



The vegetation communities of unmanaged aquatic buffer zones within conifer plantations in Ireland



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ARTICLE INFO

Article history:

Received 19 December 2014

Received in revised form 8 May 2015

Accepted 10 May 2015

Available online 29 May 2015

Keywords:

Conifer plantations
Forest management
Riparian zones
Aquatic buffer zones
Vegetation communities

ABSTRACT

The riparian zone is the interface between aquatic and terrestrial habitats and forms the ecotone where the two ecosystems intersect. Areas of the riparian zone utilised for the protection of water quality are common today, and are either left undisturbed or managed to intercept or modify impacts from adjacent land uses. In Ireland, aquatic buffer zones (ABZs) are used to protect streams from the potential impacts of commercially managed conifer forests and associated high impact forestry operations. In 1991, the Forest Service (currently of the Department of Agriculture, Food and the Marine) introduced the requirement for ABZs to be put in place on all streams identified on Ordnance Survey maps at either afforestation or restocking after clearfell. The width of the ABZs range from 10–25 m depending on the slope of the river bank in combination with the susceptibility of the soils to erode. Current practice is to leave the ABZ undisturbed allowing for natural colonization by a mix of species and establishment of various habitat types. This study describes the habitats and vegetation composition of 86 naturally vegetated riparian zones (65 ABZs in commercial conifer forests and 21 control sites) on six soil types, with a view to informing their optimum management. Across all sites, 392 taxa, within 32 habitat types were identified. The most common habitats were wet grasslands and scrub. Little variation was noted between the structure and composition of plant communities in ABZs (on afforested and clearfell & replanted) and control sites within a soil type. The communities did differ across soil types between the mineral and peaty soils, which were independent of the forest type. Within a soil type, ABZs are maintaining similar habitat and species diversity to that found on control sites indicating that current forest management practices are not impacting plant diversity in the ABZs. It is noted that tree species are not a feature of the riparian zone on peat soils and thus tree planting is not recommended as a management option unless used to control water temperatures. There is scope for tree planting on mineral soils, as control sites contained woodland habitats which were absent from the ABZs of clearfell and replanted sites.

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1. Introduction

Exotic conifer plantations, a widespread human activity, affect the hydrochemistry (Kelly-Quinn et al., 2008; Feeley et al., 2013), structure and functioning (Riipinen et al., 2010; Martínez et al., 2013) of streams and rivers that they border. However, it has been reported that the riparian vegetation can mitigate some of these effects (Quinn et al., 2004) and therefore vegetated riparian buffer

zones are commonly used for this purpose (see Richardson et al., 2012).

The riparian zone is the interface between the aquatic and terrestrial ecosystems. In the case of rivers, it is generally considered to include the bank and the portion of land influenced by river water during flooding (Gregory et al., 1991; Naiman and Décamps, 1997; Little et al., 2008). It has long been understood that vegetation in the riparian zone is an important factor in maintaining the health and condition of rivers (Vannote et al., 1980; Minshall et al., 1983). Shade cast by plants in the riparian zone reduce maximum stream temperatures (Caissie, 2006; Broadmeadow et al., 2011; Ryan et al., 2013), while their stems and root systems intercept sediment by slowing over-land flow,

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increasing water absorption rates in riverbank soils and controlling erosion by stabilising banks (Castelle et al., 1994). Riparian vegetation also contributes to allochthonous inputs from the catchment, which form the primary source of coarse and fine particle material that fuel aquatic macroinvertebrate food webs in low order streams (Tank et al., 2010). Furthermore riparian vegetation influences the contribution of terrestrial invertebrates which can form an important part of the diet of fish (Kelly-Quinn and Bracken, 1990; Nakano et al., 1999; Ryan and Kelly-Quinn, 2014).

Ireland is one of the least forested countries in Europe (MCPEE Liaison Unit Warsaw, 2007). At the beginning of the 20th century, forest cover decreased to approximately 1% (Rackham, 1986). Following the foundation of the state in 1922 the government sponsored a reforestation program focusing on marginal and upland areas unsuitable for agriculture (Giller and O'Halloran, 2004). Forest cover has steadily increased in the interim and currently stands at 10.5% (Forest Service, 2014). The majority of the forests planted comprised of fast growing non-native conifer species particularly *Picea sitchensis* Bongard (Sitka spruce), which form over half of the total forest estate in Ireland (Forest Service, 2014).

The installation of riparian buffer zones, known as aquatic buffer zones (ABZs) in Ireland, of between 10 and 25 m width along streams has been mandatory in Irish forestry since 1991 (Forest Service, 2000). The ABZs are put in place at afforestation or in older forests at replanting after clear-felling. The width of the ABZ is dependent on the slope of the area and the likelihood for soil erosion, with steeper sites on erodible soils requiring the widest buffers (up to 25 m). Within the ABZ, forestry operations are strictly curtailed, no conifers are planted, drains end before entering the ABZ, incursions of machinery is kept to a minimum and brush mats are used to protect the soil from erosion and compaction (Forest Service, 2000). These measures are intended to allow the ABZ to retain the plant communities present before the establishment of a conifer forest, thus allowing the ABZ to maintain the functions of riparian zones outlined above.

The incorporation of ABZs into Irish conifer plantations provides an opportunity to investigate management strategies that can enhance the ecology of the stream (Little et al., 2008). Before that can be achieved, a thorough knowledge is required of the mosaic of habitats and plant communities present in ABZs. This is particularly important at this time as many plantations in Ireland reach maturity.

Several studies examining the responses of upland plant communities to conifer afforestation have noted a loss of species richness (Hill, 1979) and convergence toward a community dominated by a few species (Sykes et al., 1989; Wallace et al., 1992). These changes largely relate to the degree of canopy closure, site type and forest management. These factors are not expected to be major issues for ABZs as they are not under the forest canopy (Anderson, 1979; Hill, 1979; Wallace et al., 1992; Wallace and Good, 1995). There is a paucity of research describing vegetation in riparian zones of conifer plantations in Ireland. However work carried out in the UK (Wallace and Good, 1995; Broadmeadow and Nisbet, 2002) and New Zealand (Boothroyd et al., 2004; Langer et al., 2008) indicate a community similar to that of native forest will occur in the understorey.

This study addresses these knowledge gaps by investigating the habitats and plant communities present in ABZs across Ireland. Aquatic buffer zones instated at initial forest planting (afforestation), and those put in place after clearfell & replanting are compared to natural riparian zones in catchments with no conifer plantations in the vicinity. Across the country 86 unmanaged riparian zones (65 ABZs in conifer plantations and 21 control sites) are described and compared across six soil types. This information provides insight into the current state of the ABZs in the national forest estate and will be used to inform their management into the future.

It was hypothesised that there would be a significant change in the community composition between ABZs and the controls sites with the control sites having greater vegetation and habitat diversity than ABZs on the same soil type.

2. Materials and method

2.1. Site selection

Located in northwest Europe on the Atlantic Ocean, Ireland experiences an oceanic climate with mild winter and cool summers. There is considerable variation in rainfall, the west coast receiving 2000 mm in 250 days of rain annually while on the east coast 700 mm of rain falls in 190 days. Due to past deforestation and agriculture Ireland is largely dominated by improved grassland habitats with the most productive grass varieties chosen for cultivation to facilitate livestock production. If left to develop naturally the potential vegetation would be dominated by temperate woodlands (Cross, 1998, 2006), similar to much of western Europe (Bohn et al., 2003), but with lower diversity due to territory size, island status and glacial history. Peatland areas are dominated by species such as *Eriophorum angustifolium* and *Molinia caerulea* with dwarf shrubs *Calluna vulgaris* and *Erica tetralix* (for a detailed map of potential vegetation see Cross, 2006).

Riparian zones in afforested, clearfell and replanted and control sites on six different soil types peat, peaty podzols, peaty gley, well-drained mineral (WDM), mineral gleys and mineral alluvium, were sampled, resulting in a total of 18 categories. Each ABZ site was required to have greater than 300 m length of conifer plantation on both river/stream banks, while control site were required to have no conifer plantations in the vicinity. Thus, on afforested and clearfell and replanted sites, the ABZ's were within conifer plantations bordered by a significant forested area. For the control sites, the natural riparian zone that would form the ABZ if the area was afforested was surveyed. All of the sites (both within the forest and controls) were unmanaged and left to be colonised by native vegetation and develop naturally.

A total of 86 sites were selected across the country (Table 1). The numbers of sites in some categories were low due to difficulty in finding sites matching the criteria (clearfell & replanted sites on peaty gley soil \times 2 and afforested sites on well drained mineral (WDM) & mineral gley soils \times 2).

2.2. Vegetation survey

Within each ABZ, three sampling stations (10 m \times 10 m) were established 100 m apart, on both the left and right banks (Fig. 1), creating a total of six stations. Within each station, three relevés (2 m \times 2 m), 2 m apart, were sampled along a transect perpendicular to the stream. All species present within the relevés were

Table 1

Number of sites selected for vegetation surveys classified according to 18 categories (6 soil types vs. 3 forest types).

	Afforested	Clearfell & replanted	Control	Total per soil
Peat	7	10	8	25
Peaty podzol	4	6	5	15
Peaty gley	3	2	4	9
WDM	2	6	7	15
Mineral gley	2	3	4	9
Mineral alluvium	3	4	6	13
Total per forest type	21	31	34	

WDM: well drained mineral.

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