European Commission

NWRM

Natural Water Retention Measures

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Individual NWRM

Continuous cover forestry

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I. NWRM Description

Continuous cover forestry is a broad range of forest management practices which has some beneficial hydrological effects. The main idea behind continuous cover forestry is a reduction in the number or size of clear-cuts and the protection of forest soils. Some definitions of continuous cover forestry state that no clear-cuts shall be larger than 0.25 ha. Continuous cover forestry ensures that there is an uninterrupted tree canopy and that the soil surface in never exposed. An uninterrupted tree canopy will have higher interception than a site with discontinuous tree cover. Ensuring that soils are never exposed will limit sediment production and assure soil carbon sequestration.

II. Illustration

Example of a forest submitted to a continuous cover
Source: http://www.kyphilom.com/www/tmbr3.html

III. Geographic Applicability

Land Use	Applicability	Evidence
Artificial Surfaces	No	Only applicable to forests
Agricultural Areas	No	Only applicable to forests
Forests and Semi-Natural Areas	Yes	Only applicable to forests, not relevant for other semi-natural areas.
Wetlands	No	Only applicable to forests

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Region	Applicability	Evidence
Western Europe	Yes	As continuous cover forestry is an approach of sustainable forest management instead of a specific measure, it has widespread applicability. When adapted to local conditions, continuous cover forestry is possible anywhere in Europe where trees can grow.
Mediterranean	Yes	
Baltic Sea	Yes	
Eastern Europe and Danube	Yes	

IV. Scale

	0-0.1km^2	0.1-1.0km^2	1-10km^2	10-100km^2	100-1000km^2	>1000km^2
Upstream Drainage Area/Catchment Area	Yes	Yes	Possible	Possible	Possible	Possible
Evidence	The beneficial effects of continuous cover forestry will be most apparent at a local scale. By avoiding large clearcuts, disturbance to the natural forest hydrological cycle and soil carbon will be minimized. This will likely reduce the local increase in runoff that is often seen after clearcuts and should contribute to reductions in sediment pollution and potentially reduce the amount of other harmful substances such as methylmercury entering receiving waters. The effects of runoff mitigation will probably be hard to detect in catchments much larger than 10 km^2 but the beneficial effects related to reductions in sediment load and pollutant reduction may be apparent in larger downstream rivers.					

V. Biophysical Impacts

Biophysical Impacts		Rating	Evidence
Slowing & Storing Runoff	Store Runoff	Medium	Continuous cover forestry (CCF) has the potential to lead to moderate increases in runoff storage on a landscape scale. The hypothesized mechanism for this is that CCF leads to less reduction in evapotranspiration (ET) and canopy interception than clearcuts. Due to reductions in ET and interception, clearcuts are often associated with faster and greater amounts of runoff. While there is limited empirical evidence, avoiding clearcuts during forest harvesting may contribute to both storing and slowing runoff.
	Slow Runoff	Medium	
	Store River Water	None	
	Slow River Water	None	

Reducing Runoff	Increase Evapotranspiration	Low	Continuous cover forestry is unlikely to increase evapotranspiration (ET) rates above those observed in intact forests but will almost certainly support higher rates of ET than those observed in forest stands subject to clearcutting.
	Increase Infiltration and/or groundwater recharge	Low	Continuous cover forestry may increase infiltration and groundwater recharge rates, if compared to clearcut areas.
	Increase soil water retention	Low	Continuous cover forestry has some potential to increase soil water retention, if compared to clearcut areas, especially those with whole biomass harvesting.
Reducing Pollution	Reduce pollutant sources	Medium	The intact forest canopy associated with continuous cover forestry (CCF) may be more efficient at intercepting pollutants. While there is no empirical evidence, there are strong theoretical reasons to suggest that CCF may reduce leaching of mercury. In some cases, elevated leaching of mercury, a potent neurotoxin, has been observed following clearfelling. It is hypothesized that the leaching is related to higher water tables associated with a reduction in evapotranspiration (ET) following clearcutting. If CCF is able to maintain the same ET regime as an intact forest stand, risk of mercury leaching may be reduced. Reynolds (2004) has suggested that CCF may be a better alternative to conventional forestry in acid-sensitive UK uplands.
	Intercept pollution pathways	Medium	
Soil Conservation	Reduce erosion and/or sediment delivery	Medium	Some of the erosion and sediment delivery associated with forestry occurs due to locally wetter conditions as a result of decreased evapotranspiration following clearcutting. In some cases continuous cover forestry may mechanically reduce sediment transport due to less disturbed soil and vegetation. Sediment delivery associated with forest roads and stream crossings is likely to be similar with conventional and continuous cover forestry.
	Improve soils	Medium	Depending on the amount of driving necessary, continuous cover forestry (CCF) may have positive, neutral or negative effects on soil quality. If more driving is required than with conventional forestry, CCF could harm soil quality, primarily through soil compaction. If less driving is required, and if invasive practices such as soil scarification or stump harvesting are avoided, CCF may help to conserve soil quality and potentially contribute to an improved carbon balance (through lower rates of organic carbon leaching and mineralization) in the forest landscape.
Creating Habitat	Create aquatic habitat	None	
	Create riparian habitat	None	
	Create terrestrial habitat	Low	Some forms of continuous cover and uneven stand age forestry will create terrestrial habitat. However, the loss of

			clearcuts may be detrimental to species which rely on large open patches in the forest landscape.
Climate Alteration	Enhance precipitation	None	
	Reduce peak temperature	Medium	By maintaining a continuous forest cover, clearcuts have the potential to reduce peak soil temperatures. This may help to reduce rates of carbon mineralization and other temperature dependent processes.
	Absorb and/or retain CO_2	Medium	Conventional forestry is often associated with significant losses of soil carbon following clearcut. If continuous cover forestry (CCF) can be practiced in such a way that significant soil carbon losses do not occur, then it may have positive greenhouse gas benefits. The major mechanisms for soil carbon preservation under CCF include reduced physical disturbance of the soil, cooler soil temperatures resulting in lower rates of carbon mineralization due to an intact forest cover and drier soils facilitating less leaching of organic carbon.

VI. Ecosystem Services Benefits

Ecosystem Services		Rating	Evidence
Provisioning	Water Storage	Medium	If continuous cover forestry (CCF) can maintain the same hydrologic regime as an intact forest, there will be moderate ecosystem service benefits associated with water storage and retention.
	Fish stocks and recruiting	Low	Any reduction in sediment mobilization can be expected to have benefits for fish recruitment. However, it is not clear how much continuous cover forestry can contribute to this.
	Natural biomass production	Medium	Under some circumstances, continuous cover forestry may be able to provide more biomass than conventional forestry. However, this is a topic of active research and there is insignificant empirical evidence to date.
Regulatory and Maintenance	Biodiversity preservation	High	If continuous cover forestry has mixed age stands, biodiversity benefits should be realized. However, there may be some losses of biodiversity, especially colonizer species that are reliant on forest clearcuts.
	Climate change adaptation and mitigation	High	Continuous cover forestry may lead to more effective soil carbon sequestration than conventional forestry under some circumstances. Minimizing the disturbances in the stand structure and soil reduces the risk of carbon losses.
	Groundwater / aquifer recharge	Low	Continuous cover forestry may to some extent increase infiltration and groundwater recharge rates, if compared to clearcut areas.

	Flood risk reduction	Medium	Local flooding associated with clearcuts will be reduced under continuous cover forestry. Such floods are most apparent at local (< 1km^2) scales so the flood risk reduction benefits of continuous cover forestry may be difficult to detect at a landscape scale.
	Erosion / sediment control	Medium	Local sediment release associated with clearcuts will be reduced under continuous cover forestry. However, any sediment problems associated with forest roads and stream crossings are likely to be similar with conventional and continuous cover forestry.
	Filtration of pollutants	Medium	Maintenance of vegetation over the soil surface may aid with filtering of pollutants. One of the most common groundwater chemistry problems following conventional clearcuts is increased nitrogen leaching to groundwaters. Reynolds (2004) has suggested that continuous cover forestry may get around this problem as there will always be a growing forest which is actively taking up nitrogen from the soil and atmosphere.
Cultural	Recreational opportunities	Medium	Continuous cover forestry based on uneven age stands and mixtures of species should provide more recreational opportunities and have greater aesthetic and cultural value than single species monocultures. CCF may be closer to the way forestry was practiced in Europe before the industrial revolution as the scale of harvesting would be smaller than conventional clearcuts.
	Aesthetic / cultural value	Medium	
Abiotic	Navigation	None	
	Geological resources	None	
	Energy production	None	

VII. Policy Objectives

Policy Objective		Rating	Evidence
Water Framework Directive			
Achieve Good Surface Water Status	Improving status of biology quality elements	Low	There is limited evidence as to the benefits of continuous cover forestry (CCF) for water quality. The limited number of studies available suggest that mixed age broadleaf CCF might improve water quality when compared to conifer monocultures managed for conventional forestry. Reductions in groundwater nitrogen leaching and decreases in the soil acidification associated with some coniferous monocultures could potentially improve the biological and physico-chemical status elements of downstream water bodies.
	Improving status of physico-chemical quality elements	Low	
	Improving status of hydromorphology quality elements	None	

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	Improving chemical status and priority substances	Low	By maintaining the same hydrologic regime as an intact forest, continuous cover forestry could possibly contribute to reductions of leakage of mercury following forest operations.
Achieve Good GW Status	Improved quantitative status	None	
	Improved chemical status	Medium	If continuous cover forestry can be practiced in such a manner that the whole forest is actively taking up nitrogen (N), the excessive N leaching following conventional clearcuts could be avoided. If this N leaching could be avoided, there would be beneficial effects for groundwater chemical status as compared to conventional clearcut forestry.
Prevent Deterioration	Prevent surface water status deterioration	Medium	Continuous cover forestry (CCF) may contribute to preventing deterioration of surface water and groundwater status, especially if the hydrologic functioning of an intact forest can be preserved. CCF may also help to prevent status deterioration by limiting the nitrogen leakage to groundwater associated with reduced plant uptake commonly seen following conventional clearcuts.
	Prevent groundwater status deterioration	Medium	
Floods Directive			
Take adequate and co-ordinated measures to reduce flood risks		Low	The primary flood related benefit of continuous cover forestry (CCF) is not associated with the management practice itself but with the forest land cover. While CCF, compared to conventional clearcut forestry, does contribute to a lesser extent to production of local flooding, any effects are likely to be difficult to determine at larger (catchment) spatial scales.
Habitats and Birds Directives			
Protection of Important Habitats		Medium	Continuous cover forestry (CCF) based on an uneven age stand structure of local or indigenous species could potentially improve or protect important habitats for red list species and birds. The benefits of CCF for habitat protection will be greater than the possible benefits of even age conifer monocultures.
2020 Biodiversity Strategy			
Better protection for ecosystems and more use of Green Infrastructure		Medium	Continuous cover forestry (CCF) based on an uneven age stand structure of local or indigenous tree species will provide better ecosystem protection than could be achieved with conventional even age conifer monocultures. While both CCF and conventional forestry could be conceptualized as a form of green infrastructure, there are likely to be more multi-functional benefits associated with biodiversity, recreation and aesthetics with CCF than with forest management allowing major clear-cuts.
More sustainable agriculture and forestry		Medium	Depending on definitions, continuous cover forestry (CCF) may be more sustainable than conventional forestry. However, there is a lack of long-term studies of CCF against which to benchmark this claim.
Better management of fish stocks		None	

Prevention of biodiversity loss	High	Continuous cover forestry (CCF) based on uneven aged stands of local or indigenous tree species could be an important tool for preventing biodiversity loss in European forests.

VIII. Design Guidance

Design Parameters	Evidence
Dimensions	To achieve maximum benefits, continuous cover forestry should be practiced on a large spatial scale (e.g., hundreds of hectares and larger)
Space required	As with conventional forestry, continuous cover forestry (CCF) requires a large spatial area. One of the key unanswered questions with CCF is whether more space will be needed at the local scale to facilitate harvesting without the use of clearcuts.
Location	Any location where conventional forestry can be practised is potentially suitable for continuous cover forestry.
Site and slope stability	There are the same site and slope stability requirements for continuous cover forestry as for conventional forestry.
Soils and groundwater	There are the same soil and groundwater requirements for continuous cover forestry as for conventional forestry.
Pre-treatment requirements	/
Synergies with Other Measures	The most obvious synergy of continuous cover forestry is with other measures designed to promote biodiversity in the forest landscape. There may also be synergies with measures related to water sensitive driving and appropriate design of roads and stream crossings.

IX. Cost

Cost Category	Cost Range	Evidence
Land Acquisition	/	There are no additional costs of land acquisition for continuous cover forestry as compared to conventional forestry.
Investigations & Studies	/	The empirical evidence for the water quality and natural water retention properties of continuous cover forestry (CCF) is lacking. However, there are theoretical reasons for believing that the limited disturbance to the natural hydrological cycle associated with CCF may have a lower impact on the environment than conventional forest harvesting.

Capital Costs	/	It is not clear whether existing forest harvesting equipment is suitable for continuous cover forestry or if new machines must be developed. If new machines are required, there will be a capital cost to the forest owner or manager.
Maintenance Costs	/	The ongoing costs associated with continuous cover forestry should be similar to those incurred with conventional (clearcut) forestry.
Additional Costs	/	Research is ongoing to determine whether continuous cover forestry is more expensive to perform than conventional clearcut harvesting.

X. Governance and Implementation

Requirement	Evidence
n/a	

XI. Incentives supporting the financing of the NWRM

Type	Evidence
n/a	

XII. References

Reference	Comments
Neary, Daniel G., George G. Ice, and C. Rhett Jackson. "Linkages between forest soils and water quality and quantity." *Forest Ecology and Management*258.10 (2009): 2269-2281.	Good general review of forest water issues
Pommerening, A., and S. T. Murphy. "A review of the history, definitions and methods of continuous cover forestry with special attention to afforestation and restocking." *Forestry* 77.1 (2004): 27-44.	Reviews different conceptualizations of continuous cover forestry
Reynolds, B. (2004). Continuous cover forestry: possible implications for surface water acidification in the UK uplands. Hydrology and Earth System Sciences, 8(3), 306-313.	One of the few (modelling) studies to attempt to identify possible water quality effects of continuous cover forestry
Robert Jandl, Marcus Lindner, Lars Vesterdal, Bram Bauwens, Rainer Baritz, Frank Hagedorn, Dale W. Johnson, Kari Minkkinen, Kenneth A. Byrne. 2007. How strongly can forest management influence soil carbon sequestration? Geoderma 137: 253–268	Review of experimental evidence for long-term C sequestration in relation to different forest management strategies.