



THE RESEARCH CYCLE: FOUNDATION

ASSIGNMENT 3—JOURNAL ARTICLE SUBMISSION TEMPLATE

**ASSESSING THE POTENTIAL ROLE OF RIPARIAN
WOODLANDS TO MITIGATE FLOODING THROUGH COST
EFFICIENT NATURAL FLOOD MANAGEMENT (NFM) IN
IRELAND IS AN URGENT RESEARCH PRIORITY**

Heather Lally

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ABSTRACT

In Ireland, structural and non-structural measures are commonly used to mitigate the threat of local and regional flooding when implementing the EU Flood Directive (2007/60/EC). However, the use of natural flood management (NFM) measures such as riparian woodland could combine with the above measures to increase flood protection particularly in large urbanised areas. Riparian woodlands have been shown to support regulating ecosystem services (ES) including flood mitigation but thus far, have not been recognised in Ireland. This documentary analysis aims to determine whether riparian woodlands can act as a NFM measure minimising the impact of flooding along Irish river catchments. Three objectives are considered: 1) To assess the socio-economic impacts of increased flood risk and cost saving benefits of flood defences in river catchments, 2) To examine the use of riparian woodlands as a NFM measure, and 3) To determine whether there is societal support for the use of riparian woodlands as a NFM measure. An objectivist/positivist approach to documentary analysis was applied, however due to time constraints and the small-scale nature of the research, nine scientific articles were evaluated. Results indicate that climate change and human population growth are major factors influencing the socio-economic impacts of future flood risk. Scientists and land managers recognise the cost saving benefits of implementing flood defences such as riparian woodland however, the choice of mitigation measure is surprisingly based on weak scientific research. Therefore, this documentary analysis recommends further research into the effective application of NFM measures with a view to minimising the impacts of flooding in Irish river catchments, and attitudes of Irish land owners toward EU Flood Directive policy. The introduction is followed by three sections: the first assessing the socio-economic impacts of increased flood risk and cost saving benefits of flood defences in river catchments; the second evaluating the role of riparian woodland as a potential NFM measure; and the third examining the attitudes of society towards the use of riparian woodland as a NFM measure. Finally, concluding remarks and recommendations are made.

KEYWORDS: FLOOD RISK, EU FLOODS DIRECTIVE, FLOOD PROTECTION, ECOSYSTEM SERVICES

INTRODUCTION

Ireland is predicted to experience a 20% increase in both frequency and strength of storms over the coming years (Gleeson, McGrath, & Treanor, 2013, p. 7). For Ireland to comply with the EU Flood Directive (2007/60/EC), structural (flood defences), and non-structural (flood warning system) measures have been implemented (OPW, 2014, p. 1-2). However, currently these flood mitigation measures do not include the use of natural habitats. Native riparian woodland is a rare and fragmented habitat type in Ireland (Little, Collins, Cross, Cooke, & McGinnity, 2008, p. 1), supporting ecosystem services (ES) including flood mitigation, and which is estimated at €67-76 million per annum (Woodworth & Little, 2013, p. 9-11). The establishment of structured riparian woodland along the river network could mitigate the severity of flooding and reduce the associated financial costs involved, and has thus far, not been recognised in Ireland. An objectivist/positivist approach, as defined by Jupp & Norris, (1993) (in Cohen, Manion, & Morrison, 2011, p. 253), was adopted meaning that the research will assess processes, procedures and methods with the aim of determining whether riparian woodlands offer regulating ES provisions providing a natural flood management (NFM) measure which could help minimise the impact of flooding in Irish river catchments. Documentary analysis, which makes use of materials produced by others and includes both primary and secondary sources (McCulloch, 2011, p. 248-254), will help determine the hypothesis that riparian woodlands can provide regulating ES benefits effectively reducing peak river flows and therefore act as a NFM measure in Irish river catchments. Three objectives are considered to achieve the aim: 1) To assess the socio-economic impacts of increased flood risk and cost saving benefits of flood defences in river catchments, 2) To examine the use of riparian woodlands as a NFM measure, and 3) To determine whether there is societal support for the use of riparian woodlands as a NFM measure. Due to time constraints and the small-scale nature of the research, nine scientific articles were evaluated for this journal article. The ensuing sections firstly assess the socio-economic impacts of increased flood risk and the cost saving benefits of flood defences in river catchments, and secondly evaluate the role of riparian woodland as a potential NFM measure. Thirdly, examine the attitudes of scientist and land managers towards the implementation of riparian woodland as a NFM measure, and finally concluding remarks and recommendations are made.

SOCIO-ECONOMIC IMPACTS OF INCREASED FLOOD RISK AND THE COST SAVING BENEFITS OF FLOOD DEFENCES IN RIVER CATCHMENTS

This section examines the socio-economic impacts of increased flood risk in river catchments at a European level and assesses the predicted cost saving benefits of implementing flood defences specifically for Ireland.

Rojas, Feyen, & Watkiss (2013, p. 1737-1751) combined ensemble-based pan-European flood hazard data sources and modelling techniques to analyse and assess the climatic and socio-economic impacts on river flooding and their associated financial implications. In addition to considering the long term implementation and cost saving benefits of flood risk management (FRM) particularly for countries, like Ireland, which are predicted to be most at risk from flooding (Rojas et al., 2013, p. 1738.; Gleeson et al., 2016, p. 7). Results from their research highlight climate change as a key factor influencing future flood events, something also observed by Alfieri, Feyen, Dottori, & Biancجي (2015, p. 204) using the latest climate scenario models. More interestingly, Rojas et al., (2013, p. 1737-1751) suggest that the combined impact of climate change and increasing human population growth could be the biggest factors predicting future flood risk. This corresponds with global population increases of greater than 10 billion by 2050 (Kvočka, Falconer, & Bray, 2015, p. 1792). Their model also estimates that <0.1% of the Irish population are annually affected by flooding and although the combined effects of climate change and social growth are projected to impact Ireland, with increasing numbers of people annually affected by river flooding, the percentage will remain relatively low at <0.1% up to 2080 (Rojas et al., 2013, p. 1742). However, recent finding by Alfieri et al., (2015, p. 207), using the latest climatic data sources, indicate that these figures underestimate the true impact of flooding on human populations. They put the figures at between 2-3% for Ireland by 2080, which would suggest that flooding is likely to become an increasingly important social and environmental issue in the years and decades to come.

Economically, flooding creates a huge financial burden, not only on private residents, landowners and businesses but also on governments. Human populations are most at risk from flooding and damage in densely urbanised areas along large rivers and in the flood plains (Alfieri et al., 2015, p. 204; Kvočka et al., 2015, p. 1792). Similarly,

as indicated above, the combined impacts of climate change and population growth will be greatest with the costs of flood damage in Europe predicted to rise to €20.4 billion per year by 2020, €45.9 billion per year by 2050 and €97.9 billion per year by 2080 (Rojas et al., 2013, p. 1743; Alfieri et al., 2015, p. 211). These large increases are expected for most European countries, including Ireland, regardless of FRM measures employed. Ireland is estimated to bear one of the highest annual costs due to flood damage in Europe and will consequentially endure the highest costs associated with protection and management of flood risk areas, with current costs of FRM measures estimated at €52.4 million per year, representing 0.3% gross domestic product (GDP) (Rojas et al., 2013, p. 1748). Ireland is expected to maintain flood damage costs at <0.5% of GDP up until 2080 (Rojas et al., 2013, p. 1746). However, Alfieri et al., (2015, p. 207), again suggest these figures underestimate the true costs of flooding for Ireland and put the figure at between 1-2% of GDP by 2050, decreasing slightly to 1.5% by 2080.

Implementation of FRM measures, although costly, could in the longer term reduce the financial costs associated with river flooding particularly on the tax payer and “could be a highly cost-effective strategy” (Rojas et al., 2013, p. 1748) in protecting urban areas from river flooding. While, FRM measures do not remove the threat of flooding on human populations they can lessen the socio-economic impacts. Determining what FRM measures offer the most protection and are additionally environmental, structurally sound and cost effective is difficult to determine. Nevertheless, raising flood protection, reducing peak flows through water retention, reducing vulnerability and offering relocation to safer areas are measures which should be considered (Alfieri, Feyen, & Di Baldassarre, 2016, p. 1). Over the past decade, FRM measures focused on raising flood protection via “corrective rather than preventive measures” following the flood event (Alfieri et al., 2016, p. 2), however it is now acknowledged that this measure should only be used as a last resort, as although they confine the peak flow of the river during high flow rates, they also give a false sense of security and safety in the event of a breakdown during catastrophic events (Alfieri et al., 2016, p. 2). Therefore, FRM measures should focus on reducing the impacts of flooding through implementation of reservoirs, infiltration basins, sustainable urban drainage systems (SUBS) and river renaturation such as afforestation and restoring floodplain habitats (Alfieri et al., 2016, p. 4). In

general, a combination of FRM measures working in synergy should be considered with emphasis on natural retention capacity in river catchments a priority (Alfieri et al., 2016, p. 13).

Throughout this section, factors such as climate change, increasing human population growth, and their combined influences have been identified as key factors influencing the socio-economic impacts of increased flood risk, up to 2080. Over this time, the percentage of the human population impacted by flooding will increase steadily particularly in urbanised areas, as will the associated financial costs of flood damage. However, the early intervention and implementation of a combination of FRM measures may reduce the burden of flooding on human populations thus resulting in greater cost saving benefits of flood defences.

The next section considers the socio-economic benefits of implementing riparian woodland as a natural FRM measure to reduce peak flows through increased natural retention capacity in river catchments.

RIPARIAN WOODLANDS AS A NATURAL FLOOD MANAGEMENT (NFM) MEASURE

This section examines the potential use of riparian woodlands as a NFM measure to help reduce peak flows through increased natural retention capacity in river catchments, and assesses the predicted cost benefits specific to Ireland of increased native woodland habitats.

Bullock, Hawe, & Little (2014, p. 1-10) assessed the multi-benefit ecosystem services (ES) of small, fragmented native riparian woodland in Ireland and suggest that these ES have a real economic value that should not be ignored particularly if the current area was increased by 100%, and could see them become an important NFM measure in river catchments and flood plains.

The natural capital value of native woodlands including riparian woodlands, based on multi-ES provisions include: cultural, regulating, provisioning, and supporting services (Bullock et al., 2014, p. 1). Regulating ES strongly indicate that riparian woodlands can regulate flood risk at a catchment scale, by regulating flow and rainfall runoff rates. Bullock et al., (2014, p. 3) acknowledge that native woodland

habitats do “not remove the risk of flooding” however, scientific works published by Neary, Ice, & Jackson (2009, p. 2269-2281) and Thomas & Nisbet (2008, p. 1-13) indicate that they can stem the flow of rivers during periods of increased rainfall. In particular, Neary et al., (2009) found that catchments containing woodlands show a 60% increase in base flows (low water levels) when compared to non-woodland catchments. While Thomas & Nisbet (2008, p. 5-6) showed that peak flow times in woodland catchments increased from 30 to 140 mins, reducing the risk of flash flooding (Bullock et al., 2014, p. 3), thus acting as a NFM measure helping reduce peak flows through increased natural retention capacity in river catchments.

The approximate economic value of multi-benefit ES provided by native woodlands is estimated at around €67-76 million per annum. Regulating ES provides a total of between €1 and 8 million per annum, while flood protection offers a smaller economic value of less than €1 million per annum mirroring the small area of native woodland in Ireland (1.4% or 100,000 ha land area) (Bullock et al., 2014, p. 8). These authors also identify a number of opportunities that would increase the native woodland area of Ireland by as much as 100% of the current land area including the expansion of riparian woodlands along river corridors and within catchments with a view to “moderation of flood risk” (Bullock et al., 2014, p. 6). Expanding the range of riparian woodland would have additional benefits for biodiversity and water quality. The opportunities afforded by an expansion in native woodland to 100% of the current land area could result in an estimated €10 million per annum in flood risk protection and a total of €551 million per annum in multi-benefit ES provision (Bullock et al., 2014, p. 8). However, retention of water by riparian woodlands will most likely “apply only up to a threshold” (Bullock et al., 2014, p. 6) and as stated above will not remove the risk of flooding, yet, in combination with other FRM measures could provide flood relief to downstream, urbanised areas (Alfieri et al., 2016, p. 13), particularly in light of the high financial costs associated with flooding as indicated in the previous section (Rojas et al., 2013, p. 1746; Alfieri et al., 2015, p. 207). It is important to note that while these economic values are difficult to estimate correctly from literature sources alone, the value of ES offered by native woodlands should not be disregarded.

The need for increased woodland habitats in Ireland and the expansion of riparian woodland along river corridors and within catchments, as a NFM measure, could

take place in association with other FRM measures. How to proceed with this is another issue but Bullock et al., (2014, p. 6) suggest three approaches: 1. Offer incentives to land owners focusing on ES of woodland habitats, 2. Conduct a “strategic and targeted” planting plan with landowners permission, and 3. Allocate a proportion of the catchment area to riparian or alluvial woodland, again with landowner permission. These would require collaboration from state-run organisations, non-governmental organisation (NGO’s), landowners and other interested parties and could be some time before all parties agree. To date, the Irish government has failed to see the economic value of native woodlands as a multi-benefit ES resulting in the Irish people assuming the financial costs associated with flooding.

Throughout this section, the regulating ES benefits of using riparian woodlands as a NFM measure particularly to reduce flood risk has been highlighted, in addition to the associated cost savings by providing flood protection. This is particularly true if the riparian woodland area is increased to 100% of the current land area. However, without clear direction and investment at a government level, getting all parties to agree on how to proceed with native woodland expansion may be difficult. Subsequently, this could result in further unnecessary flood risk due to a lack of agreement on the implementation of mitigation measures in non-woodland river catchments in the short to medium term.

The next section considers the attitudes of policy implementers, scientists and land managers in supporting the use of riparian woodland as an effective NFM measure in reducing flood risk.

IS THERE SOCIETAL SUPPORT FOR THE USE OF RIPARIAN WOODLANDS AS NATURAL FLOOD MANAGEMENT (NFM) MEASURES?

This section investigates whether policy implementers, scientists and land managers support the implementation of riparian woodlands as an effective NFM measure in reducing flood risk.

The proposal of NFM measures is driven by policy namely the EU Floods Directive and while these proposed measures are correct in theory, application in practise and/or scientific evidence to support their use is lacking (Wilby et al., 2010, p. 4152). Implementers of policy from state-run organisations and land managers fully endorsed the use of riparian features, including planting/rehabilitating riparian woodland, to improve river ecology and mitigate changing climatic effects within river catchments. However, evidence to support the use of riparian vegetation or whether it acts as an effective tool in building resistance or resilience to climate change are not based on scientific evidence (Wilby et al., 2010, p. 4152, 4155; McLean, Beevers, Pender, Haynes, & Wilinon, 2013, p. 2; Rouillard, Ball, Heal, & Reeves, 2015, p. 160).

McLean et al., (2013, p. 3) found only two research articles demonstrating the ability of riparian vegetation to reduce flood risk: Johnson et al., (2008) and Anderson et al., (2006) (in McLean et al., 2013, p. 3) though this may stem from the fact that riparian woodlands are more commonly associated with good water quality as opposed to flood mitigation when defining ES benefits (McLean et al., 2013, p. 3). Their research did indicate there was a “larger evidence base” (McLean et al., 2013, p. 8) to suggest riparian vegetation could be a potentially useful NFM measure in providing multi-benefit ES, similar to Wilby et al., (2010, p. 4156), Woodworth & Little (2013, p. 9-11), and Bullock et al., (2014, p. 1-10). With the lack of monitoring-based evidence to support riparian vegetation to reduce flood risk (McLean et al., 2013, p. 8) their use is currently not thought to be a valid or viable NFM measure along river corridors in the UK and Ireland, until further research is conducted. However, this is contrary to Thomas & Nisbet (2008, p. 1-13) and Neary et al., (2009, p. 2269-2281) who, as detailed in the previous section, showed that wooded catchments do reduce flow rates and flood risk along river corridors. It is therefore concluded that more scientific research is indeed needed to clarify this position.

In an effort to investigate which proposed NFM measures are considered from policy by land managers, Rouillard et al., (2015, p. 156-157) and Wilby et al., (2010, p. 4159) concluded that the key drivers were economic gain, cost-effectiveness, sustainability and personal security from flooding. A key factor highlighted was “the level of local interest in flood risk” (Rouillard et al., 2015, p. 163) therefore, indicating that only people previously affected or with the potential to be affected by flooding

are concerned. These are important considerations particularly in catchments with large urban areas where the impacts of flooding and their associated costs have a much greater effect, as detailed in previous sections (Rojas et al., 2013, p. 1748; Alfieri et al., 2015, p. 207). Without a willingness to protect rivers and their associated riparian areas and an understanding of the multi-benefit ES offered by riparian woodland, in particular FRM measures at a catchment scale, it is difficult to convince land managers of their ES benefits and associated cost savings to local and downstream urban areas. This suggests that most local issues are governed at a local scale and may not mirror national or European flood legislation. It's also important to consider that not all land managers would be receptive to the implementation of riparian woodlands regardless of whether it was determined by EU policy and legislation.

Two questions are therefore raised: 1. Should riparian woodlands be included as a NFM measure until scientific evidence suggests? and 2. How can we effectively prove riparian woodlands provide regulating ES including those of flood protection in river catchments? These questions are currently not addressed by either McLean et al., (2013) or Wilby et al., (2010) and will require further, collaborative scientific research. To this end, Wilby et al., (2010, p. 4160) encourages “smarter monitoring, modelling and experimentation”, and the involvement of “solutions that are low-regret, and evidence-based” providing multi-benefit ES. A good starting point may be the implementation of measurable variables of ES and indicative NFM tools such as those experimented by McLean et al., (2013). In the meantime, the implementation of structural and non-structural FRM measures to increase flood protection levels and reduce flood peak flows are important until scientific evidence is fully able support the use of NFM measures including that of riparian woodlands.

Throughout this section, it is clear that while policy implementers and scientists recommend the use of riparian woodlands as a NFM measure, there is currently weak scientific evidence to support their use. In addition, their implausible linkages to multi-benefit ES were highlighted. Consequently, the opinions of land managers showed that most were open to the idea of implementing riparian woodland as a NFM measure but only if they were to provide substantial economic gain, sustainability, cost effectiveness, and personal security from flooding.

The final section summarises important findings and makes several concluding comments and recommendations regarding the use of riparian woodlands as a NFM measure capable of minimising the impact of flooding in Irish river catchments.

CONCLUSIONS & RECOMMENDATIONS

This documentary analysis aimed to determine whether riparian woodlands offered regulating ES provisions thus acting as a NFM measure, which could minimise the impact of flooding in Irish river catchments. To this effect the hypothesis is accepted although further scientific research is required to further substantiate the claims that riparian woodlands can provide regulating ES provisions effectively reducing river peak flow rates thus acting as a NFM measure.

Findings from this documentary analysis highlight:

- Climate change will be the key factor influencing future flood events.
- Population growth in combination with climate change will exacerbate the socio-economic impacts of flooding particularly in large urbanised areas.
- Flooding will be an important social, political, financial and environmental issue in the short- and long- term for both Ireland and Europe.
- Ireland will bare one of the highest annual costs of flood damage in Europe at 1-2% of GDP by 2050 and will consequentially endure the highest costs associated with protection and management of flood risk areas.
- A combination of FRM measures should be utilised to reduce the impacts of flooding specifically raising flood protection and reducing peak flows.
- NFM is a key measure emphasising the natural retention capacity in river catchments.
- Riparian woodlands are a potential NFM measure.
- The regulating ecosystem services (ES) afforded by riparian woodlands in providing some NFM function via reduced peak flows through increased natural retention capacity in river catchments.
- Financial cost savings associated with multi-benefit ES of riparian woodland from flood protection, estimated to be €1 million per annum for Ireland.

- Expansion in native woodlands to 100% of the current land area could result in an estimated €10 million per annum in flood risk protection for Ireland.
- The current failure of the Irish government to see the economic value of native woodlands in providing flood protection.
- Lack of agreement between involved parties in how to proceed with native woodland expansion in Ireland.
- Policies such as the EU Floods Directive drive the proposal of NFM measures.
- Weak scientific evidence to support the linkage between multi-benefit ES provided by riparian woodlands and reduced flood risk capacity.
- Despite this, implementers of policy from state-run organisations and land managers fully endorsed the use of riparian features to improve river ecology and mitigate changing climatic factors within river catchments, if evidence supports their use.
- Key drivers of compliance by land managers with national and European policy are economic gain, cost effectiveness, sustainability, and personal security from flooding.
- Need for more scientific research to clarify the use of riparian woodlands as a NFM measure.

The following conclusions were observed from the key research articles:

- Climate change and increasing human population growth are major factors influencing the socio-economic impacts of future flood risk.
- Riparian woodlands offer multi-benefit ES including the potential to act as a NFM measure reducing peak flows.
- The economic value of ES offered by native woodlands should not be disregarded particularly in reducing the costs of flood damage.
- There is conflicting scientific research regarding the effectiveness of riparian woodlands to perform regulating ES benefits and flood protection.
- In summary, the research hypothesis was accepted as this documentary analysis has shown that riparian woodlands do offer some regulating ES provisions and therefore do act as a NFM measure, however their

effectiveness in minimising the impact of flooding in Irish river catchments needs further scientific investigation.

This documentary analysis recommends two key areas of further research. Firstly, investigating the effectiveness of NFM measures in minimising the impacts of flooding in Irish river catchments. This will require long-term experimental trails assessing multi-benefit ES using measureable variables such as those indicated by McLean et al., (2013). Secondly, assessing the attitudes of landowners toward EU Flood Directive policy, flooding issues and mitigation measures. The views of land managers on NFM and their willingness to implement measures will play a major role in effectively complying with the EU Flood Directive in Ireland.

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