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The use of conservation biomass feedstocks as potential bioenergy resources in the United Kingdom

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HIGHLIGHTS

- Estimated the amount of biomass available from conservation areas in the UK.
- Examined the combustion properties of the species available.
- Studied the combustion of wood logs, Reeds and charcoal in a stove.
- Most of the conservation biomass could be used as a domestic fuel.

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ABSTRACT

A number of countries have introduced energy policies to reduce the emission of carbon dioxide which, in the case of bio-heat, has resulted in increased use of small wood burning stoves and boilers, particularly in Europe. There are issues surrounding the supply of sustainable wood feedstock, prompting a desire to utilise local biomass resources. This includes biomass generated through the management of natural woodlands in nature reserves and conservation areas. These management practices can also extend to other areas, such as raised bog wildernesses and estuary Reed beds. We term the biomass from this resource as conservation biomass. This study is concerned with the viability of this resource as a fuel within the United Kingdom, and combustion tests were carried out using a small domestic stove. It was concluded that there is as much as 500 kt y^{-1} that could be used in this way.

1. Introduction

European policies and targets for reducing emissions of carbon dioxide have led to an increase in the use of biomass in stoves and boilers throughout Europe. As a consequence, there are potential problems surrounding the availability of sustainable supplies of wood feedstock in Europe. With the requirement of large quantities of imported biomass for electricity generation in the UK (DUKES, 2015), coupled with the desire to achieve security of supply, there is a growing necessity to use local biomass resources. Sustainable bio-heat remains a challenge in many European countries. Thus, small-scale combustion applications may have to be increasingly used, although with appropriate attention to environmental and sustainability issues (Gerssen-Gondelach et al., 2014). In 2014, the UK used approximately 4.9 Mt of fuel wood (DUKES, 2015) of which 354 kt of wood pellets and briquettes were produced using locally grown woods and recycled Grade A wood (Forestry Statistics, 2015). For small scale bio-heat, alternative feedstocks from local sources are an attractive option for both consumer and supplier; however, there are issues about where this is sourced. Particular areas of the countryside are designated with a protected status to ensure that their high value nature and wildlife is not altered or destroyed. Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) within the UK represent a significant expanse of land, covering a range of environments such as forests, moorlands and wetlands.

Although the UKs woodlands have been historically managed, a declining use of wood products has resulted in many forested areas becoming neglected, negatively impacting upon biodiversity and their long-term ecology (Read et al., 2009). The biodiversity of an area can be preserved through a passive management approach, but inaction can result in the suppression of important habitat values and, as a result, can be detrimental to conservation. Therefore, active management, such as small scale felling within previously managed woodlands, or the removal of invasive species, can

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become an environmental necessity. UK sites with significant nature conservation value, such as Sites of Special Specific Scientific Interest (SSSIs), are currently undermanaged, with less than half of the reported areas undergoing positive conservation management. Consequently, management practices hold a great environmental importance (Bernes et al., 2014; Ditlhogo et al., 1992; DEFRA, 2014).

In addition to the existing unmanaged woodland located within the UK, there are other conservation areas that require regular upkeep, namely Reed beds, which are predominantly located on the UK's wetlands. In total, there are 5 kha of Reed beds located within the UK, which require intensive management to safeguard their preservation. The regular cutting of the Reeds is necessary ensuring the correct conditions for rare breeding and migratory birds are achieved, thus improving biodiversity. Cutting the Reeds is a common management practice; however they are often openly burned (Ditlhogo et al., 1992). The inefficient combustion is associated with high emissions of pollutants (Lemieux et al., 2004). In addition, open burning releases CH_4, N_2O and carbonaceous aerosols which are important drivers of climate change (Jacobson, 2014). The practice of harvesting Reeds over a prolonged period of time increases the density of the grown Reeds, but also decreases their shoot thickness (Cowie et al., 1992). Estimates of the above-ground biomass production in the existing literature indicates that Reeds can produce 14–15 t ha^{-1} annually, suggesting that undertaking the required management practices of Reed bed conservation could result in a potentially significant source of local biomass resource (Kuhlman et al., 2013; Kobbing et al., 2014). Other estimates indicate that the productivity in wetlands can be as low as 10% of this figure, similarly in grasslands it can be as low as 6 t ha^{-1} (Wichtmann and Schafer, 2007) while coppiced woodlands can achieve a productivity of 2–5 t ha^{-1} (Hytonen and Issakainen, 2001). As a result, the variability in conservation sites gives rise to a wide variety of different biomass forms that could be utilised in the production of bioheat (Kuhlman et al., 2013; Kask et al., 2013/2014; Wichtmann et al., 2014; Ranjitkar et al., 2014; Sommersacher et al., 2015). Consequently, conservation management practices can produce a considerable amount of biomass wastes that are currently disposed of by open burning. This product is therefore available on a sustainable basis as a by-product of management actions aimed at conserving habitats and their incumbent wildlife. However the amount available of this biomass is dependent upon the proportion left in situ to maintain the health of the habitat, a figure which can vary from 10% to 100% (Welfe et al., 2014). This data enables us to estimate an approximate value for the availability of 'conservation' biomass later in this paper.

Thus this study aims to examine the potential and fuel characterisations for some of these biomass feedstocks produced from conservation management processes. The resources considered include a variety of native broadleaved wood species and harvested common Reeds, sourced from Areas of Outstanding Natural Beauty (AONB), SSSIs, and dedicated nature reserves.

Table 1
Areas of Special Conservation and Special Protection in the UK.

Region	SAC		SPA	
	No. sites	Area (ha)	No. sites	Area (ha)
England	230	1,068,476**	81	1,054,353
Scotland	236	939,727**	152	1,205,988
Wales	85	590,864	17	172,149
England/Scotland*	3	112,564	1	43,637
England/Wales*	7	95,132	3	209,247
Northern Ireland	54	85,831**	16	114,052
Total	615	2,892,594	270	2,799,426

* Areas that cross the border,
** Includes Sites of Community Importance (SCIs).

2. Materials and methods

2.1. Source of the fuels

The sources of all of the conservation fuel in the UK are set out in Table 1. We have studied typical samples in particular locations described below and the samples studied are listed in Table 2. In addition to the raw (unprocessed) biomass samples, charcoal (biochar) produced from the peat grown Willow has been investigated, whilst both biochars and briquettes had been produced using the harvested Reed. The separate carbonising (charring) and briquetting processes were undertaken for us using traditional heated kiln methods.

The Humberhead Peatlands National Nature Reserve is considered the largest area of raised bog wilderness in lowland Britain and is located in South Yorkshire. The site is classified as both a SAC and a SPA due to its habitat and consequent role as a breeding

Table 2
Description of samples used in the study.

Type	Sample name	Site type	Sample type
Woods	Ash (*Fraxinus excelsior*)	Woodland (AONB[3])	Heartwood, bark
	Birch (*Betula pendula*)	Peat (SAC[1])	Heartwood, bark, homogenised
	Hazel (*Corylus avellana*)	Woodland (AONB[3])	Heartwood, bark
	Willow (*Salix caprea*)	Peat (SAC[1])	Homogenised
	Willow (*Salix caprea*)	Floodplain (SSSI[2])	Heartwood, bark
	Willow SRC (*Salix viminalis*)	Short rotation coppice	Homogenised
	Willow billets (*Salix* spp)	Tidal estuary	Heartwood, bark
	Willow char 1	Peat (SAC[1])	Traditional thermal kiln
	Willow char 2	Peat (SAC[1])	Traditional thermal kiln
Herbaceous	Reed raw (*Phragmites australis*)	Tidal estuary	Common Reed as harvested
	Reed char 1	Tidal estuary	Traditional thermal kiln
	Reed char 2	Tidal estuary	Traditional thermal kiln
	Reed washed	Tidal estuary	Lightly washed in room temp. distilled water
	Straw raw (*Triticum* spp)	Agricultural land	Wheat straw as harvested
	Washed straw	Agricultural land	Lightly washed in room temp. distilled water
	Peat turf	Peatland in Ireland	Cut bog peat, air dried

[1] Special Area of Conservation.
[2] Site of Specific Scientific Interest.
[3] Area of outstanding natural beauty.