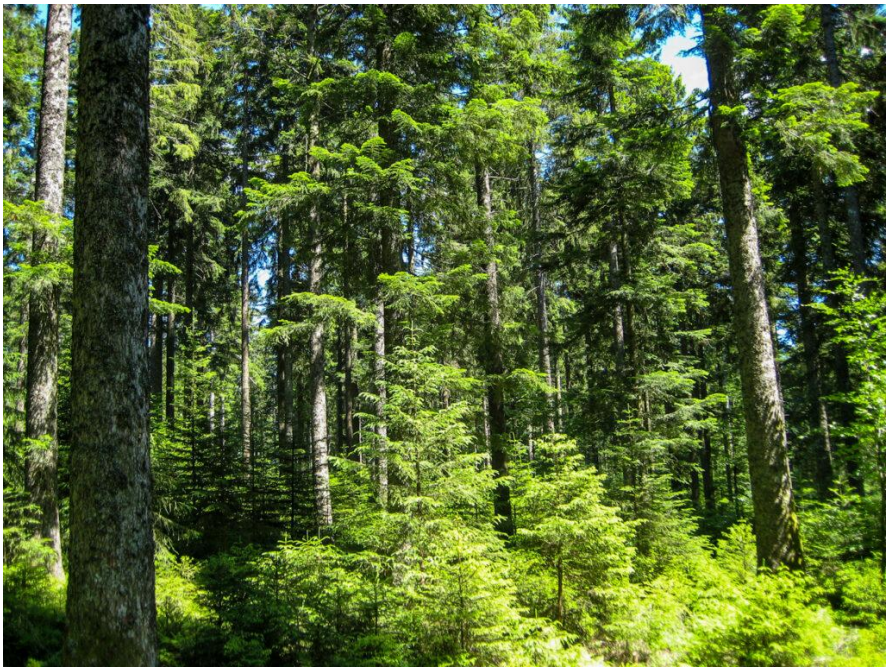


Figure 1: Clearcut regeneration method in action. Keep in mind that this technique regenerates an even-aged stand after just one harvest.

https://silviculture.org.uk/silviculture/
A uniform age group of Sitka spruce (Picea sitchensis) is being managed through a clear-cutting approach. The stand depicted in this image has not undergone thinning and is currently undergoing harvesting. Following this process, the area will be replanted to commence the next growth cycle. Kielder Forest, England. April 2023. Photo credit: © 2023 Edward Wilson/Silviculture Research International.



https://silviculture.org.uk/silviculture/
A stand primarily composed of Norway spruce (Picea abies) is being managed using a single-tree selection system. This stand exhibits an irregular structure, featuring trees across all age and size categories, ranging from regeneration to the desired dimensions for final harvesting. Freudenstadt, Black Forest, Germany, August 2008. Photo credit: © 2008 Edward Wilson/Silviculture Research International.

Seed Trees: A select number of trees are preserved to supply seeds for natural regeneration.
Exposed Microclimate: The removal of many trees, akin to clearcutting, creates open conditions conducive to seed germination.
Natural Seeding: The preserved seed trees yield the seeds that will sprout and develop into a new forest stand.
Seed Tree Removal: After the establishment of the new stand, the seed trees may be removed to mitigate competition.

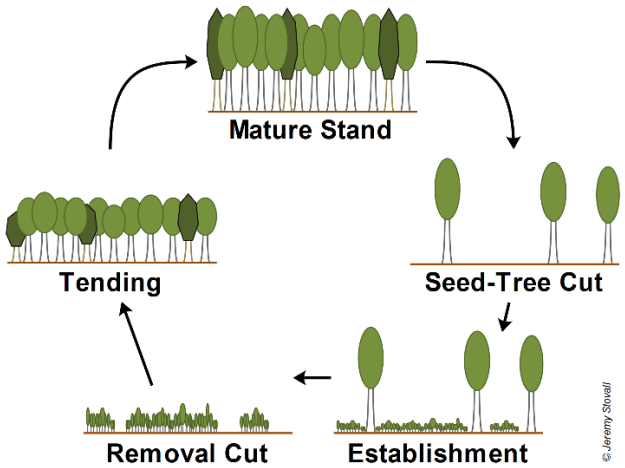


Figure 2: A seed-tree regeneration technique demonstration. Keep in mind that this technique regenerates an even-aged stand through two harvests.

Shelterwood systems represent a middle ground between even-aged stand management and individual tree silviculture, warranting a more comprehensive explanation. These systems facilitate the regeneration of new trees by systematically diminishing the overhead canopy through a series of stages (see Figure 3). The primary objective is to utilize the current canopy to foster the growth of the next generation of trees or to create a more intricate forest structure than previously existed. Consequently, the regeneration

within a forest stand may be either uniform and even-aged or irregular and somewhat uneven-aged, contingent upon the specific shelterwood system employed.

https://silviculture.org.uk/silviculture/

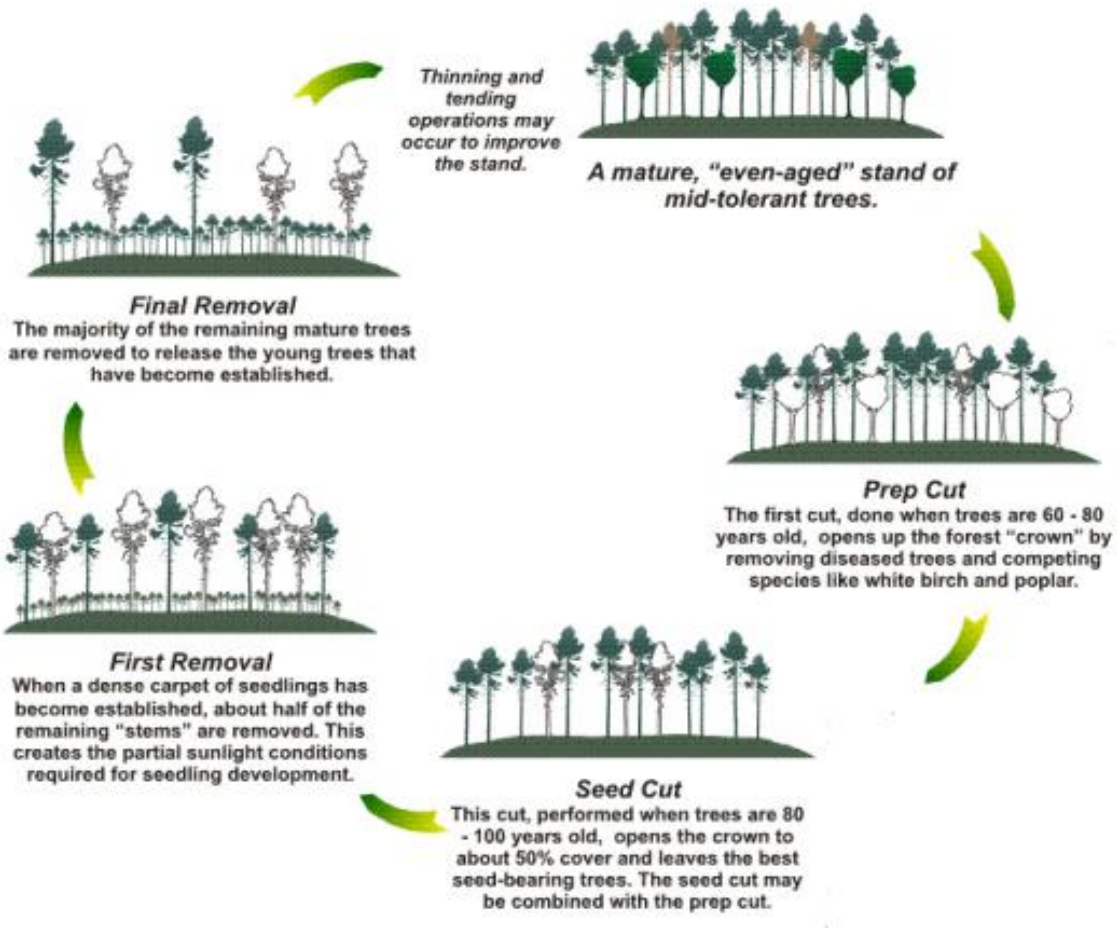
Figure 3: Scots pine (Pinus sylvestris) is being cultivated under a uniform shelterwood silvicultural system. The overstorey has been systematically reduced to facilitate the natural regeneration of the stand, which is particularly beneficial for shade-intolerant species like Scots pine. At the final stage, the overstorey may be entirely removed, resulting in a predominantly even-aged stand; however, a few veteran trees per hectare may be preserved for their habitat and conservation significance. Kinveachy, Strathspey, Highlands, Scotland, December 2023. Photo credit: © 2023 Edward Wilson/Silviculture Research International.

Shelterwood Systems

The primary categories of shelterwood range from uniform to irregular regeneration patterns within the managed stand. Here are *four more prevalent types of shelterwood* to demonstrate how the resulting stand structure can be characterised as relatively uniform (even aged) or irregular.

Uniform Shelterwood System:

This approach involves the gradual removal of the overstorey through a series of stages. The process begins with a preparatory intervention, during which the entire stand is thinned to enhance the stability of individual trees and to increase light penetration to the forest floor. The remaining trees, known as the *residual stand*, serve as a source of seeds, provide shade, and offer protection for the establishment of natural regeneration. Following this initial stage, subsequent interventions occur over several years, progressively removing the overstorey trees. This action releases the understorey regeneration from the shade, facilitating the development of a new stratum. Typically, the process consists of two or three stages before the complete removal of the overstorey, which is influenced by the stand's previous history and the extent of natural regeneration present at the onset of the shelterwood. The terminology of two-stage or three-stage uniform shelterwood arises from the number of stages involved. During the regeneration phase, the stand comprises two age classes, or cohorts: the overstorey and the understorey. Once the final overstorey trees are eliminated, the new stand is classified as even aged.



The canopy is systematically opened across the entire area of the stand to achieve consistent regeneration beneath the protection of the remaining mature crop. This approach is intended for implementation in regions where Sitka spruce has been recently planted in Muirside, Scottland.

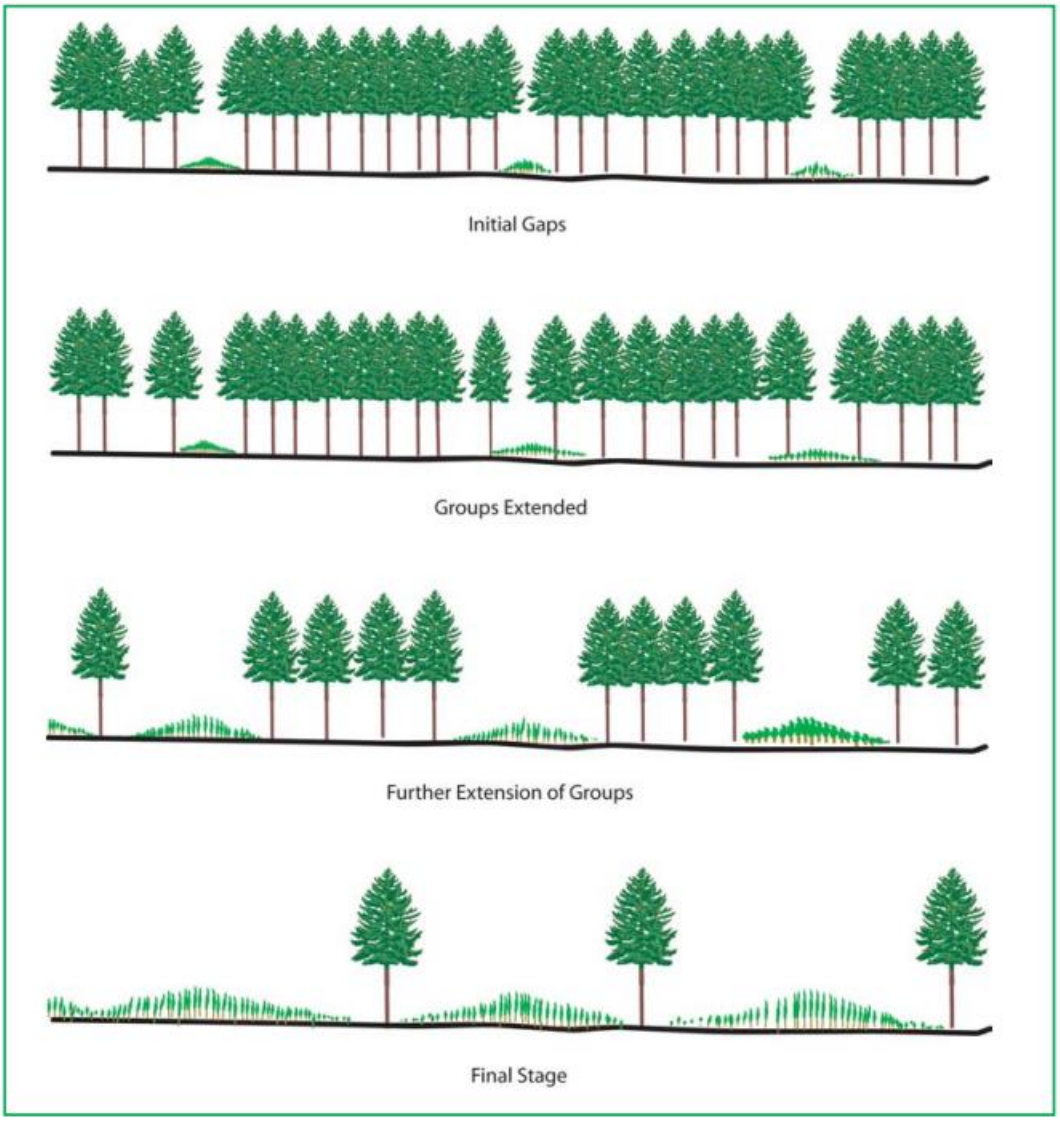
https://forestryandland.gov.scot/media/cf3jzdiq/sw-fife-forests-lmp-2021-plan-v-15-accessible.pdf

Strip Shelterwood:

In this system, interventions are made in relatively narrow strips that advance progressively through a stand over the time frame of the regeneration period. Interventions take place in the stand as uniformly staggered linear strips at right angles to the prevailing wind. Seed is blown from the residual stand into the opened strip and any windblown edge trees are salvaged at the next intervention. Succeeding strips are added beside the initial strips and progress into the wind until the entire overstorey is removed and the understorey fully established. Harvesting in each strip may occur gradually and following a sequence of preparatory, regeneration and removal interventions.

Group Shelterwood System:

The group shelterwood system represents a method in which *clusters of trees* are selectively removed, as opposed to a uniform or strip-cutting approach, to form small openings within the forest. These openings, which typically range from one to two tree lengths in diameter, differ in size and shape, creating optimal conditions for regeneration. Over time, these gaps may be enlarged or new ones established to facilitate the release and more thorough regeneration of the forest stand. The timing and degree of each regeneration phase play a crucial role in shaping the future structure of the stand. This method can serve to achieve continuous cover forestry, owing to the irregular patterns that emerge from the spatial and temporal distribution of the openings.



Group system showing successive stages of regeneration (after Matthews 1999).

Irregular Shelterwood System:

The irregular shelterwood system is characterized by the *timing of regeneration establishment* rather than by the spatial configuration of trees. This approach incorporates aspects from various systems, particularly group and single-tree selection, and may involve a blend of these methods. The duration of the regeneration phase is prolonged to the extent that the resulting stand does not exhibit even-aged characteristics. The *term "irregular" signifies the diversity in tree heights* within the new stand. Consequently, the irregular shelterwood system is intentionally employed to enhance structural diversity. Goals related to aesthetics, wildlife, and biodiversity conservation are typically aligned with this system.

Figure 3e. An example of an irregular shelterwood harvest profile depicting a pre-harvest eastern white cedar dominated stand (a), stand conditions 15 years after a first partial harvest (b), and 50 years after partial harvest (c) (illustrations by Jodi Hall).

Figure 3e. An example of an irregular shelterwood harvest profile depicting stand conditions 15 years after a first partial harvest (b) (illustrations by Jodi Hall).

Figure 3e. An example of an irregular shelterwood harvest profile depicting 50 years after partial harvest (c) (illustrations by Jodi Hall).

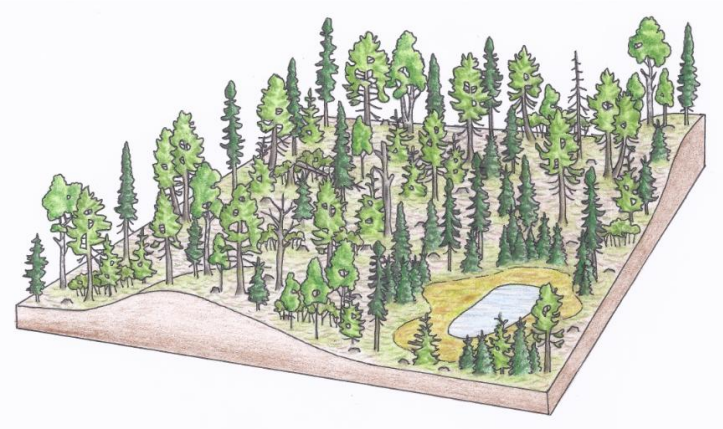


Figure 3f. An aerial view of an irregular shelterwood harvest in a cedar dominated stand 15 years after harvest (a) (illustrations by Jodi Hall).

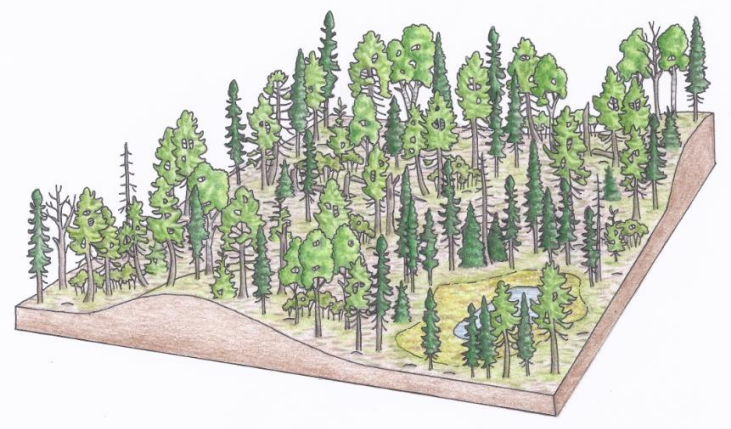


Figure 3f. An aerial view of an irregular shelterwood harvest in a cedar dominated stand 50 years after establishment resulting in a multi-aged stand (b) (illustrations by Jodi Hall).

https://www.ontario.ca/page/forest-management-guide-silviculture-great-lakes-st-lawrence-and-boreal-forests-ontario

Irregular shelterwood, Cairngorns National Park © Ted Wilson

3.2. Outline two advantages and two disadvantages of each system

***Clearcutting**:*

Advantages
Swift Regeneration: This method allows for the rapid establishment of new growth, particularly for species that flourish in open environments.
Enhanced Yield: It can optimize timber production over the long term.
Streamlined Management: Managing a uniform-aged stand is generally simpler than overseeing a mixed-age forest.
Wildlife Habitat: Clear-cutting can create open spaces that are beneficial for specific wildlife species.

Disadvantages
Environmental Consequences: This practice may result in soil erosion, habitat fragmentation, and alterations in water quality.
Aesthetic Concerns: The visual impact can be negative, particularly in regions with significant public exposure.
Risk of Failure: If the regeneration process fails, the area may remain unproductive or become overrun by invasive species.

Clearcutting is a controversial technique. Even if it has its benefits, it's important to consider any possible consequences on the environment and put precautions in place to lessen the dangers.

***Seed-Tree Method**:*

Advantages
Natural Regeneration: This approach leverages natural processes to establish the new stand, which may lead to cost savings.
Genetic Diversity: It can contribute to the preservation of genetic diversity within the forest ecosystem.
Reduced Disturbance: This method causes less disruption to the site compared to clearcutting.
Intermediate Cover: The remaining seed trees offer shade and protection for the newly regenerating seedlings.

Disadvantages
Slower Regeneration: The process of natural seeding may occur at a slower pace than the planting of seedlings.
Risk of Failure: The method may not succeed if the seed trees are unproductive or if conditions for regeneration are not favourable.
Competition: Seed trees may compete with the regenerating seedlings for essential resources.
Limited Control: There is reduced control over the timing and location of regeneration when compared to the planting of seedlings.

The seed-tree method is frequently employed in regions where natural regeneration is dependable and where there is a preference for maintaining a more natural forest structure. Nonetheless, it may not be appropriate for all species or site conditions.

Uniform Shelterwood System

Advantages
Natural regeneration: This system encourages the growth of naturally regenerated trees, often resulting in healthier and more diverse forest stands.
Shade and protection: The remaining overstorey provides essential shade and protection for the regenerating understorey, which helps to alleviate stress and enhance survival rates.
Seed source: The overstorey acts as a vital seed source for natural regeneration processes.
Gradual change: The incremental removal of the overstorey facilitates a smoother transition to the new stand, thereby minimizing disturbances to the ecosystem.
Improved stand structure: This approach can foster a more open and varied stand structure, which is beneficial for wildlife and other components of the ecosystem.

Disadvantages
Longer time frame: The uniform shelterwood system typically requires a longer duration to achieve completion compared to other silvicultural methods.
Risk of windthrow: The remaining overstorey may be more vulnerable to windthrow, particularly during storms or high-wind events.
Competition: If the regeneration in the understorey becomes overly dense, it may compete with the existing overstorey trees for essential resources, impeding their growth and development.
Complexity: Implementing this system can be intricate, necessitating meticulous planning and ongoing monitoring.

Strip Shelterwood System

Advantages
Natural regeneration: This system encourages natural regeneration, fostering a more diverse and resilient forest stand.
Reduced windthrow risk: The narrow strips of cleared land are less prone to windthrow compared to larger, open areas.
Efficient seed dispersal: Wind effectively carries seeds from the remaining trees into the cleared strips.
Improved stand structure: It can lead to a more open and varied stand structure, which benefits wildlife and other components of the ecosystem.
Reduced disturbance: The gradual removal of the overstory in narrow strips helps to minimize disruption to the ecosystem.

Disadvantages
Complexity: Implementing the strip shelterwood system can be more intricate than other silvicultural methods, necessitating thorough planning and monitoring.

Slower regeneration: The gradual approach may result in a slower rate of regeneration compared to alternative techniques.
Edge effects: The boundaries of the cleared strips may be more vulnerable to windthrow and other disturbances.

Group Shelterwood System

Advantages
Natural regeneration: This method encourages natural regeneration, fostering a more diverse and resilient forest stand.
Reduced disturbance: By creating small, dispersed openings, it minimizes disruption to the overall forest ecosystem.
Improved stand structure: It can lead to a more open and varied stand structure, which benefits wildlife and other components of the ecosystem.
Continuous cover forestry: The irregular arrangement of openings helps maintain continuous cover, providing habitat for a variety of species.
Flexibility: The group shelterwood system allows for adaptability in the size, shape, and spacing of openings, accommodating different site conditions.

Disadvantages
Complexity: Implementing this system can be more intricate than other silvicultural approaches, necessitating careful planning and monitoring.
Slower regeneration: The gradual removal of trees in small clusters may lead to slower regeneration rates compared to alternative methods.
Windthrow risk: The creation of small openings can, in some instances, elevate the risk of windthrow, particularly if the remaining trees are isolated.

Advantages and Disadvantages of the Irregular Shelterwood System

Advantages
Natural regeneration: This system fosters natural regeneration, resulting in stands that are more diverse and resilient.
Enhanced structural diversity: The deliberate establishment of uneven-aged stands creates a more intricate and varied habitat for wildlife and other species.
Aesthetics and biodiversity: It is particularly effective in meeting aesthetic objectives while also supporting biodiversity conservation efforts.
Flexibility: The system provides adaptability regarding the timing and intensity of regeneration, accommodating various site conditions.

Disadvantages
Complexity: Implementing the irregular shelterwood system can be quite complex, necessitating meticulous planning and ongoing monitoring.
Slower regeneration: The prolonged regeneration period may lead to a slower rate of stand development.
Windthrow risk: The uneven-aged structure may heighten the risk of windthrow, particularly in areas with isolated trees or gaps in the canopy.

In summary, the irregular shelterwood system presents numerous advantages, especially concerning natural regeneration, structural diversity, and the promotion of biodiversity conservation.

3.3. Identify what is meant by the term continuous cover forestry

Continuous cover forestry (CCF) represents a specific methodology for forest management, extending beyond the confines of a silvicultural system. Silvicultural systems, such as shelterwood, selection, and patch clear felling, serve as tools for achieving the established management goals.

CCF is considered synonymous with 'alternatives to clear felling' and the term 'low impact silvicultural system' (LISS). A LISS has little negative effect on either the forest crop or its general environment.

Sitka spruce regenerating naturally in an area of 'windblown' trees in Ballyedmonduff forest

https://www.coillte.ie/a-beginners-guide-to-continuous-cover-forestry/

Karen Woods, Operation manager from Coillte Nature outlines their success with CCF practice as follows: A significant advantage of Continuous Cover Forestry (CCF) is its facilitation of forest management through natural regeneration processes. There is no longer a necessity for manual tree planting, as new seedlings emerge naturally from seeds that either fall from the canopy or are dispersed by wind or bird excrement. The light requirements for these seedlings vary according to species: Pioneer species such as Scots pine (native), larch (non-native), and birch (native) require abundant light for their growth. In contrast, spruce and Douglas fir (both non-native) exhibit a greater tolerance for shade and do not require as much light. Additionally, species like beech and western hemlock (both non-native) are highly shade-tolerant and can thrive in significantly darker environments.

Overall Benefits of CCF

Resilience

CCF fosters the establishment of a multigenerational forest characterized by a diverse array of species, resulting in a more robust forest ecosystem that creates optimal conditions for the germination and growth of young trees. Populations of young seedlings that arise through natural regeneration can swiftly acclimate to the local environmental conditions influenced by a changing climate. The diffused light present in irregular forest structures can suppress weed growth, thereby facilitating the development of tree seedlings. The existing canopy cover provided by CCF offers protection and enhances the growing conditions for a variety of shade-tolerant tree species, thereby increasing the overall species diversity

within the forest. Trees within a CCF framework are better equipped to endure high winds due to the formation of deep crowns and extensive root systems.

Ecosystem services

The machinery utilized for CCF management can be restricted to felling tracks, which helps to preserve soil integrity and prevent compaction and erosion. CCF maintains a canopy of large, mature trees that effectively capture airborne pollutants and safeguard forest soils, thereby supporting the long-term sequestration of carbon. By emulating natural processes, CCF creates a more irregularly structured woodland that harmonizes with the local landscape, providing an inviting environment for recreational activities that promote health and well-being. CCF sustains natural woodland water cycles by buffering stormwater, which enhances flood mitigation and improves water quality.

Timber production

The practice of selectively removing individual trees or groups of trees, known as thinning, generates a consistent income stream and a sustainable timber yield. By implementing a strategy of minimal and frequent felling, CCF can effectively manage competition among individual trees for space, light, and nutrients. Cultivating a variety of tree species can help mitigate the effects of fluctuations in timber prices, enabling the timely harvesting of different species and supporting the sustainability of timber income. A forest rich in species diversity is more resilient to challenges posed by climate change, high winds, and pests and diseases, thereby safeguarding your timber supply.

Finally, CCF encourages the development of established trees in conjunction with a varied understorey comprising mosses, flowering plants, shrubs, young trees, and deadwood. This strategy fosters habitats for a range of plants, animals, and fungi, thus improving the overall ecological health of the forest.

References:

https://www.sfasilviculture.com/index.php/textbook
https://silviculture.org.uk/silviculture/
https://www.forestresearch.gov.uk/tools-and-resources/fthr/resources-on-managing-resilient-forests/continuous-cover-silviculture-what-is-a-silvicultural-system/
https://forestryandland.gov.scot/media/cf3jzdiq/sw-fife-forests-lmp-2021-plan-v-15-accessible.pdf
https://link.springer.com/article/10.1007/s10021-023-00875-9
https://www.gov.uk/government/publications/the-benefits-of-continuous-cover-forestry/the-benefits-of-continuous-cover-forestry#:~:text=Continuous%20cover%20forestry%20(%20CCF%20)%20is,timber%20whilst%20retaining%20canopy%20cover.
https://cdn.forestresearch.gov.uk/1999/01/fcin029.pdf
https://cdn.forestresearch.gov.uk/1995/03/fcbu115.pdf
https://www.ccfg.org.uk/
https://www.coillte.ie/a-beginners-guide-to-continuous-cover-forestry/
https://forestrycommission.blog.gov.uk/2024/07/11/the-wider-benefits-of-continuous-cover-forestry/