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Research paper

Biomass recovery from invasive species management in wetlands

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ABSTRACT

Reed represents an opportunity fuel that can be obtained from wetland restoration activities designed for reducing the dominance of invasive reed over native matrix vegetation. Equipment used for reed recovery must be light enough to negotiate soft terrain. At the same time, it needs to be versatile, so that investment cost is depreciated on a variety of different tasks, given the seasonal character of reed collection. The study tested a new system designed for harvesting reed during winter, under unfrozen soil conditions. This system was based on a modified snowcat (trail groomer) and on light orchard tractors, for maximum floatation. Reed chopping, windrowing, baling and extraction took 12 h ha^{-1} and incurred a cost of 500 € ha^{-1}, or 111 € t^{-1} dry matter. Assuming that reed biomass would obtain a price of 80 € t^{-1} dry matter, the cost of reed control would amount to 160 € ha^{-1}, which is better than the 242 € ha^{-1} required for chopping to waste. Furthermore, savings can be accrued by better operator selection (baling) and by improving extraction technique, which would bring reed collection cost below 100 € ha^{-1}. Reed biomass has favourable fuel qualities, including low water mass fraction. For this reason, reed can be used to build a strategic reserve to be tapped in winter, at times of peak demand. Furthermore, reed grows on land that is not suitable for other uses, and therefore it is unlikely to compete with food crops.

1. Introduction

Wetland ecosystems represent extremely valuable habitats [1] but they are often threatened by human activity, which has greatly reduced their natural extension [2]. The European Union (EU) has suffered the greatest loss in wetland areas compared with the rest of the world [3], and for this reason EU legislators have extended protection status to many of the remaining European wetlands under the EU Habitat Directive of 1992. Additional protection measures are also offered by the EU Birds Directive of 1979, the Bonn Convention on migratory bird species and the Bern Convention on wetland conservation [4].

These regulations have severely restricted those human activities that threaten wetlands directly, such as drainage and peat extraction. However, current regulations cannot prevent habitat loss through indirect anthropogenic effects, such as eutrophication and climate change. In particular, agriculture and urban development have favoured the spread of invasive species through increased nitrogen availability [5]. Among such species, the most aggressive is probably common reed (*Phragmites australis* Cav.), which is encroaching on native matrix vegetation in disturbed wetlands all over the world [6]. Common reed displaces matrix vegetation in two ways. On one hand, reed can outcompete other native species because it is fast-growing [7], and exceptionally tolerant to salinity [8], to flooding, to exposure and in general to climatic variations [9], which makes it especially dangerous in the face of climate change [10]. On the other hand, reed actively suppresses its competitors by spreading through root suckers, while building a thick mulch layer that prevents contact between the soil and the seeds of other species [11]. If that was not enough, reed roots secrete allelochemical compounds that inhibit the growth of those species that may have overcome all other obstacles [12].

The effective protection of wetland habitats requires that reed is controlled through grazing, burning, cutting and herbicide

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application [13]. These measures can reduce reed dominance and increase plant biodiversity but their effect is only temporary, and therefore require frequent application [14]. Hence, the strong interest in devising cost-effective reed management techniques that may reduce the strain on a land manager's limited financial resources. Although much reduced in their extension, European mires alone still cover over 150,000 km^2 [3] and there is simply not enough money to manage them all, at current cost levels.

In that regard, one interesting opportunity comes from the growing bioenergy market [15]. All the qualities that make reed a redoubtable competitor, also make it an ideal source of biomass, which is demonstrated by the recent success of other reed species like reed canary grass (*Phalaris arundinacea* L.) and giant reed (*Arundo donax* L.) as dedicated biomass crops [16,17]. Tests have shown that a 1:3 reed to wood mix can be successfully fed to conventional biomass plants without any negative effects on emissions, ash production or ash slagging [18]. If reed could be sold to local biomass plants, then part of the reed control costs could be recouped, thus increasing the financial sustainability of this operation [19]. The financial viability of reed collection requires the design of a cost-effective system for cutting, collecting and delivering reed biomass fuel. In most cases, the main hurdle to cost-effective recovery is terrain access, because reed grows on soft terrain. Conventional harvesting equipment can only operate during the two extreme seasons, when the soil is frozen or it is so dry that in can support machine traffic. Unfortunately, these conditions only occur for a very short time every year, and they are becoming increasingly rare as a consequence of climate change [20]. The alternative consists in developing new high-floatation machines that can negotiate soft soil, but this operation requires a relatively large investment while producing a specialized piece of equipment that may lack the versatility for easy depreciation of the significant capital outlay [21]. In that regard, a good solution might consist in adapting existing machinery, which is generally cheaper to acquire compared with dedicated equipment. Such solution may offer a good compromise between investment cost and terrain capability, which may significantly extend the harvesting season and reduce harvesting cost.

The goal of this study was to design and test a new high-mobility system for effective reed harvesting under wet soil conditions. In particular, the study aimed at determining: 1) the supply cost of reed bales, 2) the effect of extraction distance on extraction system choice and cost and 3) the energy balance of reed harvesting for fuel use. This study focuses on the management of common reed (*Phragmites australis* Cav.), not other reed species, although its findings might be generalized to some extent.

2. Materials and methods

The new high-mobility harvesting system was designed for the production of reed bales, given the very low density of loose reed. The system consisted of four units, tasked with performing the same jobs as in the typical dry-land version already in use, and namely: chopping, windrowing, baling and extraction [22].

Reed was cut and chopped with a dedicated swing-hammer mower attached to a 110 kW Ratrac Rolba 140 snow cat (trail groomer), fitted with auxiliary coolers and filters for working in a warmer and dustier environment than it was originally designed for (Fig. 1A - top left). Chopped reed was windrowed with a commercial rotary hay rake, attached to a light Claas Nectis 257F orchard tractor (Fig. 1B - top right). The tractor had a power of 65 kW and the whole unit weighed, 2850 kg. Windrows were left to dry in the sun for one or two days and were then baled with a Tonutti-Wolagri Pony 100 fixed-chamber round baler, powered by a 67 kW Fendt 209 orchard tractor (Fig. 1C - bottom). This unit weighed 2750 kg and produced small round bales, with a diameter of 100 cm and width of 100 cm. Bales were then extracted to the roadside with the same Claas tractor used for windrowing. Two alternative extraction techniques were adopted, depending on extraction distance: when the extraction distance was within

Fig. 1. The reed collection system on trial: chopping (top left), windrowing (top right) and baling (bottom).