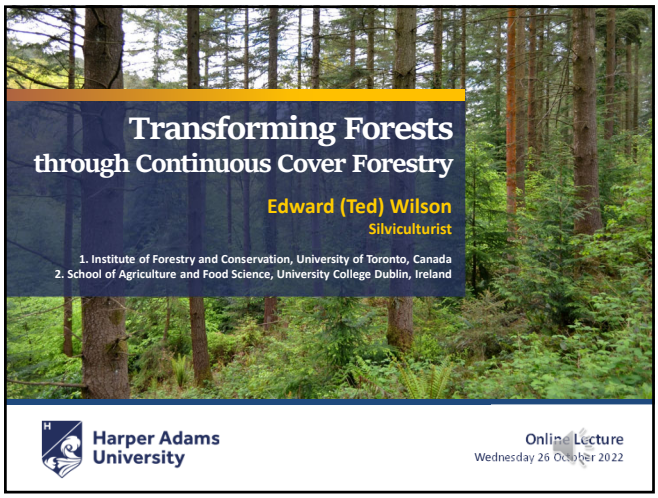


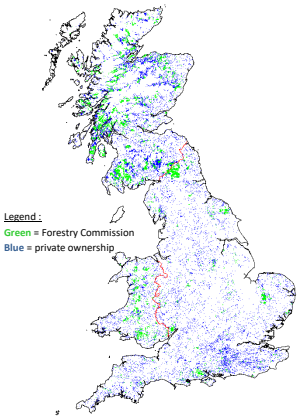
1

Outline of Presentation

- Overview of UK Forestry
- What is CCF?
- What are the benefits of CCF?
- Transformation of even-aged forests to CCF
- Managing transformation
- Integrating CCF in the landscape

"All our resolves and decisions are made in a mood or frame of mind which is certain to change."
Proust

2



Forest Cover in Britain

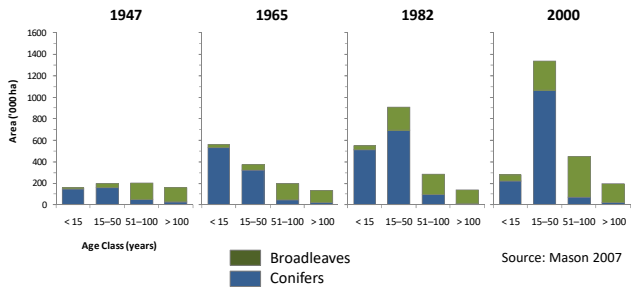
- Approx 3.1 M ha total woodland area.
- **13 % of GB land area**
  - 19% in Scotland
  - 11% in England
- One of the most highly deforested countries in Europe
- **EU average forest cover approx 35% of land area**

- **Present forest cover is result of a century of reforestation.**
- 1919: < 5% of land area was woodland
- Forestry Commission created to establish "strategic reserve" of timber.
- 2020: Current strategy is to increased woodland cover, for economic, social and environmental purposes
- Climate change is a key driver

3

Area of High Forest by Age Class Groups

1947-2000



Source: Mason 2007

- The area of woodland has increased dramatically from 1947-2000
- The amount and complexity of older woodland is increasing

4

5

Threats to British Forests

- **Climate change**
  - Summer dry periods likely, especially in South and East
  - Extreme rain and flooding events are more likely
  - Ecosystem change – especially ground plants
- **Pests and diseases**
  - Native and exotic
- **Low Resilience of Existing Forest Resources**
  - Low number of productive species
  - Monoculture stands are most common

6

Independent Panel on Forestry (2012)

- **Keywords:**
  - **Climate change** (**43** mentions)
  - **Adapt/Adaptation** (**14** mentions)
  - **Woodland Culture** (**19** mentions)
  - **Resilience/resilient** (**22** mentions)

*"Action taken now to increase the **resilience** of our woodland resource will help reduce the future costs of dealing with the effects of climate change."* (p. 8)

7

Policy Drivers for UK Forestry

Policy Drivers:

1. Increase ecological resilience
2. Promote multi-functional forest management
3. Maintain timber production and quality

Strategy:

- Increase species and structural diversity at stand and landscape scales

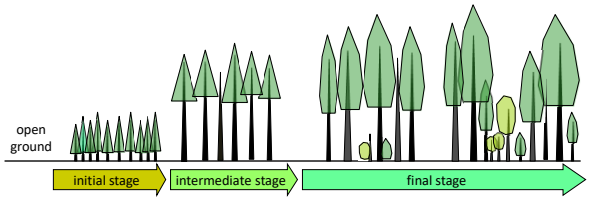
***f*(forest area ↑ + species ↑ + structure**

8

Silvicultural Strategies for Enhancing Forest Resilience

Succession stages in an single-species planted forest stand

(Oliver and Larson 1996)



Species choice
- genetics/provenance

New species introduced

Wider use of "minor" species

Mixed species

Assisted migration of native species

Modify thinning regimes

Natural regeneration

Under-planting

Extend "rotations"

CCF

Transformation

Adapted from diagram by Jens Haufe, UK Forestry Commission

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Continuous Cover Forestry: an alternative approach

Continuous Cover Forestry (CCF):

- *"...the use of silvicultural systems whereby the forest canopy is maintained at one or more levels without clear felling."* **Mason et al. 1999**
- *"... is a management option in which canopy cover is maintained continuously, the soil is never exposed, and clearfelling is avoided ..."* **Ní Dhubháin 2003**
- *"While CCF is not a silvicultural system per se it can be implemented using various silvicultural systems that do not involve clearfelling."* **Yorke 1998**

Guiding principles:

1. Managing the forest ecosystem
2. Using natural processes
3. Working within site limitations
4. Diversifying stand structure

Close-to-Nature forestry

- Can be applied to any forest type: mixed, broadleaf, conifer.
- Promoters: Pro Silva Europe (1989), CCFG (1991), Pro Silva Ireland (1990).

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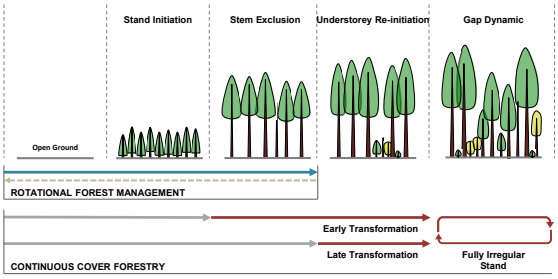
Forest development stages and forest management systems



Rotational forest management (RFM) generally works with stands in the stand initiation and stem exclusions phases of forest development.
Continuous cover forestry (CCF) leads through an early or late transformation to irregular stands that are analogous to the gap dynamic phase.

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Origins of Continuous Cover Forestry

Alfred Möller (1860-1922)
Professor of Forestry (mycologist)
State Forestry Academy, Eberswalde

- Permanent forest as guiding principle of "natural forestry"
- Concept of self-organising "forest organism"

Resting place of Prof Alfred Möller
Eberwalde University Forest

"The permanent forest concept", 1923 (posth.)
(= Continuous Cover Forestry)

Troup, R.S. 1927. *Dauerwald. Forestry* 1:78-81

Troup, R.S. 1928. *Silvicultural Systems.* Clarendon Press

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There is world-wide interest in CCF

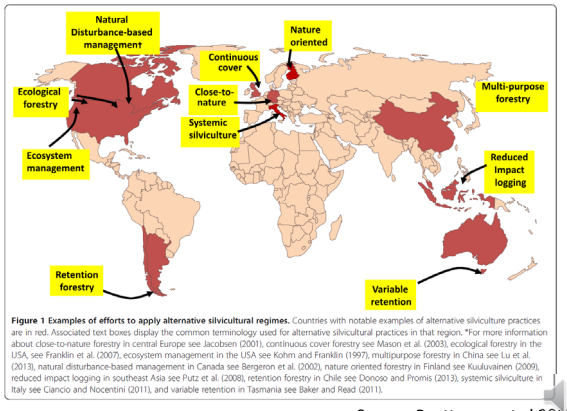


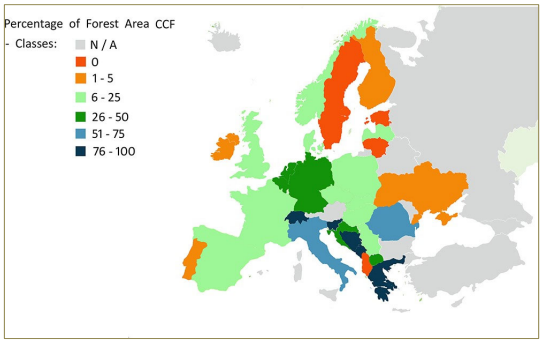
Figure 1 Examples of efforts to apply alternative silvicultural regimes. Countries with notable examples of alternative silviculture practices are in red. Associated text boxes display the common terminology used for alternative silvicultural practices in that region. *For more information about close-to-nature forestry in central Europe see Jacobsen (2001), continuous cover forestry see Mason et al. (2003), ecological forestry in the USA, see Franklin et al. (2007), ecosystem management in the USA see Kohm and Franklin (1997), multipurpose forestry in China see Lu et al. (2013), natural disturbance-based management in Canada see Bergeron et al. (2002), nature oriented forestry in Finland see Kuuluvainen (2009), reduced impact logging in southeast Asia see Putz et al. (2008), retention forestry in Chile see Donoso and Promis (2013), systemic silviculture in Italy see Ciancio and Nocentini (2011), and variable retention in Tasmania see Baker and Read (2011).

Source: Puettmann et al 2015

15

Percentage of forest area managed by CCF across Europe

Mason et al. 2022



Forestry (Lond), Volume 95, Issue 1, January 2022, Pages 1–12, https://doi.org/10.1093/forestry/cpab038

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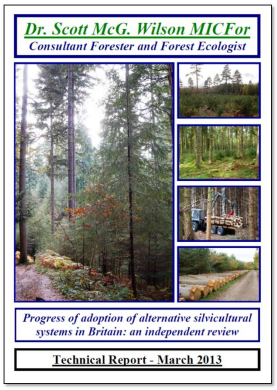
CCF - Coming in from the Fringe



- **Cyril Hart (1995)**
- Demonstrated tradition of alternative silvicultural systems
- Wide range of systems applied and developed using a broad range of species
- Strong influence from Europe
- **Update Review: Scott McG Wilson (2013)**
- **Ireland – Vitkova et al. 2014**

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The Read Report (2009)

Combating climate change

- Key findings "THE **ADAPTATION** OF UK FORESTS AND WOODLANDS TO CLIMATE CHANGE" (Chapter 9, p. 164) …

  "The majority of woods are likely to be treated as high forest in different forms. Whereas clearfell systems have predominated in the past, **in future continuous cover forestry approaches may become more advantageous,** *because:*
  - they are thought to be more windfirm
  - maintain a more even carbon storage
  - show lower soil carbon losses during harvesting
  - maintain higher humidity levels."

- "However, the evidence that they will deliver these benefits needs strengthening."
- "The silvicultural system per se is however, less important than the structures that it creates and their resilience and robustness in relation to climate change."

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Potential Environmental Benefits of CCF for Soils and Water Resources (Ireland et al. 2006)

- Reduced risk of reductions in soil fertility on site
- Maintain soil organic matter within forest stands
- Potential to reduce and minimise soil acidification
- Reduced and mitigated soil disturbance (although stand interventions and operations are likely to be more frequent than in Clear-fell system)
- Greater control over risks of soil erosion and compaction
- Reduced risk of soil contamination and pollution
- Enhanced resilience of multi-species and multi-aged stands in response to threats from pests and diseases, and windstorms

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Potential Benefits of CCF on Upland Forest Sites (Reynolds 2004)

- Move away from clear-fell likely to have benefits in terms of reduced nitrate leaching and reduced stream acidication
- Partial harvest encourages retention of nitrate capacity within the soil-plant system
- CCF encourages retention of base cations within soil-plant system, which should minimise long-term soil and stream water acidifciation associated with soil base cation depletion
- If CCF results in smaller proportion of mature Sitka spruce forest, this will reduce nitrate leaching on well-drained acid soils
- Mixed species woodland ecosystems with greater potential to retain nitrogen deposited from the atmosphere should be beneficial on acid sensitive sites

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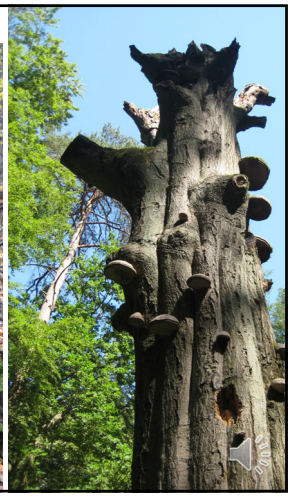
Standing and Down Wood in CCF



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Stand Transformation

Transformation:

Transformation is the phase in management where a planted stand of trees is modified from an even-aged to irregular structure. This is achieved through a series of planned interventions, and a shift from area-based management to individual tree management and decision-making.

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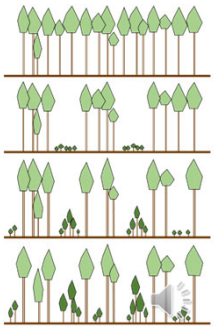
Stand Transformation Schütz 2001

A programme of stand interventions that facilitate the transition from an even-aged to an irregular structure stand.

1. **Differentiation**
   - The main aim is to promote each valuable element, which ensures structural development and stability
2. **Promoting Regeneration**
   - The focus is on favouring new decentralised regeneration groups
3. **Structural Development**
   - The focus is to achieve good horizontal and vertical distribution of structural elements
4. **Structure Achievement**
   - The focus is to achieve vertical individualisation of the remaining groups



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Silvicultural Objectives in Stand Transformation

1. **Sustain timber production**
2. **Promote timber quality**
3. **Transform structure**
   - Understand and **control stand basal area** (BA)
   - Biological/ecological processes for regeneration/growth
   - Vegetation and deer management
4. **Promote anchorage of trees/stand stability**
   - Height:Diameter ratios
   - <60 = poor quality, **60-80 = stable**, >80 = unstable
5. **Retain habitat and biodiversity attributes**

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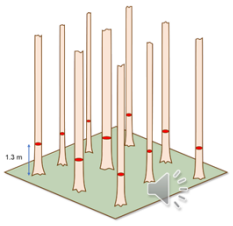
Basal Area

- An important parameter for quantifying a forest stand:
  - **Basal area of a tree** = cross-sectional area of a tree at breast height (1.3 m)
    - Easily calculated by determining the DBH of a tree.
  - **Stand basal area** = sum of the basal area of all (living) trees in a stand, expressed in m^2/ha
  - It may be seen as a summary of the number and the size of trees in a stand.
  - It is also correlated with competition or the density of a stand.
  - Useful as a guide for managing natural regeneration
  - Symbols are "**BA**" or "**G**"

Image: Wikipedia



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Management of Seedling Establishment and Growth

Light demand of conifer seedlings

Species	Overstorey BA for seedling establishment [m^2/ha]	Overstorey BA for seedling growth [m^2/ha]	Shade tolerance of seedlings
JL/EL	20-25	15-20	Intolerant
SP/LP/CP	25-30	20-25	
SS	30-35	25-30	Intermediate
DF	35-40	30-35	
NS WH	40-45	35-40	Tolerant

leader/lateral shoot ratio > 1

Note: Light demand for seedling establishment may be considerably lower than for seedling growth.

⇒ **management of light level is important**

(Source: Forestry Commission Operational Guidance OGB 7)

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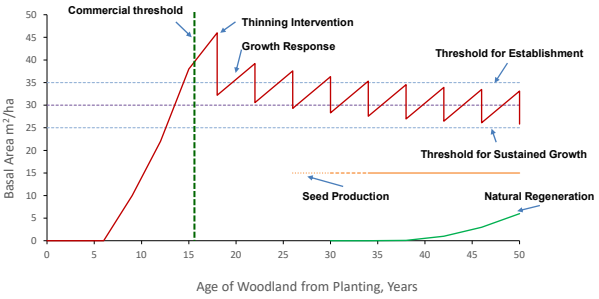
Conceptual Model for Stand Transformation

Basal Area dynamics with Sitka spruce



Stand transformation is basically a process of thinning with purpose
We maintain continuous production, but preserve the forest ecosystem

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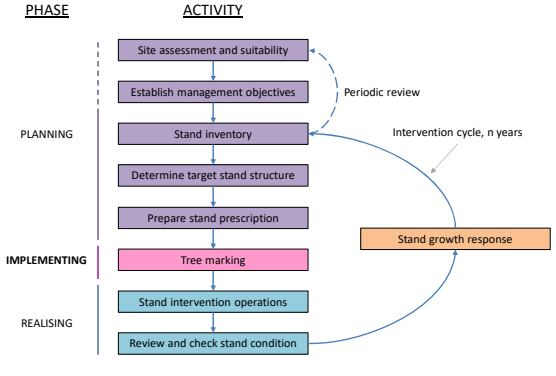
Key steps involved in implementing prescriptions in CCF stand, embedding an adaptive management approach



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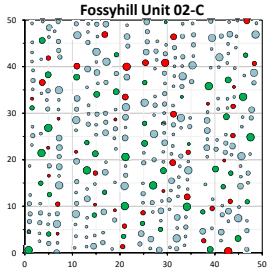
CROWN THINNING
CCF Transformation Pathway



Example plot from Fossyhill Forest

Target Basal Area reduction: 12.5% (20%)
Marking Pattern: **Crown**
Cutting cycle: **3-4 yrs**

Selection Reasons:

Q-Trees	Thinned
Stem straightness	Release
Light branching	Negative quality
Good vigour, stable	Spacing
No damage	Damage
Healthy foliage	Suppressed

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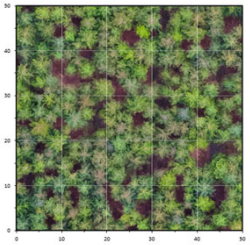
Ballycullen Forest

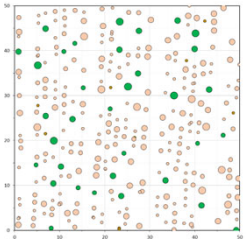
Plot 13-Crown Thinning

Selecting quality trees drives the structural irregularity of the stand

a. Aerial photo of plot

b. Tree size classes and marking plan

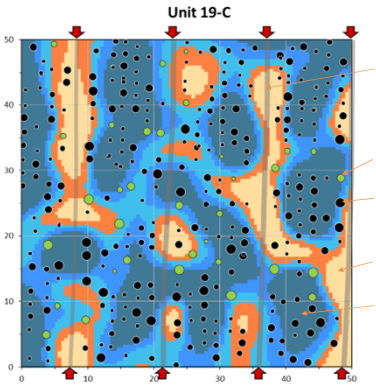




- Q tree (Q1/Q2 marked for retention as future crop tree)
- Matrix/Rack tree (retained after thinning)
- Standing dead (retained after thinning)

35

CCF - Integrating timber production with natural regeneration



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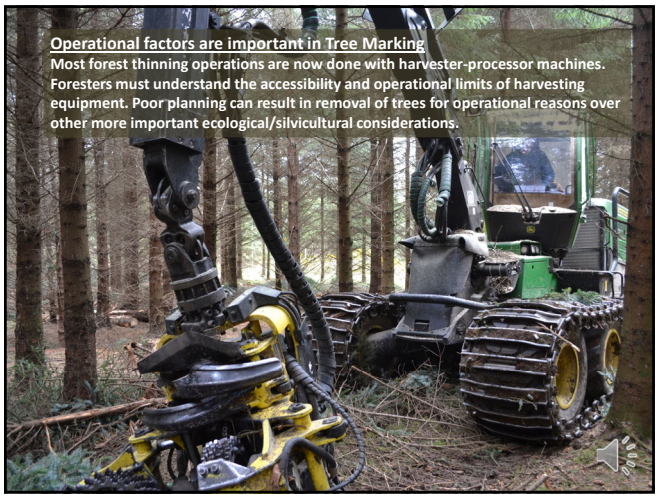
Operational factors are important in Tree Marking
Most forest thinning operations are now done with harvester-processor machines. Foresters must understand the accessibility and operational limits of harvesting equipment. Poor planning can result in removal of trees for operational reasons over other more important ecological/silvicultural considerations.

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CCF will likely generate a more diverse product mix at each stand intervention, but also earlier removal of small sawlogs (due to a focus on removing competitors to the best quality trees). As a result, financial returns may be higher than in low (conventional) thinning at early interventions.
Rossy Hill (

38


KESLA
Cloragh (2019)

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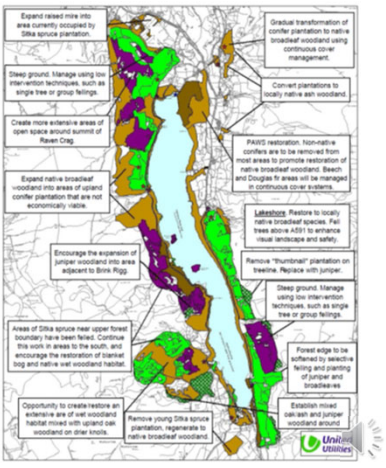
Thirlmere Forest
Management Plan
2008

Example of how CCF can be integrated within a forest management plan



Source: Wilson and Leslie 2009

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Conclusions

- Management of forest resources exists within a complex historical, economic, ecological and cultural context
- We are currently challenged to find new approaches that ensure the resilience and sustainability of our woodland resources
- Continuous Cover Forestry(CCF) is the use of silvicultural systems whereby the forest canopy is maintained at one or more levels without clear felling and an important approach for the delivery of diverse ecosystem services
- Stand transformation is best achieved through early interventions and modified thinning control, adopting crown thinning or similar, as opposed to the traditional low thinning approach
- There are now well-established management systems for CCF, but evidence for the wider benefits/practice of CCF needs strengthening in the UK

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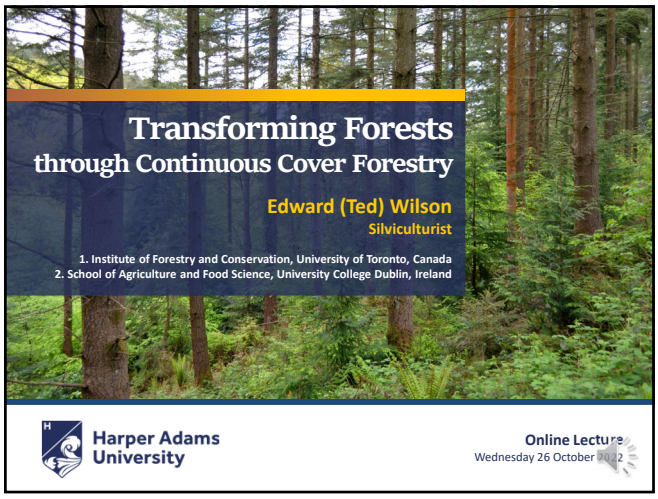

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