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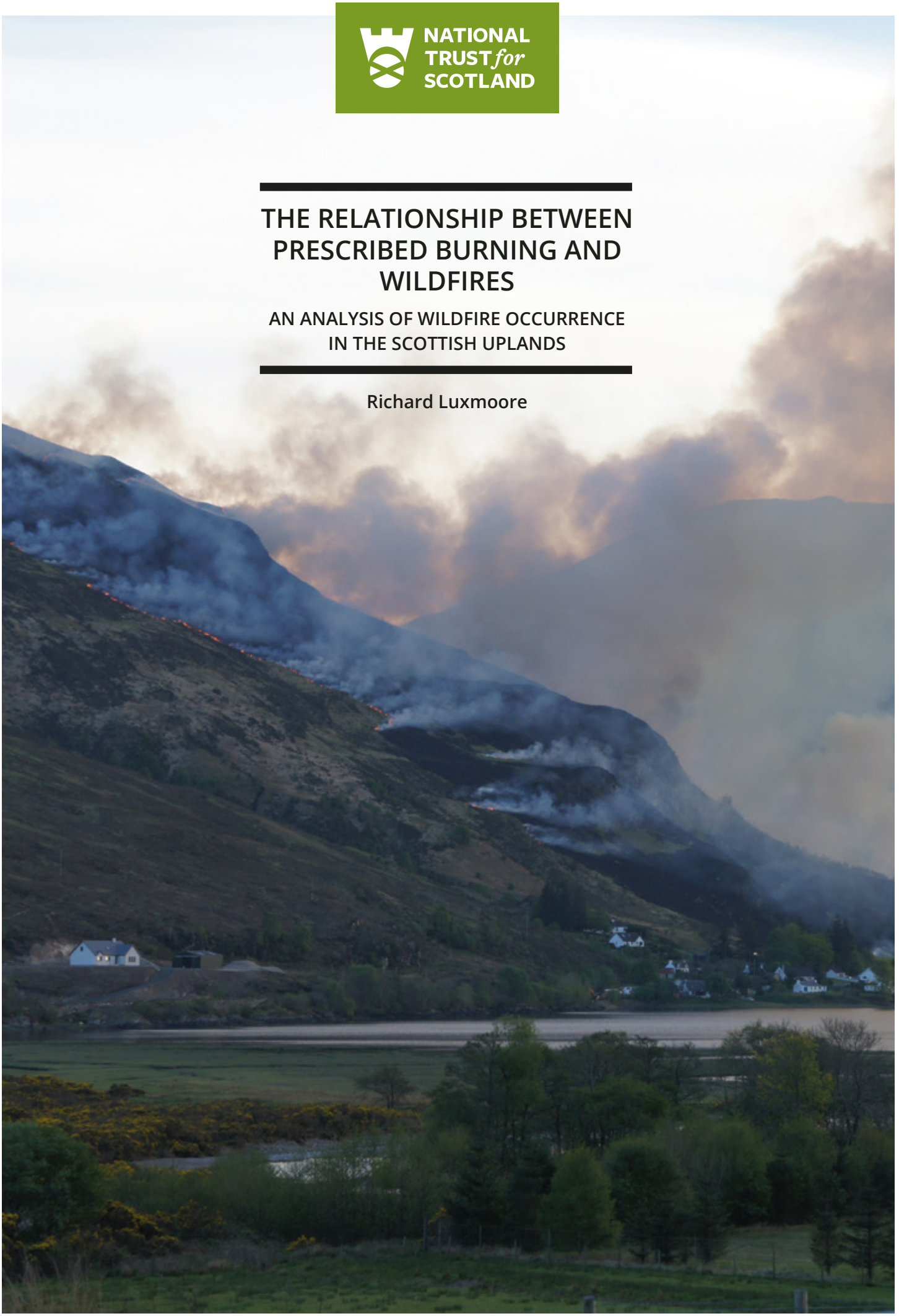
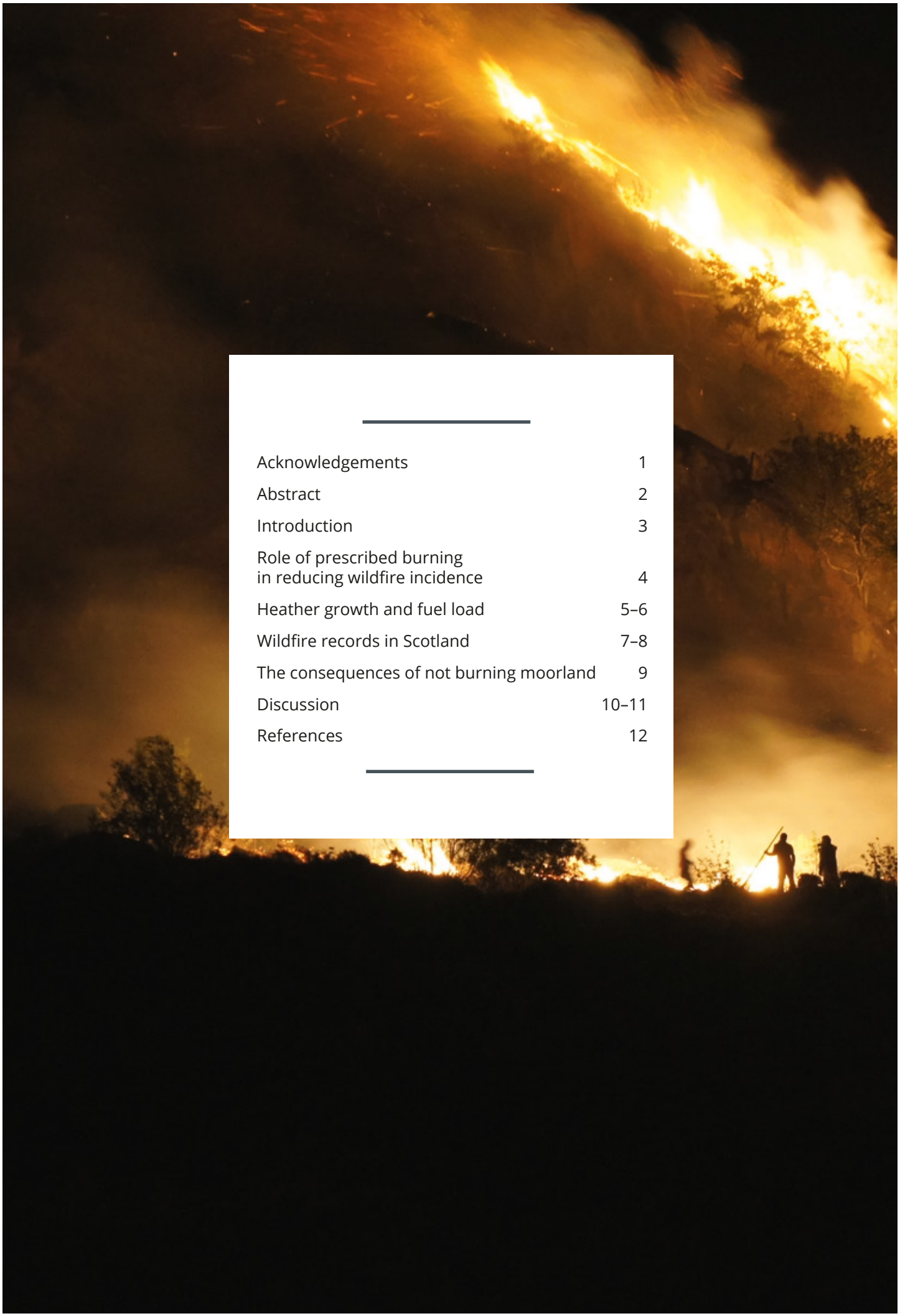
THE RELATIONSHIP BETWEEN PRESCRIBED BURNING AND WILDFIRES

AN ANALYSIS OF WILDFIRE OCCURRENCE IN THE SCOTTISH UPLANDS

Richard Luxmoore





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Abstract

Richard Luxmoore is the Senior Nature Conservation Adviser at the National Trust for Scotland. His interests include the management of land for conservation purposes with particular emphasis on the uplands.

National Trust for Scotland, Hermiston Quay, 5 Cultins Road, Edinburgh, EH11 4DF, United Kingdom

+44 131 458 0200

rluxmoore@nts.org.uk

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Prescribed burning is an established management technique in the UK for heather moorland and helps to improve the habitat for sheep and deer grazing, and for the production of red grouse for recreational shooting. By reducing fuel loads as a by-product of these uses, it is also claimed to reduce the risk of wildfire. Wildfires in the uplands can be damaging to habitats such as moorland and forestry plantations, and can also ignite underlying peat where they are difficult to extinguish and impact on carbon storage in peat soils. Wildfires result from a number of causes including lightning, campfires and arson, but a significant number, particularly of the larger fires, result from escaped prescribed burn.

This paper examines the relationship between wildfire and prescribed burning in Scotland, drawn from published research, statistics compiled by the Scottish Fire and Rescue Service (SFRS) and wildfire incidence on the National Trust for Scotland (NTS) estate. SFRS data indicate that the majority (>60%) of moorland wildfires in Scotland are likely to be caused by escaped prescribed burns. Evidence from the NTS estate, which is no longer subject to prescribed burning, shows that only 2% of the upland area has been affected by wildfire over 18 years. Refraining from prescribed burning would therefore likely result in considerably less moorland being burnt from all causes. This finding calls into question current government guidance on the burning of moorland and suggests that a radical revision is needed for the protection of private property and natural capital, including biodiversity and carbon storage of peatlands.

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Introduction

Muirburn is used to remove old heather, promoting new growth

Fire has been used as a management tool in the uplands of the UK for centuries. It is currently associated mainly with the management of moorland dominated by heather (*Calluna vulgaris*) for the recreational shooting of red grouse (*Lagopus lagopus scoticus*), but it is also used to improve grazing conditions for domestic livestock and deer (Worral *et al.*, 2011; Glaves *et al.*, 2013). In Scotland, the practice of prescribed burning is known as 'muirburn'. Douglas *et al.* (2015) estimated that prescribed burning had taken place, across 8550 1km squares throughout Great Britain within the last 25 years.

Muirburn is used to remove the longer, old heather, promoting new growth and creating a mosaic of habitat structures that favour red grouse and a range of other species (Anon., 2011b). It also helps prevent scrub encroachment and maintains the dominance of dwarf shrub cover. However, burning may also have a negative impact on the environment, particularly on biodiversity, carbon storage and water quality (Worral *et al.*, 2011; Glaves *et al*. 2013), although the severity of these effects is disputed (Davis *et al*., 2016). One claim frequently used to support the practice is that the regular burning of heather reduces the risk of wildfire by reducing the fuel load of the remaining vegetation (Anon., 2011b; McMorrow *et al.*, 2009).

Evidence from the USA (Ryan *et al.*, 2013) and Australia (Altangerel and Kull, 2013) shows that prescribed burning can reduce fuel loads and the severity and frequency of wildfires in forest ecosystems, although the effect varies considerably between different forest types and can be absent in some (Brewer and Rodgers, 2006). There has been little published evidence to support the hypothesis that prescribed burning protects against wildfire in upland heathland communities in Europe; Worral *et al.* (2011) and Davis *et al.* (2016) both identified this as a topic urgently requiring verification.

Role of prescribed burning in reducing wildfire incidence

While prescribed burning reduces fuel load and therefore the hazard of wildfire, it is also a cause of ignition of wildfire – the net effect may be an increase in the overall risk. It is therefore very important to assess the role of prescribed burning as a source of wildfire.

This paper examines the relationship between wildfire and muirburn from published sources, from records obtained from the Scottish Fire and Rescue Service and from an analysis of the incidence of wildfires on property owned by the National Trust for Scotland. It attempts to quantify the proportion of wildfires that are attributable to escaped prescribed burns and assess the likely consequences on wildfire incidence of adopting a no-burn policy.

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Heather growth and fuel load

Both live heathers and dead plant litter present a fire hazard and provide potential fuel for fires.

When heather is allowed to grow unchecked it gradually increases in height over a period of about 20–25 years, after which it ceases to be able to support itself and falls over with the main stem lying horizontally on the ground. At this point, parts of the stem may take root – a process known as layering. During the growth phase, the weight of live heather (biomass) increases and dead plant litter accumulates on the ground. Both present a fire hazard and provide potential fuel for fires. The intensity of the fire increases in proportion to the fuel load. There is surprisingly little information on the risk of fire in relation to fuel load but studies by Gimingham (1972) have shown the relation between fuel load (the biomass of live heather plus accumulated litter) and the age of the heather (Fig. 1).

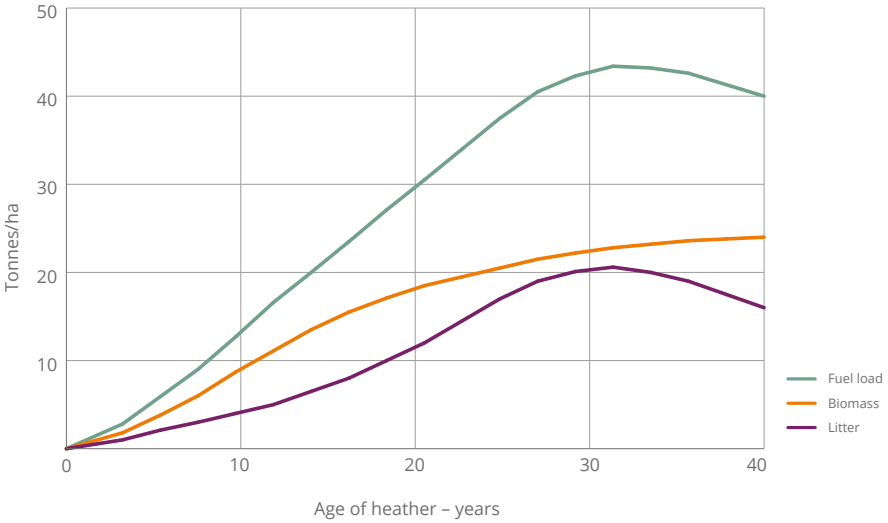

Figure 1. The relationship between fuel load and age of the heather (after Gimmingham, 1972)

In older heather, the rate of litter accumulation falls off as the heather becomes less vigorous and the underlying layer of sphagnum moss increases, swamping some of the accumulated litter and eventually incorporating it into the peat.

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Heather growth and fuel load (continued)

One of the problems of intense wildfires is that they can ignite the underlying peat.

Normal practice in managing heather moors for grouse involves burning small patches of heather in rotation at intervals of 15–20 years. This maintains the heather in its young phase which provides better feeding for the grouse, while leaving some longer patches to provide shelter (Anon., 2011a). It also has the effect of continually removing biomass, thereby ensuring that there is on average less fuel load and, it is argued, less danger of wildfire. Under such a regime, the fuel load on a newly burnt patch of moorland would increase over time to around 25–30 tonnes per hectare (t/ha) (see Fig 1) before being burnt again and returning to zero. The pattern would repeat over subsequent burn cycles, giving rise to a saw-tooth cyclical pattern of fuel load which would result in an average fuel load over time of around 13–15 t/ha. An unburnt moor would be expected to have a fuel load around 40 t/ha. Thus, a regularly burnt moor should have a considerably lower fuel load than an unburnt moor also dominated by heather – this gives rise, it is argued (Legg *et al.*, 2006; McMorrow *et al.*, 2009), to a lower fire hazard and wildfires of lower intensity when they do occur. One of the problems of some intense wildfires is that they can ignite the underlying peat. This makes them much more difficult to extinguish and results in greater loss of soil carbon, which contributes to greenhouse gases in the atmosphere (Worral *et al.*, 2011).

Another objective of burning for grouse moor management is to increase the cover of heather at the expense of other vegetation types, such as purple moor grass (*Molinia caerulea*) or *Sphagnum*-dominated mires. The resulting uniform dwarf-shrub-dominated dry heath is itself much more prone to wildfire than a mixture of habitats and so a prolonged regime of burning can itself increase fire hazard (Worral *et al.*, 2011).

The overall risk of wildfires occurring is assessed by the product of fire hazard (fuel load, vegetation type and moisture content) and the risk of ignition. Wildfires start from a variety of causes of ignition including natural (eg lightning strike), accidental (eg cigarettes, disposable barbecues, campfires), malicious (arson) and escaped management fires (McMorrow *et al*., 2009). In order to assess the overall risk of wildfires it is important to understand the causes and likelihood of ignition.

Wildfire records in Scotland

Most of the primary wildfires were in the Highland region (an average of nearly 12 per year), but the highest proportion potentially caused by muirburn (100%) was in Perth and Kinross (Fig. 3).

The Scottish Fire and Rescue Service (SFRS) maintains records on its Incident Reporting System of major or 'primary' wildfires (defined as those attended by five or more firefighting appliances) and also records the known or suspected cause of each fire. This system was queried to identify wildfires potentially caused by muirburn by using keyword matching combined with the internal incident logs provided from SFRS Command and Control systems (where the narrative logs of the incidents indicated that the cause was muirburn or burning gone out of control). These records represent the best judgement of the senior fire officers attending each incident and are therefore the most reliable records available. From 2009/10 until 2014/15 they reported a total of 233 primary wildfires throughout Scotland, ranging from 25 in 2009/10 to 60 in 2011/12 (see Fig 2). Of these, 140 (60%) were 'potentially caused by muirburn', ranging from 48–67% per year. A chi-square test was used to compare the frequency distributions of all wildfires annually and those attributed to muirburn, calculating expected values of wildfires per year attributed to prescribed burning as the proportion attributable to muirburn across years (0.60) multiplied by the total wildfires that year. There was no significant difference between the two distributions ($\chi^2_5 = 1.86$, $P = 0.868$), suggesting a consistent association between annual occurrence of wildfires and those attributed to escaped prescribed burns.

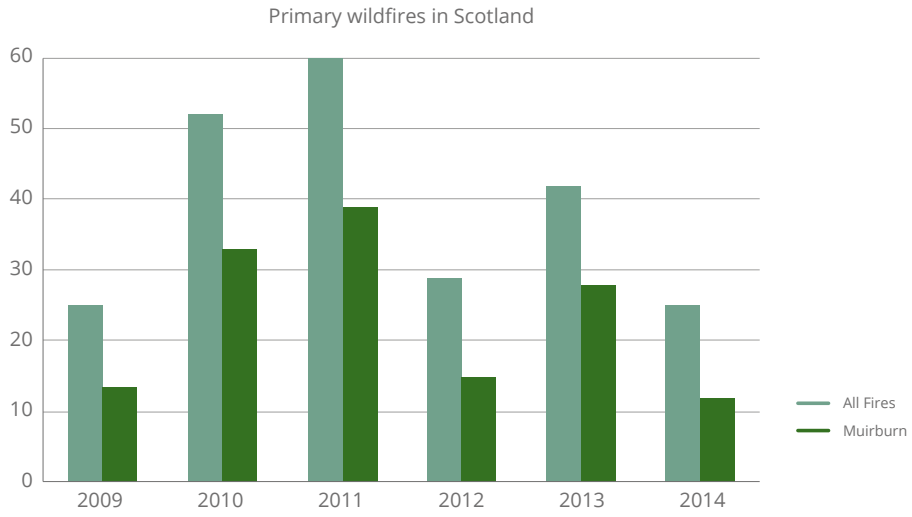

Figure 2. Major (primary) wildfires in Scotland, showing the number recorded as 'potentially caused by muirburn' (Source: Scottish Fire and Rescue Service)

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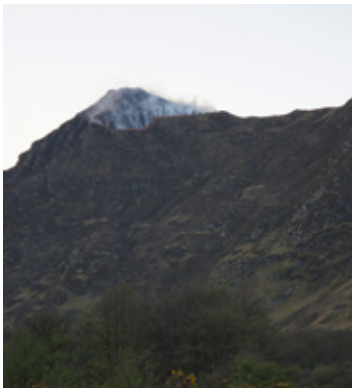
Wildfire records in Scotland (continued)



Most of the primary wildfires were in the Highland region (an average of nearly 12 a year), but the highest proportion potentially caused by muirburn (100%) was in Perth & Kinross (Fig. 3).

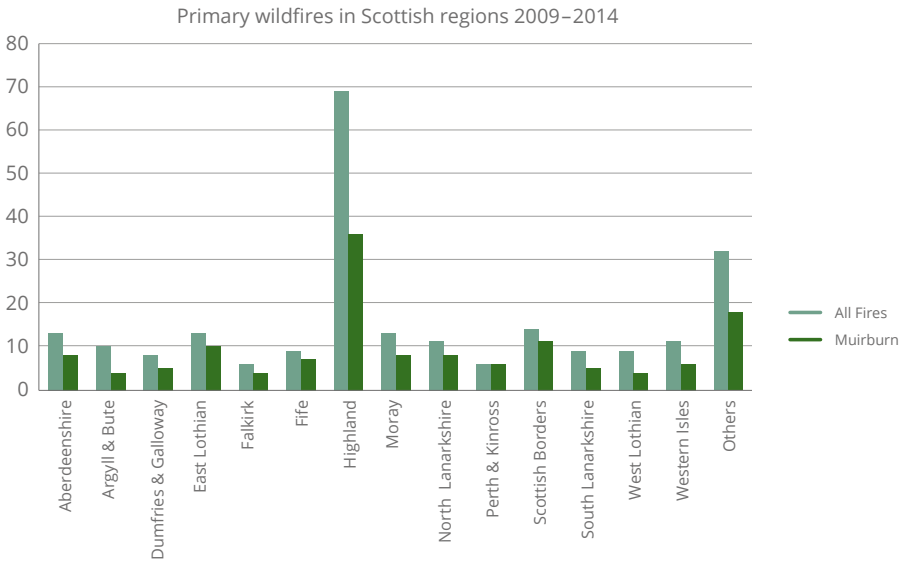


Figure 3. Major (primary) wildfires in Scotland in 2009–2014, broken down by local authority area, showing the number recorded as 'potentially caused by muirburn' (Source: Scottish Fire and Rescue Service)

The consequences of not burning moorland

It is important to note that had there been a policy of carrying out managed burning, the entire area of moorland would have been burnt in a period of 18 years.

The hypothesis that managed burning of heather moorland reduces the risk of wildfires can be examined by studying the incidence of wildfires in moorland that is not managed by burning. The National Trust for Scotland is the fourth largest landowner in Scotland, having 76,000 ha of land, of which about 63,500 ha is in the uplands. With only one exception, this land is managed entirely without burning.

Over the last 18 years (1998–2015), there have been a total of 12 large wildfires on the major upland properties, which burnt a total mapped area of 1,463 ha. This represents about 2% of the total estate or 2.3% of the upland area (Table 1). At two properties, Goatfell and Torridon, the fires have burnt 17% and 11% of each property respectively.

It is important to note that if there had there been a policy of carrying out managed burning, the entire area of moorland would have been burnt in a period of 18 years (the approximate median of the recommended burning interval of 15–20 years). Even if this had been successful in preventing all wildfires, which is unlikely, the net result would have been to burn 63,316 ha in order to save 1,463 ha – a clear case of the 'cure' being worse than the 'disease'. In practice, an unknown percentage of the upland area would have been unsuitable for burning (rock, scree, open water, etc) but excluding this would not affect the overall conclusion.

NTS Property	Total Area (in ha)	Upland Area (in ha)	Wildfires	
			Number	Area burnt (in ha)
Balmacara	2,748	1,059	1	45
Ben Lomond	2,174	2,079	1	2.5
Glencoe	5,680	4,930	3	5
Goatfell	2,285	2,285	2	397
Iona	848	400	1	12
Kintail/W Affric	11,093	10,449	1	250
Mar Lodge Est	29,380	27,165	2	66
Torridon	6,379	3,591	1	685
Other upland properties	12,802	11,358	0	0
Total	**73,389**	**63,316**	**12**	**1,463**

Table 1. The incidence of wildfires on National Trust for Scotland upland properties, showing the number of fires and the total area burnt between 1998 and 2015.

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Discussion

Muirburn is mainly carried out in the spring (February to April) in dry weather, when the moisture content of the vegetation is low.

While it seems plausible that burning of heather-dominated moorland, carried out in accordance with the guidelines, should reduce the immediate fuel load relative to unburned heather-dominated moorland, paradoxically the practical experience of the SFRS confirms that a clear majority (around 60%) of moorland wildfires in Scotland appear to have been caused by escaped muirburn.

A study in the Peak District of central England showed that, while only 10 out of 41 fires from 1976 to 2004 were attributable to escaped management fires, they tended to be much larger, so that 51% of all wildfires by area resulted from this cause (Worral *et al.*, 2011). A further questionnaire survey of 41 Scottish estates reported a total of 17 wildfires in 2003, of which 9 had been caused by muirburn and a further 2 by farmers trying to manage the vegetation for grazing. This made a total of 65% caused by escaped management fires (Legg *et al.*, 2006). The figures are broadly consistent with the SFRS statistics.

Legg *et al.* (2006) claim that most of the fires set for management purposes are closely controlled and that very few escape. However, the estates that practise muirburn do so on a large scale – they estimated that each of the 20 estates who conducted muirburn in the 2003 survey set an average of 215 fires a year, with the largest practitioner setting 900–1000 fires in a season. It would not take very many of these fires to get out of control to produce the paradoxical result highlighted above.

Muirburn is mainly carried out in the spring (February to April) in dry weather, when the moisture content of the vegetation is low. This often occurs after periods of low rainfall and high winds – conditions that contribute to a high fire hazard. This is understandable, because it is necessary to carry out muirburn at times when the vegetation burns well, but it greatly increases the risk of wildfire.

One of the main threats posed by wildfires in the Scottish uplands is to commercial coniferous woodlands, which are often located adjacent to open moorland. The damage caused by a fire passing through a commercial woodland can be extremely costly (Anon., 2014). Forest Enterprise Scotland (FES) manages the national forest estate and is the largest landowner in Scotland. They are the landowner with the largest amount to lose from the threat of wildfires and yet, while they do cut some firebreaks around their plantations, they do not carry out prescribed burning on adjacent moorland to reduce fire hazard (FES, pers. comm.).

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Discussion (continued)

Experience on NTS land managed without burning shows that a relatively low percentage (2%) of land has been subject to wildfires over a period of 18 years.

This points to the conclusion that the risk posed by managed burning is unacceptably high and that, far from reducing the incidence of wildfires in the Scottish uplands, it is actually the major cause.

In contrast, the consequences of not carrying out muirburn are not severe.

Experience on NTS land managed without burning shows that a relatively low percentage (2%) of land has been subject to wildfires over a period of 18 years. It would be nonsensical to burn 100% of the land on an 18-year cycle in order to protect 2% of it. The impact of burning on soil carbon storage is generally negative and there is emerging consensus that controlled burning results in carbon losses under most conditions (Worral *et al.*, 2011; Glaves *et al.,* 2013). The experience of wildfires on NTS properties suggests that a programme of controlled burning would have resulted in far higher losses of soil carbon than tolerating a few wildfires.

McMorrow *et al.* (2009) conclude that 'controlled burning, grazing or cutting to reduce fuel load is an *effective management solution*, since managed heather moorlands in the Peak District National Park are statistically less prone to wildfire' (*emphasis added*). But this depends on what problem the management is designed to solve. It may be able to reduce the absolute number of wildfires but it does not reduce the area burnt by wildfire (see Worral *et al.*, 2011). More importantly, it certainly does not reduce the overall number of fires or the overall amount of soil carbon potentially lost to fire, as the managed burning necessitates burning the whole moor at regular intervals. Evidence from SFRS statistics in Scotland suggests that there may even be no benefit in reducing the number of wildfires, since muirburn in Scotland is the overwhelming cause of wildfires.

This study demands a radical reassessment of the current guidance on muirburn if the intention is to reduce the damaging consequences of wildfires on private property, biodiversity and carbon storage in the Scottish uplands. Alternative means for reducing wildfire risk, such as ensuring that moorland water tables remain high, or creating a diverse sward and reducing the over-dominance of heather, may be more effective and certainly less damaging.

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