Image 1. '*Most of the world's mussel stocks are in decline and some species face extinction like the freshwater pearl mussel Margaritifera margaritifera*.' (Technical University of Munich, 2016)

Discussion document for the first meeting of an expert committee of the Technical Advisory Panel (TAP) of Woodlands of Ireland on 'developing criteria for mapping potential Protective Forest Zones in catchments.' March '21.

Contents

Summary

While forests can have *protective functions related to regulating water flow, protecting aquifers and preventing erosion, landslides and avalanches* (Eurostat 2010) they can also protect biological diversity within them and in adjacent habitats, plus carbon stocks, soil and infrastructure. Around 12% 0f European Forests are designated as 'Protective Forests' (MCPFE 2003) Most forests in Europe are semi-natural and a mix of many species, in contrast to the island of Ireland, where most forests are plantations of very few species.

Due to the Climate Change and Biodiversity Crises globally and the commitments that Ireland has entered into internationally and as an EU partner, including the UNCBD, the Paris Agreement, the Water Framework Directive, Flood Directive, Drinking Water Directive, Habitats and Birds Directives, it may be time to consider legally designating areas in catchments as protective forest zones, as a category for the land use planning process.

When considering mapping potential protective forest zones in Ireland, there are factors that may distinguish the island from mainland Europe. These factors include policies on Peatlands, Freshwater Pearl Mussel (FPM), Pressures on water from Agriculture and Forestry and the form and function of Tree Cover in general.

The primary functions of protective forests are described in relation to these factors and there is the beginning of a review on Irish and International literature on the specifications and use of remote sensing technology such as LiDAR in mapping protective forest zones.

Because of the critical nature of the FPM situation, and potential conflict regarding the location of protective forests, Dr. Evelyn Moorkens was consulted as a follow up to the COFORD/ EPA funded FORMMAR report of 2014.

However, the DAFM 'Woodland for Waters' 2018 specification for forest buffers *'combining new native woodland and an undisturbed water setback'* of 30m plus in width, reflects international standards from the literature and appears to be a good foundation to build on.

Reference is made to how this proposal compliments the work of achieving a Framework of Integrated Land and Landscape Management as proposed by An Fóram Uisce (2020) as well as the upcoming reports from the EU COST Action Programme 'Payments for Ecosystem Services (Forests for Water)' on March 17/18 2021.

The intention is to invite a range of stakeholders to discuss the criteria that they would like to see included in the specifications for a mapping of potential protective forest zones in catchments project.

1.Introduction: When considering the criteria for mapping potential protective forest zones on a catchment basis, there are many factors to take into account regarding existing land use, the likelihood of change in that land use and the form and function of existing forestry combined with other configurations of tree cover in both rural and urban habitats.

The global overarching factors are the Climate Change crisis and the Biodiversity crisis and the mechanisms that we use to respond to them.

In the UN FAO Forestry Paper 155: *Forests and Water: A thematic study prepared in the framework of the Global Forest Resources Assessment 2005* (Hamilton 2008):

'It is recommended that each country undertake an assessment of its key riparian zones and classify them for conservation management, protection or restoration. Adequate legislation on riparian buffer zone maintenance should be established in each country; models are available from FAO. It is also recommended that countries report their national regulations or guidelines for maintenance in future FRAs (Global Forest Resources Assessment) p.67

To ensure optimum water quality, drinking-water supply catchments should have legal status as protected areas or be designated as protective forest.' p.68

2. Key Factors include: 'The Water Framework Directive (WFD) requires all European surface water – lakes, rivers, transitional and coastal water, and groundwater – to reach "good status" by 2015'. 'The maximum deadline possible is 2027.' The WFD requires the identification of Drinking Water Protected Areas (DWPAs). These are lakes, reservoirs, rivers and groundwater bodies from which water is abstracted for people to drink. *'Member States shall implement the necessary measures to prevent deterioration of the status of all bodies of surface water, thus maintaining a range of high status water bodies is also required'.*

'The Floods Directive requires Member States to identify and map areas at risk of flooding, and to make plans to manage and reduce those flood risks.'

With the OPW the concept and the term 'Protection/Protective Forest' would be categorised as 'Natural Water Retention Measures' i.e. *measures that aim to protect water resources and address water-related challenges by restoring or maintaining ecosystems as well as natural features and characteristics of water bodies using natural means and processes*. (Conor Galvin pers.com 2020)

Both the OPW and the EPA have committed to the exploration of NWRM for flood risk management and water quality functions in their Flood Risk Management Plans (FRMP) and River Basin Management Plans respectively. The OPW FRMPs, which are available to view at www.floodinfo.ie, have a specific NWRM measure, as follows:

The OPW will work with the Environment Protection Agency, Local Authorities and other agencies during the project-level assessments of physical works and more broadly at a catchment-level to identify any measures, such as natural water retention measures (such as restoration of wetlands and woodlands), that can have benefits for WFD, flood risk management and biodiversity objectives. (Conor Galvin pers.com 2020) See also https://nwrmireland.wordpress.com/slowaters/

Recent EU Court rulings (as referred to in answer to Dáil Debate Question 475 by DAFM Minister Creed on 19/11/2019) reinforce the realisation that forestry plans or proposals cannot have any negative impact on sites or species protected under the Habitats or Birds Directives.

In the 'Significant Water Management Issues in Ireland' Public Consultation Document of August 2020, the impact of the past approach to forestry is described as follows:

'Inappropriately-sited forests and poorly-managed forest operations can negatively impact on water quality and aquatic habitats and species. The most common water quality problems arising from forestry relate to the release of sediment and nutrients to the aquatic environment and impacts from acidification. Forestry may also give rise to modified stream flow regimes caused by associated land drainage.'

'Poorly managed operations in legacy forests' contribute to siltation, which is particularly of concern in the Freshwater Pearl Mussel catchments. The legacy forests are generally composed of the species Sitka spruce and Lodgepole pine. Maintaining the financial incentives (Native Woodland Conservation Scheme and occasionally EU LIFE currently) towards the modification and or removal of these forest stands should be considered a priority. Some of the techniques involved which are geared towards minimising silt release are described in the 'Restoring native riparian woodland on conifer plantation sites' section of the Woodlands of Ireland Information note: 'Native Riparian Woodlands – A Guide to Identification, Design, Establishment and Management' which can be accessed at: https://www.woodlandsofireland.com/sites/default/files/No.%204%20%20Riparian%20Woodlands.pdf

Riparian Zone management as recommended by Inland Fisheries Ireland (IFI) in the context of a Framework for Integrated Land and Landscape Management (An Forám Uisce 2020), should protect and restore natural processes in waters. A good example of IFIs' perspective for urban riparian zones can be accessed at: https://www.fisheriesireland.ie/extranet/fisheries-management-1/1756-ifi-urban-watercourses-planning-guide-2020-update/file.html

Compared to Corine Land cover categories (image 2 below), how would sections of catchments be categorised? For example:

- Peatlands, Moors and Heath including plantation forest and semi-natural tree cover
- Agricultural grazing/ grass land
- Agricultural arable/ploughland
- Urban and Industrial

3. Peatlands, tree cover and achieving favourable habitat for the Freshwater Pearl Mussel.

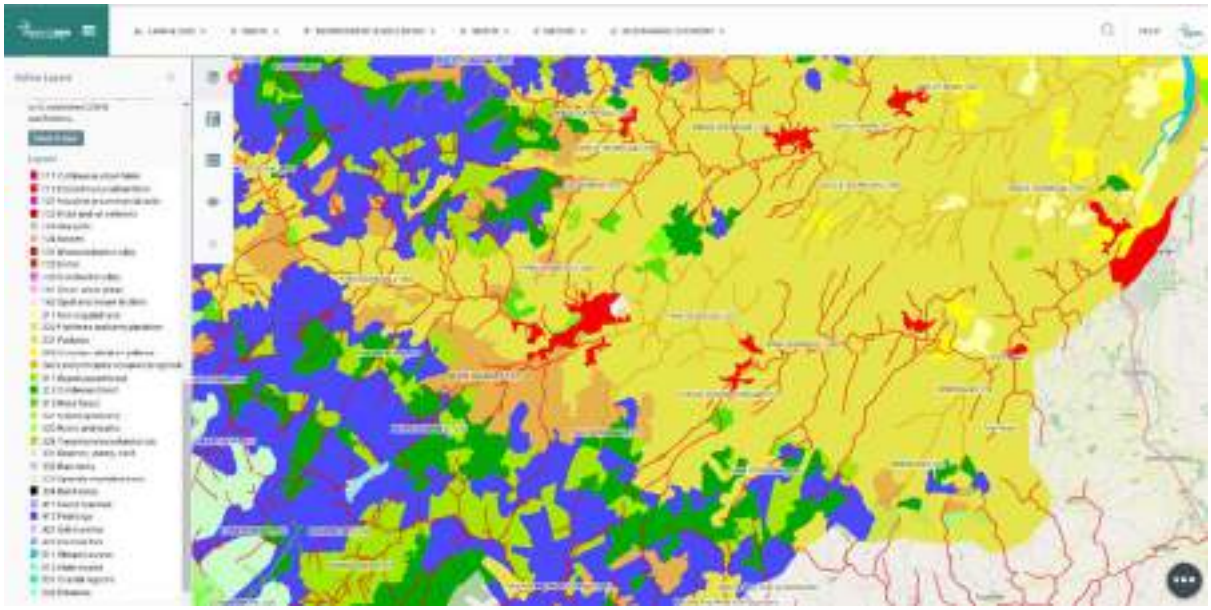


Image 2: A section of the Arney catchment in Donegal/ Tyrone. Source EPA 2020

The section of the Arney catchment in image 2 illustrates the concentration of conifer woodland located as a Corine land use type adjacent to/ or in Peat bogs and Moors and Heaths. Rivers marked in red are those under most pressure from surrounding land use.

In his Opening Statement to the public session of the Joint Committee on Agriculture and the Marine (02/03/2021) on the subject of 'Rewetting of peatlands and the impact on drainage for surrounding farmland', Dr David Wilson outlined the current land use on peatlands shown in the extract below.

The vast majority of peatlands in Ireland (~85%) have been drained either for turf cutting, energy production, horticulture, agriculture, and forestry (Figure 1). In each case, the fundamental goal of drainage is to lower the water level within the soil to facilitate the movement of machinery across the peat (e.g., for peat extraction or farming activities), for the grazing of livestock, and the growth of plant species, such as agricultural grasses, and trees, which do not thrive under water saturated conditions.

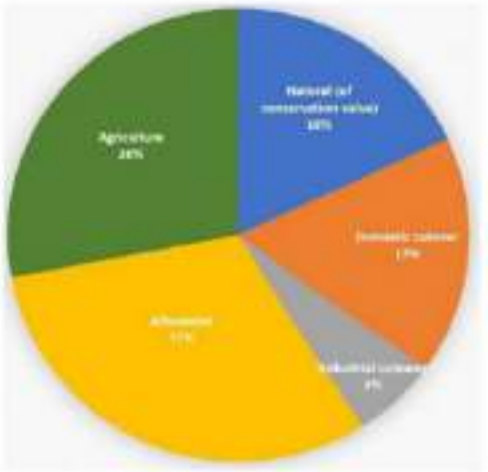


Figure 1: Estimated peatland area cover (%) in Ireland under major land use classifications.

Image 3. Extracted from Dr. David Wilson opening statement to the Joint Committee on Agriculture and the Marine 2021[1].

Dr. Wilson also reiterates that: '*Rewetting of peat soils has been suggested as an important climate change mitigation tool to reduce GHG emissions, to create suitable conditions for carbon sequestration, to stimulate biodiversity and to improve water quality.'*

This rewetting of peat soils is vital for the survival of the Freshwater Pearl Mussel species in Ireland and consequently should have a significant influence on where, when and how protective forest zones are situated.

The following includes text contributions from Dr. Evelyn Moorkens as part of recent dialogue and correspondence with Woodlands of Ireland:

When Moorkens, Purser, Wilson and Allot (2014) produced the Forestry Management for the Freshwater Pearl Mussel (FPM) Margaritifera Final Report (FORMMAR)in 2013 for COFORD and the EPA, it contained in the Executive Summary:

'The strong recommendation, based on the current literature of FPM requirements and potential flow, sediment and nutrient release risk, is that future forest management in the "top 8" FPM populations should be primarily for protection of water quality and conservation objectives in those catchments. The management of grazing pressure to a level that will allow the generation of more diverse protective forests in these catchments is considered to be essential.'

Since the production of this 2014 report, a number of changes have occurred. The first is that research into the flow requirements of the freshwater pearl mussel has demonstrated that the reduction of flow velocities is the primary cause of decline in most large Irish populations. Subsequently site-specific Conservation Objectives for a range of FPM populations have now included the restoration of hydrology to levels that can support the survival of FPM, and most particularly their juvenile cohorts.

The restoration of open peat habitats with a restored water table is therefore the most important target for the very large "Top 8" FPM populations with peat-dominated soils, which restricts the recommendations from the FORMMAR report to 7.2.3 "Restore natural hydrology":

"This would be a policy level decision whereby, following felling of an existing forest crop, the Minister with responsibility for forestry would waive any replanting obligation. Artificial (man made) drains on the previously forested area would be blocked in an attempt to restore the natural vegetation and hydrology (see 7.2.7), thereby restoring the sponge effect of the site and its buffering effect on flow with knock-on benefits in terms of reduced sedimentation, enrichment and eutrophication."
Although it was anticipated that some tree planting could form part of this solution, at present it is unlikely that further tree planting would pass Appropriate Assessment as part of a peat rehabilitation process.

Also in the FORMMAR report, 7.2.7 the Drain Blocking measure that was originally considered for the creation of wet areas should now be assessed with regard to the raising of the water table as part of catchment rewetting. (E. Moorkens pers.com 2021)

[1] https://data.oireachtas.ie/ie/oireachtas/committee/dail/33/joint_committee_on_agriculture_and_the_marine/submissions/2021/2021-03-02_opening-statement-dr-david-wilson-earthy-matters-environmental-consultants_en.pdf

See also https://www.pearlmusselproject.ie/

http://kerrylife.ie/destination/freshwater-pearl-mussel-project/

4. Pressures on water: Within the Framework for Integrated Land and Landscape Management (2020) recently proposed by **An Fóram Uisce**, there needs to be identification of and implementation of a Protective/Protection Forest Zone strategy in each catchment: *'further legislation is likely to be needed to (1) enable safeguard zones to be legally designated, where appropriate, (2) provide for strengthened protection measures within these zones and (3) assign legal responsibilities in protecting drinking waters through safeguard zones.'* This zoning is common practise and tradition in many other European states and North America. (Motta et al 2000) (Ring et al 2018)

In an island of Ireland context, the function of a protective forest can be:

- Protection of drinking water sources.
- Protection of Natura 2000 habitats and species.
- Protection of Fisheries.
- Reducing the risk of flooding and landslide.
- A buffer around designated woodland sites and other habitat to protect biological diversity.
- Community protective woodland in urban areas to moderate temperature, provide shade, absorb pollutants and contribute to public wellbeing.

'The most important features of a protective forest are its stability properties, that is, its ability to carry out its protective function reliably and continuously and, if this is achieved, its ability to maintain its structure and vitality in the face of internal and external influences'. (Motta et al 2000)

Protective Forest Zones require active management using Continuous Cover Forestry (CCF) silvicultural systems.

Agriculture and Forestry combined form 69% of the pressures on water (EPA various). Protective Forest Zones establishment would also mean modification of existing forests until they provide protective functions as their primary function.

This concept of Protective Forest links in with the objectives of the National Technical Implementation Group[2] (NTIG) of the River Basin Management Plan[3] (RBMP) 2018-2021 (p.104). Much of this is outlined in 'Woodland for Water: Creating new native woodlands to protect and enhance Ireland's waters' (DAFM 2018) and the 'Forests & Water' (DAFM, 2018)' *to provide the basis for identifying key locations where new native woodland will contribute most to protecting and enhancing water, and for engaging with farmers and other landowners to undertake such planting.'*

[2] *National Technical Implementation Group (NTIG) This group oversees the technical implementation of the RBMP at a national level and provides a forum to ensure co-ordinated actions amongst all relevant State actors and to address operational barriers to implementation that may arise. The group is chaired by the EPA, and membership includes Local Authorities, OPW, Inland Fisheries Ireland, Teagasc, DAFM, Irish Water, DHPLG, Coillte, NPWS and other implementing bodies, as appropriate. It reviews progress on an ongoing basis and provides updates to the National Co-ordination & Management Committee (NCMC) on the implementation and effectiveness of measures. The NTIG is also a forum for information exchange and to promote the consistency of regional implementation. The EPA, who is statutorily responsible for reporting on the WFD, will coordinate ongoing tracking of the implementation of actions and will, in conjunction with others, undertake assessment of their effectiveness via the monitoring programme.*

[3] The next River Basin Management Plan for 2022-2027 is currently being developed; a public consultation on the Significant Water Management issues in Ireland can be viewed at https://www.catchments.ie/public-consultation-significant-water-management-issues-for-irelands-2022-2027-river-basin-management-plan/

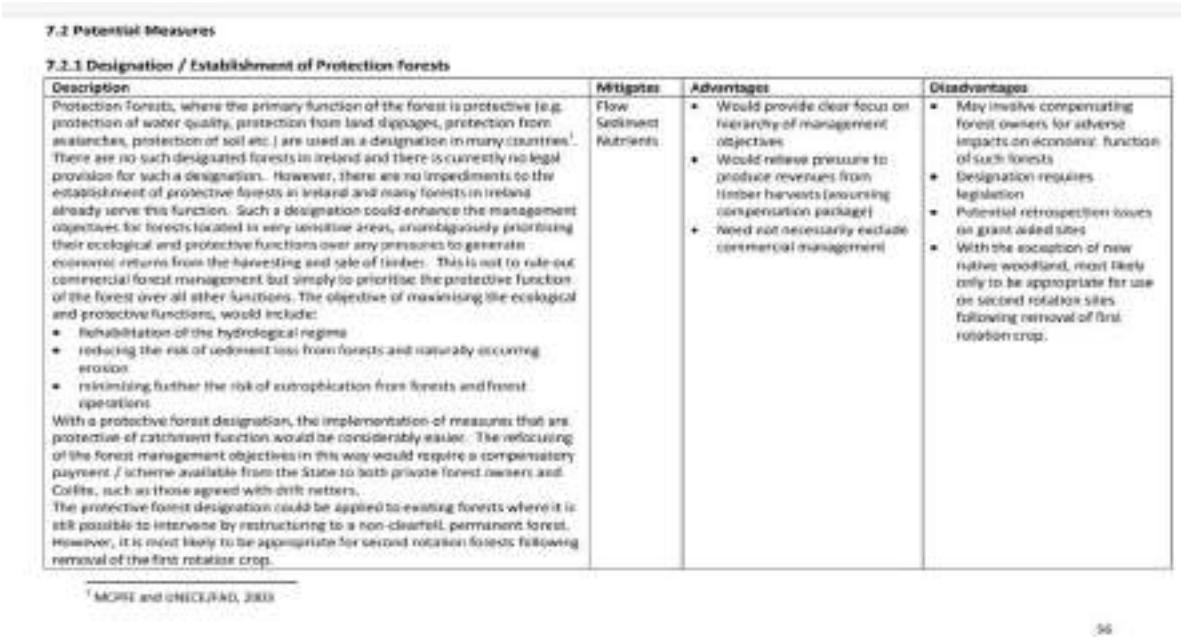
The 'Forests and Water' document contains summary details of research, current guidelines and the benefit of various schemes incl. Native Woodland and Agroforestry schemes. See also:

https://www.catchments.ie/irelands-woodlands-and-forests-a-renewed-focus-under-the-second-cycle-of-the-river-basin-management-plan/

5. Primary functions of protective forests

Table 7.2.1 below at image 3 from the FORMMAR report 2013 provides a useful synopsis of what the primary function of protective forests can be and suggests how the process of developing them could be commenced.

The key focus in this case was on improving water quality for aquatic organisms and in particular the critically endangered FPM. Since the FORMMAR report the rehabilitation of catchment hydrology has become urgent, and conservation objectives have been set for this emphasis (see above).



7.2 Potential Measures

7.2.1 Designation / Establishment of Protection Forests

Description	Mitigates	Advantages	Disadvantages
Protection Forests, where the primary function of the forest is protective (e.g. protection of water quality, protection from land slippages, protection from avalanches, protection of soil etc.) are used as a designation in many countries[1]. There are no such designated forests in Ireland and there is currently no legal provision for such a designation. However, there are no impediments to the establishment of protective forests in Ireland and many forests in Ireland already serve this function. Such a designation could enhance the management objectives for forests located in very sensitive areas, unambiguously prioritising their ecological and protective functions over any pressures to generate economic returns from the harvesting and sale of timber. This is not to rule out commercial forest management but simply to prioritise the protective function of the forest over all other functions. The objective of maximising the ecological and protective functions, would include: • Rehabilitation of the hydrological regime • reducing the risk of sediment loss from forests and naturally occurring erosion • minimizing further the risk of eutrophication from forests and forest operations With a protective forest designation, the implementation of measures that are protective of catchment function would be considerably easier. The refocusing of the forest management objectives in this way would require a compensatory payment / scheme available from the State to both private forest owners and Coillte, such as those agreed with drift netters. The protective forest designation could be applied to existing forests where it is still possible to intervene by restructuring to a non-clearfell, permanent forest. However, it is most likely to be appropriate for second rotation forests following removal of the first rotation crop.	Flow Sediment Nutrients	• Would provide clear focus on hierarchy of management objectives • Would relieve pressure to produce revenues from timber harvests (ensuring compensation package) • Need not necessarily exclude commercial management	• May involve compensating forest owners for adverse impacts on economic function of such forests • Designation requires legislation • Potential retrospection issues on grant aided sites • With the exception of new native woodland, most likely only to be appropriate for use on second rotation sites following removal of first rotation crop.

[1] MCPFE and UNECE/FAO, 2003

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The example of freshwater pearl mussel is a useful one in demonstrating the role of protective forests in the decision-making process. There are over 130 populations of FPM in Ireland, none of which have been protected from the threat of extinction, and some of which are close to extinction, or already extinct. Of these, 27 populations are protected as SACs, and of these, 8 have been prioritized for recovery to full natural function. While we cannot go back in time to wilderness conditions in all our catchments, and a balance must be made between ongoing development and nature conservation, the full rehabilitation of 8 catchments – the 6% of Irish populations that hold 80% of Irish mussels- will concentrate on prioritizing benefit for this world endangered species, while simultaneously rehabilitating peat catchments and providing long term carbon sequestration through restored peat growth when the water tables have been raised.

In the other 122 FPM catchments, the removal of forestry and the rehabilitation of blanket bog is unlikely to create large sustainable FPM populations. Most are small remnant populations and many have lost physical river habitat, and thus hydrological recovery alone will not repair these populations. However, there are conservation Objectives in the 19 remaining SAC populations outside the Top 8.

In these, a greater understanding on the hydrological drivers of near bed velocity is needed. For example, in the smaller populations dominated by mineral soils, small numbers of mussels are

supported by bends in the river, series of gradient changes and sometimes islands in rivers that promote preferential flow down one limb during low flows. Where these habitats have secure, consistently beneficial near bed velocity during low flow conditions because of river morphology, they are not reliant on catchment level wetness. In these situations protective forests are unlikely to negatively affect mussels. If compared with other land use such as arable crops, they are likely to be beneficial.

The identification of peatlands is improving with new iterations of the SAFER project (Connolly 2009, 2021). See also Connolly & Holden 2011 (a, b) (E.Moorkens pers.com 2021)

6. Mapping Protective Forest Zones

Since the time of writing of FORMMAR there have been technological advances in remote sensing particularly LiDAR used to map underlying ground forms: '*Spatial and temporal changes in land cover have direct impacts on the hydrological cycle and stream quality. Techniques for accurately and efficiently mapping these changes are evolving quickly, and it is important to evaluate how useful these techniques are to address the environmental impact of land cover on riparian buffer areas.'* (Zurqani et al 2020).

In addition, there is now a technique of 'Wet Mapping' indicating the location of water at seasonal high and low flow periods as illustrated below in Image 4.

The Wasser et al Study 2015 study in North America '*demonstrates that airborne LiDAR data can be used to accurately map riparian buffer vegetation width, height and canopy cover..'* over extensive land masses.

In the Western River Basin District Literature review (Hutton et al 2008) Section 3.3.1 on Risk Assessment regarding Riparian Buffer Zones (p.38-48) the following extracts are relevant to the criteria to be applied to mapping:

'It is therefore imperative to be able to identify sites that are potentially at risk from suspended solids. The risk assessment methodology utilised in Ireland to identify these sites is based on areas of high erosion potential identified using peat soil and sandstone derived soil layers' from the Teagasc National Soil Maps, a generated critical slope map (critical slope is >= 15% slope) and 60m buffer (either side) of river water bodies, and extracting critical young forestry types from the Forestry Inventory and Planning System (FIPS) database in conjunction with EPA records of river SS scores and river Q data (European Union, 2004). The impact potential contains factors that lead to the creation of a potential for erosion, namely vulnerable soils, steep slopes, proximity to watercourses and presence of coniferous forest.'

4.0 Mitigating Measures: There are four main mechanisms by which the amount of nutrients and sediment reaching the aquatic zone can be reduced: 1) minimisation of soil disturbance; 2) settlement via sediment traps; 3) filtration via buffer/riparian zones; and 4) brash mats.

4.3 Buffer/riparian zones: a balance needs to be reached between the benefits and costs of increased riparian buffer widths, based on the considerations of the main functions of the riparian buffer in relation to the sensitivity of a given site (Broadmeadow & Nisbet, 2004).

Cartographic depth-to-water maps (DTW-maps) are a useful tool for locating wet areas and streams (Fig. 4). These maps are generated from digital elevation models based on high-resolution elevation scans using LiDAR technology, and they model the depth to a hypothetical groundwater surface (Murphy *et al.* 2008, Ågren *et al.* 2015). Thus, the closer the groundwater level is to the ground surface, the wetter the soil.

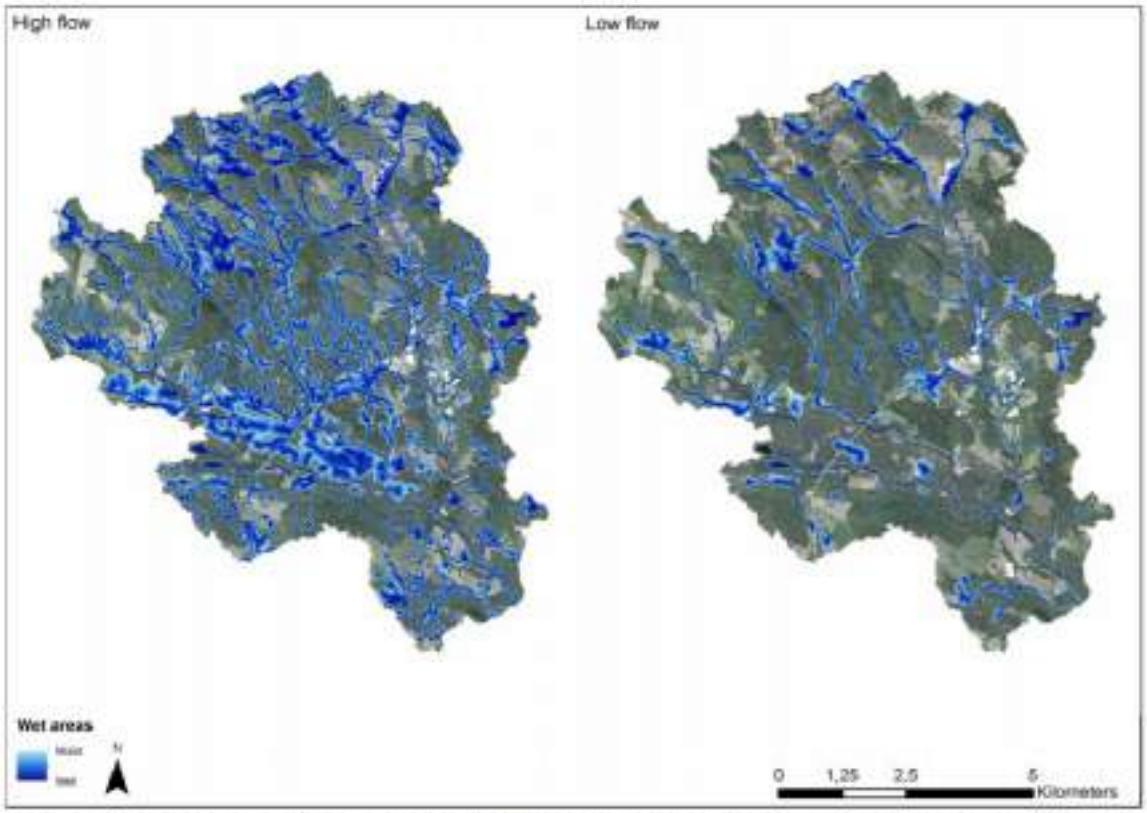

Fig. 4. Depth-to-water maps of the stream network in the Krycklan Catchment, northern Sweden, during high flow (left) and low flow (right). Modified from (Ågren *et al.* 2015). Illustration by William Lidberg.

Image 4. Wet mapping overview (Ring et al 2018)

5.1 Pressure: The question raised therefore is, are the recommended buffer widths and riparian vegetation effective at mitigating impacts of eutrophication and sedimentation in Irish forests?'

In addition, regarding Drinking Water protection, the practical reality of what constitutes a Source Protection area and a Zone of Contribution[4] as defined by the National Federation of Group Water Schemes (NFGWS 2020) needs to be fully incorporated into the mapping criteria [5].

This combination of new knowledge may have implications on

- where and how clear felling should be permitted
- where continuous cover forestry/ low impact silvicultural systems should be applied
- where forest removal is appropriate such as on blanket bogs[6]
- where native tree cover from planting or natural regeneration may be appropriate.

7. Some additional extracts from literature on factors to consider when designing buffer zones:

Lundholm et al (2020) in a recent Society of Irish Foresters Journal article reiterated that '*Buffer zones have been shown to reduce nutrient loading into watercourses (Kelly-Quinn et al. 2016), and the reduction potential is generally more affected by the topography than the vegetation in buffer zones (Ranalli and Macalady 2010)*.'

While in China studies concluded that *'Structurally diverse riparian buffers, i.e., those that contain a mix of trees, shrubs, and grass, are much more effective at capturing a wide range of nutrients than a riparian buffer that is solely of trees or grass'* (Cao et al, 2018).

The US Army Engineer Research and Development Center publication on 'Design Recommendations for Riparian Corridors and Vegetated Buffer Strips' is recommended reading: *..the benefits of variable buffer strip designs (e.g., width, length, type of vegetation, placement within the watershed) are effectively unrecognized. There have been few systematic attempts to establish criteria that mesh water quality width requirements with conservation and wildlife values; specifically, the ability of these buffer strips to function as habitat or as corridors for wildlife dispersal between habitats in highly fragmented landscapes. Even less information is available relating riparian vegetation characteristics to hydraulic, sediment transport, and bank stability conditions of streams.* (Fischer & Fischenich, 2000) Image 5 below is a table from the same publication.

'In general, the ability of buffer strips to meet specific objectives is a function of their position within the watershed, the composition and density of vegetation species present, buffer width and length, and slope. Some benefits can be obtained for buffers as narrow as a few feet while others require thousands of feet.' (Fischer & Fischenich, 2000)

[4] Source Protection Area: The catchment area around a groundwater source which contributes water to that source (Zone of Contribution (ZOC)), divided into two areas: the Inner Protection Area (SI) and the Outer Protection Area (SO). The SI is designed to protect the source against the effects of human activities that may have an immediate effect on the source, particularly in relation to microbiological pollution. It is defined by the 100-day time of travel (TOT) from any point below the water table to the source. The SO covers the remainder of the zone of contribution of the groundwater source. Zone of Contribution (ZOC): The land area over which some of the rainfall percolates downwards to the groundwater table that eventually ends up at the well or spring.

[5] From NFGWS, 2020. *A Handbook for Source Protection and Mitigation Actions for Farming.* Published by the National Federation of Group Water Schemes. Available for download at www.nfgws.ie

[6] https://www.coillte.ie/coillte-nature/ourprojects/wildwesternpeatlands/ accessed 19/02/2021

Table 4. General Riparian Buffer Strip Width Guidelines

Function	Description	Recommended Width[1]
Water Quality Protection	Buffers, especially dense grassy or herbaceous buffers on gradual slopes, intercept overland runoff, trap sediments, remove pollutants, and promote ground water recharge. For low to moderate slopes, most filtering occurs within the first 10 m, but greater widths are necessary for steeper slopes, buffers comprised of mainly shrubs and trees, where soils have low permeability, or where NPSP loads are particularly high.	5 to 30 m
Riparian Habitat	Buffers, particularly diverse stands of shrubs and trees, provide food and shelter for a wide variety of riparian and aquatic wildlife.	30 to 500 m +
Stream Stabilization	Riparian vegetation moderates soil moisture conditions in stream banks, and roots provide tensile strength to the soil matrix, enhancing bank stability. Good erosion control may only require that the width of the bank be protected, unless there is active bank erosion, which will require a wider buffer. Excessive bank erosion may require additional bioengineering techniques (see Allen and Leach 1997).	10 to 20 m
Flood Attenuation	Riparian buffers promote floodplain storage due to backwater effects, they intercept overland flow and increase travel time, resulting in reduced flood peaks.	20 to 150 m
Detrital Input	Leaves, twigs and branches that fall from riparian forest canopies into the stream are an important source of nutrients and habitat.	3 to 10 m

[1]Synopsis of values reported in the literature, a few wildlife species require much wider riparian corridors.

Image 5 from 'Design recommendations for riparian corridors and vegetated buffer strips' (Fischer & Fischenich, 2000)

Dr. Moorkens recent perspective on protective forests is contained in the following remarks:

'The benefits of continuous cover tree growth on soil stability, flood prevention and nutrient amelioration is evident. There is no doubting the benefits of protective forests in the context of lowland mineral soils and intensively managed catchments, and protected catchments for which forest cover is the main qualifying interest.

There remains a potential conflict in catchments that suffer from lowered hydrology, and where high water tables are required for high ecological status.' (E. Moorkens pers.com 2021)

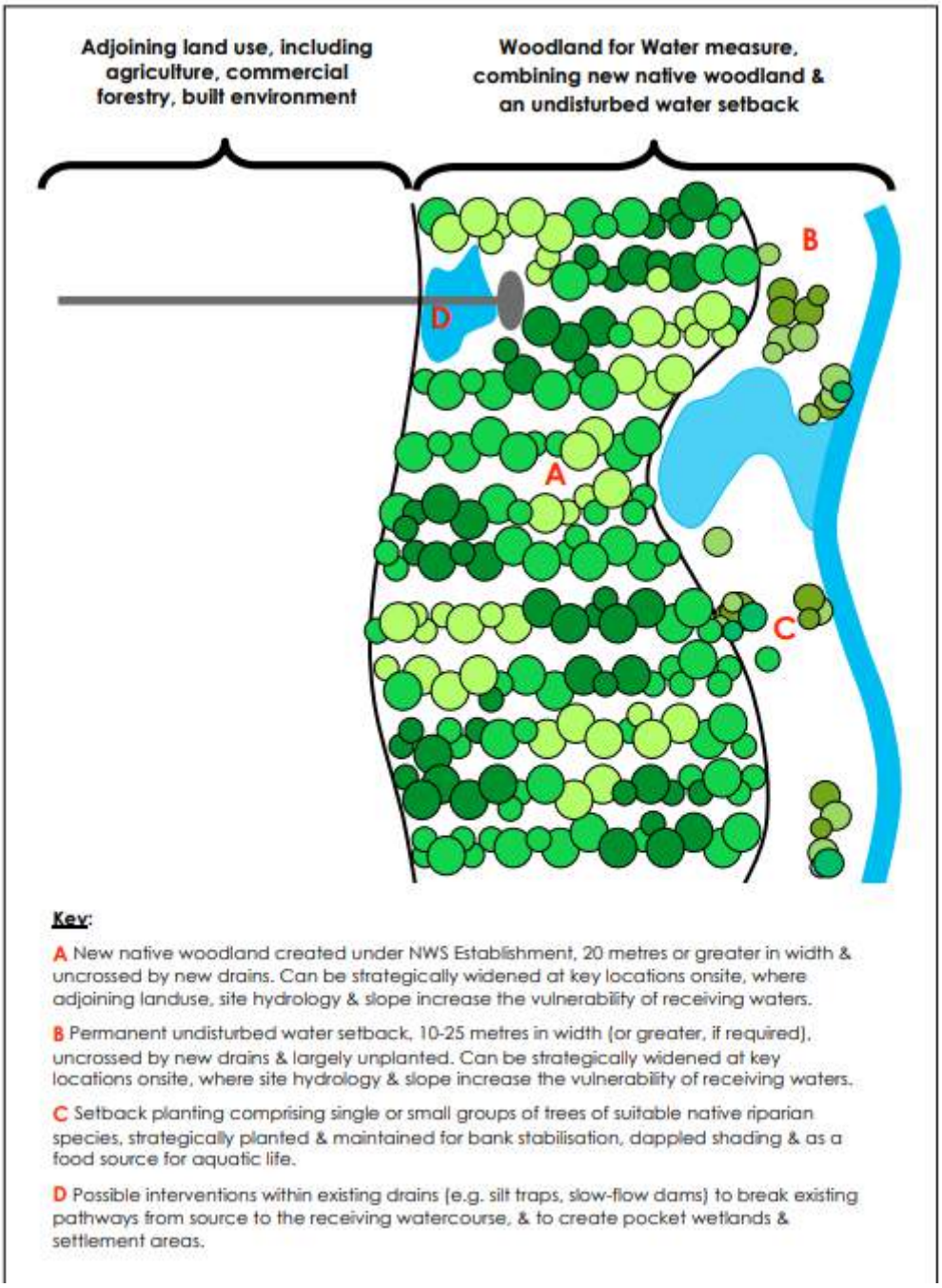

Image 6: Overview of the Woodland for Water measure. (DAFM 2018)

8.Discussion: The term 'Protective Forest Zone' although rarely used in island of Ireland reporting on Forestry and Ecology, provides a linkage to the broader global research and application of technology to the appropriate management and new application of predominantly native tree cover in buffering the impacts of forestry, agriculture and urbanisation on catchments and protected habitats and species.

The mapping of protective zones based on the criteria advised by An Fóram Uisce, IFI, Loughs Agency, LAWPRO, EPA, OPW, Uisce Éireann, SWAN Ireland, NPWS, DAFM, DAERA, Teagasc, NFGWS,

Coillte, Local Authorities, IWT and others, could be used as a component of a Framework to achieve Integrated Land and Landscape Management as proposed by An Fóram Uisce (2020) .

Designated protective zones should enable Local Authorities and Government Depts and Agencies to provide clear guidance on planning for activity or constraints in these zones.

Those designing new agri-environment, agroforestry and native woodland measures for the next round of CAP should build in structural and species flexibility (see image 7 below) in order to maximize the benefits from biodiversity and climate change mitigation.

Protective Zones will need to be maintained and may also lead to losses in income from farming, forestry or other land uses. These issues are explored in the EU COST Action Programme 'Payments for Ecosystem Services (Forests for Water)' known as PESFOR-W COST Action.

Ireland is represented on PESFOR-W COST Action by representatives from Teagasc, NUI - Dublin and Dr. Declan Little for Woodlands of Ireland. See www.forestry.gov.uk/fr/ pesforw for details.

Please note that the final Virtual Conference for that Programme is on the 17th and 18th of March.

This a link to the free registration:https://www.linkedin.com/pulse/virtual-conference-17-18-mar2021-payments-ecosystem-rik-de-vreese/

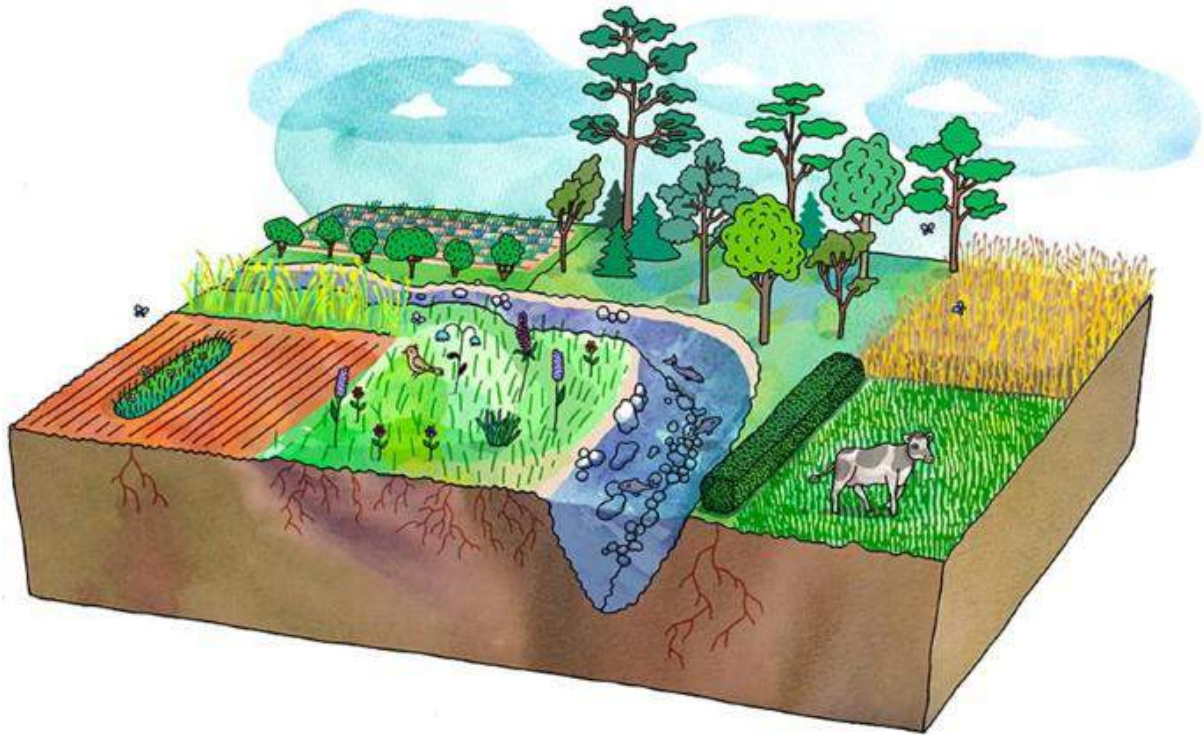

Image 7: Illustration of the variety of vegetated strips used within and around fields. Interventions include: in-field strips such as beetlebanks, hedgerows, forested shelterbelts, shrubs, grassy strips, and wildflower margins. (Haddaway et al 2018)

9.Proposal: Through an expert committee of the Technical Advisory Panel, seek the views of a range of stakeholder agencies and individuals to assist the process of developing criteria for the mapping of potential forest zones in catchments.

10. Intended outcome: produce agreed criteria from multiple stakeholders on the mapping of potential protective forest zones in catchments. This would then be included in a tender document seeking estimates on the cost of producing the maps, in a project to be funded by relevant government departments or agencies.

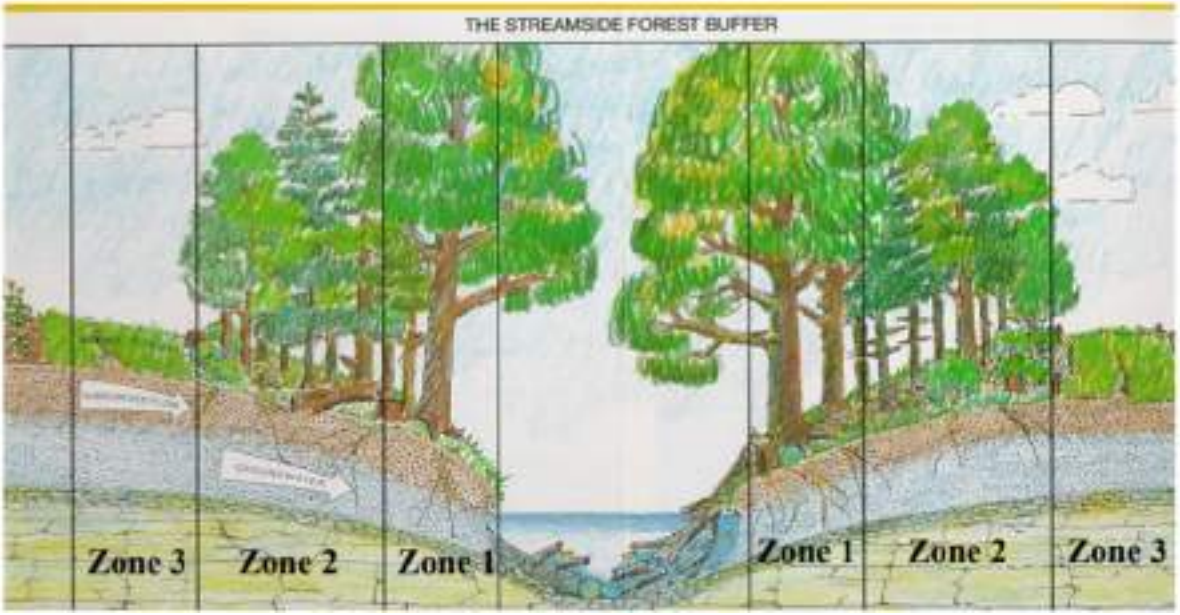

Image 8: Depiction of a three-zone buffer approach developed for the Chesapeake Bay Watershed (Welsch 1991 in Fischer & Fischenich, 2000)

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References:

An Fóram Uisce 2020. *Protecting and Enhancing Our Environment: A Framework for Integrated Land and Landscape Management.* Available at: https://thewaterforum.ie/app/uploads/2020/07/An-F%C3%B3ram-Uisce_Framework-for-Integrated-Land-and-Landscape-Management.pdf

Cao, X., Song, C., Xiao, J. and Zhou, Y., 2018. The Optimal Width and Mechanism of Riparian Buffers for Storm Water Nutrient Removal in the Chinese Eutrophic Lake Chaohu Watershed. *Water*, [online] 10(10), p.1489. Available at: http://dx.doi.org/10.3390/w10101489

Catchments.ie, (2019). Significant Pressures: Forestry. [online] www.catchments.ie. Available: https://www.catchments.ie/significant-pressures-forestry/ [Accessed 2021-03]

https://www.catchments.ie/public-consultation-significant-water-management-issues-for-irelands-2022-2027-river-basin-management-plan/

Connolly, J. and Holden, N. M. (2009) 'Mapping peat soils in Ireland; updating the Derived Irish Peat Map'. Irish Geography, 42(3), p343-352.

Connolly, J. and Holden, N. M. (2011a). 'Classification of peatland disturbance' Land degradation and development, 24(6), p548-555. https://doi.org/10.1002/ldr.1149

Connolly, J. and Holden, N. M. (2011b). 'Object oriented classification of disturbance on raised bogs in the Irish Midlands using medium- and high-resolution satellite imagery'. Irish Geography, 44 (1), p111-135.

Connolly, J. 'Derived Irish Peat Map version 2' [Online] www.EPA.ie. Available at http://erc.epa.ie/safer/resource?id=4b9efdbe-7f4e-102d-b891-8d8f2407b579 [Accessed: 2021-02-24]

DAFM. (2018). Forests & Water Achieving Objectives under Ireland's River Basin Management Plan 2018-2021. [pdf]. Available at: file:///C:/Users/User/Downloads/45025_0be86708ba444d7e9b7f549159c82d99%20(1).pdf [Accessed 2021-03]

Epa.ie, (2016). HYDROFOR: Assessment of the Impacts of Forest Operations on the Ecological Quality of Water. [online] www.epa.ie. Available: https://www.epa.ie/pubs/reports/research/water/researchreport169.html [Accessed: 2021-03]

Eurostat Statistical books 2010 *Environmental statistics and accounts in Europe.* Luxembourg: Publications Office of the European Union.

Fischer, R. A., and Fischenich, J.C. (2000). "Design recommendations for riparian corridors and vegetated buffer strips," EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes.army.mil/el/emrrp

Gis.epa.ie/EPAMaps/

Haddaway, N.R., Brown, C., Eales, J., Eggers, S., Josefsson, J., Kronvang, B., Randall, N.P., & Uusi-Kämppä. J., (2018) 'The multifunctional roles of vegetated strips around and within agricultural fields. Environ Evid' 7 (14). https://doi.org/10.1186/s13750-018-0126-2

Hamilton, L.S 2008 *Forests and Water: A thematic study prepared in the framework of the Global Forest Resources Assessment 2005.* FAO Forestry Paper 155: Food and Agriculture Organization of the United Nations Rome. http://www.fao.org/3/i0410e/i0410e00.htm

Horner, W.R. (2014) 'A Scientific Foundation for Shaping Riparian Buffer Protection Regulations' [online] Conservationtools.org. Available at https://conservationtools.org/library_items/1272-A-Scientific-Foundation-for-Shaping-Riparian-Buffer-Protection-Regulations [Accessed 2021-03]

Horner, W.R., Sweeney, B.W (2014) 'The Science Behind the Need for Riparian Buffer Protection' [online] Conservationtools.org. Available at https://conservationtools.org/library_items/1271-The-Science-Behind-the-Need-for-Riparian-Buffer-Protection [Accessed 2021-03]

Hutton, S.A., Harrison, S.S.C. & O'Halloran, J. (2008) Forests and surface water eutrophication and sedimentation – Final report; 67pp. Western River Basin District.

King County. (2019) Synthesis of Riparian Best Available Science to Inform Variable-Width Buffers in the Lower Snoqualmie Valley [pdf]. Prepared by Josh Kubo, Michael Thai, Beth leDoux, and Kollin Higgins, Water and Land Resources Division. Seattle, Washington.p.79. Available at: https://www.kingcounty.gov/~/media/services/environment/watersheds/snoqualmie-skykomish/snoqualmie-fish-farm-flood/Buffers_Task_Force/Final_Synthesis_of_Riparian_Buffer_Best_Available_Science_8_1_19.ashx?la=en [Accessed 2021-03]

Lundholm, A., Corrigan, E., Black, K., & Nieuwenhuis, M. (2020). 'Ecosystem services provision from alternative management options was modified to Ireland's western peatland forests under future development scenarios'. Irish Forestry, 77(1&2), 49-73. https://journal.societyofirishforesters.ie/index.php/forestry/article/view/10985

Mc Conigley, C., Lally, H., Little, D., O'Dea, P., Kelly-Quinn, M. (2017) The influence of aquatic buffer zone vegetation on river macroinvertebrate communities, Forest Ecology and Management, 400, p621-630. https://doi.org/10.1016/j.foreco.2017.06.043.

Moorkens, E., Purser, P., Wilson, F. and Allott, N. 2013. *Forestry Management for the Freshwater Pearl Mussel Margaritifera Final Report - FORMMAR*. University of Dublin, Trinity College -copies available from Woodlands of Ireland.

Motta, R. (2009). Protective Forests and Silvicultural Stability. Mountain Research and Development. 20. p180-187. https://www.researchgate.net/publication/232679646_Protective_Forests_and_Silvicultural_Stability

Ranalli, A.J. and Macalady, D.L. (2010) The importance of the riparian zone and instream processes in nitrate attenuation in undisturbed and agricultural watersheds –A review of the scientific literature. Journal of Hydrology 389(3-4), p406-415. https://doi.org/10.1016/j.jhydrol.2010.05.045

Reeves, G. H., Pickard, B., R. Johnson, K. Norman. (2016) *An initial evaluation of potential options for managing riparian reserves of the Aquatic Conservation Strategy of the Northwest Forest Plan.* Gen. Tech. Rep. PNW-GTR-937. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 97 p. https://doi.org/10.2737/PNW-GTR-937

Ring, E., Andersson, E., Armolaitis, K., Eklöf, K., Finér, L., Gil, W., Glazko, Z., Janek, M., Lībiete, Z., Lode, E., Małek, S., Piirainen, s. (2018) Good practices for forest buffers to improve surface water quality in the Baltic Sea region [pdf]. ARBETSRAPPORT 995-2018. Available: https://converges.eu/wp-content/uploads/2020/10/ring_2018.pdf [Accessed 2021-03]

Ring, Eva; Johansson, Johanna; Sandstro¨m, Camilla; Bjarnado´ttir, Brynhildur; Fine´r, Leena; Libyan, Zane; Lode, Elve; Stupak, Inge; Sætersdal, Magne (2017). Mapping policies for surface water protection zones on forest land in the Nordic-Baltic region: Large differences in prescriptiveness and zone width. Ambio, 46, p878-893. https://doi.org/10.1007/s13280-017-0924-8

Technical University of Munich (2016). The Status Quo on Europe's Mussels [image] Available at: https://www.tum.de/nc/en/about-tum/news/press-releases/details/32865/ [Accessed 2021-02]

Theilacker, J., Horner, W.R., Loza, A.M. (2014) 'Riparian Buffer Protection via Local Regulation: A Guide and Model Ordinance for Pennsylvania Municipalities' [online] Conservationtools.org. Available at https://conservationtools.org/guides/119 [Accessed 2021-03]

State of Europe's Forests 2003 The MCPFE Report on Sustainable Forest Management in Europe Jointly prepared by the Ministerial Conference on the Protection of Forests in Europe Liaison Unit Vienna and UNECE/FAO

Wasser, L., L. Chasmer, R. Day, and A. Taylor. 2014. Quantifying land use effects on forested riparian buffer vegetation structure using LiDAR data. Ecosphere 6(1):10. **http://dx.doi.org/10.1890/ES14-00204.1**

Woodland for Water: Creating new native woodlands to protect and enhance Ireland's waters DAFM 2018 https://www.teagasc.ie/media/website/crops/forestry/grants/Woodland-for-Water-April18.pdf

Zurqani, H.A., Post, C.J., Mikhailova, E.A., Cope, M.P., Allen, J.S., Lytle B. A., (2020). 'Evaluating the integrity of forested riparian buffers over a large area using LiDAR data and Google Earth Engine'. Scientific Reports **10,** 14096. https://doi.org/10.1038/s41598-020-69743-z