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A novel agroecosystem: Beef production in abandoned farmland as a multifunctional alternative to rewilding

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ABSTRACT

In much of Europe policy is challenged by the abandonment of crop and pasture land and its replacement by natural forest regrowth. Rewilding is one option. An alternative, multifunctional, strategy is extensive beef farming coupled with carbon storage in herbage and naturally regenerating trees. An economic model is developed in the context of Estonia, where many of the constraints and opportunities relating to natural forest regrowth are in particularly sharp focus, but the approach will be widely applicable. Production of niche market beef, carbon sequestration, and other ecosystem services can proceed in parallel. A novel concept of support payments is proposed. Net present value assessment, with cash credits for carbon storage, demonstrates that the model is viable. A 100 ha tract of abandoned land, stocked with 35 beef cows, would produce beef profitably. Provisioning, regulating and cultural ecosystem services would be delivered, including a net storage of carbon, and rural regeneration would be promoted. The study provides further scientific underpinning for a policy discussion on abandoned land, which represents a growing proportion of Europe's land area. Extensive beef production is compatible with net carbon storage and can provide sustainable ecosystem services together with rural regeneration.

1. Introduction

Land abandonment is one of the main drivers of landscape change in Europe (Plieninger et al., 2016) where cropland has decreased by 19%, and pastures and semi-natural grasslands by 6%, between 1950 and 2010 (Fuchs et al., 2012). Alcantara et al. (2013) estimated abandoned farmland to cover 8.2% of their central-eastern European study area – about a fifth of the area that is being actively farmed or pastured. In some mountainous areas, arable farming may have ceased altogether, particularly in southern Europe (Lasanta et al., 2015).

There is no ecological or policy consensus on how abandoned lands should be managed (van der Zanden et al., 2017). One option is to do nothing with these areas; this only differs in degree from rewilding, which is defined by Pereira and Navarro (2015) as “the passive management of ecological succession with the goal of restoring natural ecosystem processes and reducing the human control of landscapes”. Although rewilding can have economic as well as biodiversity benefits (Cerqueira et al., 2015) for it to be admissible as a policy option further clarification of concepts is needed (Murray, 2017; Nogués-Bravo et al., 2016). Also needed is more elucidation of the practical benefits for biodiversity and for species and landscape conservation (Sutherland et al., 2010), though evidence is accumulating (Sandom, 2016). The relationships of rewilding to provision of food and energy, and to the cultural benefits of landscapes also need further consideration (Lorimer et al., 2015). Possible uses of abandoned land other than rewilding should therefore be considered.

Multiple-use models are finding favour in applied ecological research (Maskell et al., 2013) and could be applied to the management of abandoned land. When European food security under climate change is taken into account, a multifunctional strategy is, arguably, better than one based on increase of productivity (Holman et al., 2017). There must be compatibility with rural development policies, and resilience to climate change. A linkage between agri-environment schemes and ecosystem services (Whittingham, 2011), is now expected in environmental policy and practice (for example, by the UK Government; Defra, 2018). In the present study, a multifunctional system is developed for the management of abandoned farmlands to supply provisioning, regulating, and cultural ecosystem services. The social and ecological background to land abandonment differs among countries (Alcantara et al., 2013) and this model is devised with particular, but not exclusive, reference to Estonia. This is because certain features of the phenomenon are strongly accentuated here, with parallels elsewhere in Europe.

Extensive beef production is suggested here as a silvopastoral system which can deliver a particularly wide range of ecosystem services. The carbon sequestration of the tree and herbage components can

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more than compensate for the carbon footprint of beef production. Thus, provisioning and regulating services are provided, together with cultural services in the form of rural regeneration. Measures to exploit these abandoned lands must be distinguished from those aimed at conservation of traditional wood pastures, many of which are threatened by abandonment (Bergmeier et al., 2010; Van Uytvanck and Verheyen, 2014). There, the priority is very clearly conservation of floral and faunal biodiversity and of cultural landscapes, and management will be site-specific (Forestry Commission Scotland, 2004).

Pasture-based beef production in Europe is, in many, probably most countries, only viable because of support payments which are provided for societal benefits. For example, in Scotland, Voluntary Coupled Support is provided as a payment (€104–158) for each qualifying beef calf produced (Scottish Government, 2017). The total annual disbursement is €43 million, to 7000 eligible producers. Another mechanism, which for many livestock farmers in the UK, as elsewhere, is essential to their livelihoods, is support under High Nature Value farming schemes (Morgan-Davies et al., 2017).

Beef in Estonia is relatively expensive with about half of consumption being of imports (Gavrilova and Vilu, 2012) but there is growing interest in high value and organic beef production (Lepasalu et al., 2009; Rucinski, 2016). Historically, dairy cattle have predominated and Estonia has no native beef breeds (Pae et al., 2009) but many beef cattle are being used to manage semi-natural, High Nature Value grasslands (Hermanson et al., 2013). The EU-funded Horizon 2020 Pegasus project has been studying development of an innovative organic grass-fed beef chain in Estonia which currently accounts for about 8% (approximately 6000 head) of the country's beef cattle (Peepson et al., 2017). The present study is intended to complement these activities.

The positive effects cattle can have on the biodiversity of woodland are well known (Forestry Commission Scotland, 2004; Nilsson et al., 2013). When grazing intensity in wood pastures is low, forest-grassland segregation is predicted to replace forest-grassland ecotones (Peringer et al., 2016b). In ungrazed abandoned arable fields in Latvia a heavy layer of dead grass accumulates, which favours Norway spruce *Picea abies* and Scots pine *Pinus sylvestris* establishment rather than the birch *Betula* spp., aspen *Populus tremula*, alder *Alnus glutinosa* and willow *Salix* spp. predicted in the classical boreal succession model (Ruskule et al., 2016). The opportunity therefore exists to determine, by appropriate stocking rates, the forms into which a new wood pasture will develop (Peringer et al., 2016a).

In Estonia there is a clear social and political will for traditional and natural landscapes to be conserved (Roellig et al., 2016), but almost all the 850,000 ha of species-rich wooded meadows present in 1900 have been lost (Kana et al., 2008; Sepp et al., 1999). People do not like to see abandoned land (Kaur et al., 2004), and extensive livestock grazing could replace this apparent dereliction by engendering a diversity of attractive landscapes (Lasanta et al., 2015). Such management might be of the highest priority in areas close to surviving patches of wood pasture or of particular scenic or cultural significance, and could restore connectivity between fragmented areas of conservation importance.

However, much abandoned farmland is in areas of lower potential for these approaches and this is the land resource of particular interest in the present study. Beef production imposes a carbon footprint of about 20 $kgCO_2eq\ kg^{-1}$ beef carcass in European systems (Foley et al., 2011; Persson et al., 2015). Reducing numbers of livestock kept under currently favoured husbandry systems will clearly mitigate climate change (Bryngelsson et al., 2016; Sozanska-Stanton et al., 2016). However, market demand for beef, as for other products of ruminants, will persist and means should be sought for meeting this demand in environmentally sensitive ways. This could be achieved by offsetting (sequestrating carbon dioxide elsewhere in the system). This is possible, through tree regeneration, if stocking rates are low. Abandoned farmlands, of zero current economic value, are the only land class that is available for such a purpose. Meat produced in such a system, duly audited, could achieve organic status or could be marketed as "nature friendly", "carbon neutral", or under some name of that kind and could appeal to a niche, environmentally-aware market. The proposed system offers one such model.

2. Materials and methods

2.1. Background

The business model presented here is for a beef enterprise of 20 years duration. Benchmark data are from a standard farm management text (pages 140–141, 154–155 "Hill Suckler Cows"; Craig, 2016). Data from individual enterprises are also available (Hedgeley Farms, 2014). A suckler beef operation is designed, where calves are kept with cows until weaning, then grown to slaughter weight. Relevant data on carbon transfers in abandoned fields stocked with cattle are not extensive and there is likely to be very wide variation between sites, so in the model the key variables of herd size (35 cows) and of land area (100 ha) were fixed in the light of experience elsewhere. In England the average size of a suckler herd is 28 cows (Topliff, 2015) and, in Scotland, 50 cows (Morgan-Davies et al., 2014).

Land area was fixed on the basis of preliminary calculations of carbon sequestration and biomass availability. Three discount rates were applied: 0.089, the rate considered appropriate for Estonian government real estate projects by Sander et al. (2011); 0.075, the rate often adopted for agroforestry projects (Schroeder, 1993); and 0.035, the mid-range of the rates cited by Triviño et al. (2017) which is also the relevant discount rate recommended in the UK (HM Treasury, 2013).

Carbon prices vary greatly. The 2019 price under the EU Emissions Trading Scheme was expected by Twidale (2017) to be over €7, perhaps up to €9.80, $t^{-1}CO_2eq$. Over 40 national and regional governments set carbon prices and some companies operate their own pricing systems (Bartlett et al., 2017), for example €29 and €48 $t^{-1}CO_2eq$, by the large corporations Unilever and Michelin respectively.

2.2. Specification of variables

2.2.1. Stocking rates and forage availability

Extensive cattle systems in Europe (Table 1) operate very variable stocking rates in the grazing season (over 100 cows per 100 ha) and for year-round subsistence, sometimes considerably lower than 3–5 ha cow^{-1} (20–33 cows per 100 ha). There is much practical experience, though relatively little formal research, on the productivity of cattle in these systems, many of which have environmental management as a primary aim. Former arable or pasture land in Estonia is frequently (R.G.H. Bunce, personal communication) in relatively small (around 20 ha) patches of, essentially, three types; unused for three to seven years, unused for seven to 20 years and being colonised by shrubs, or with regenerated trees dating back to the early 1990s. The system proposed here is based on 100 ha of rent-free land, preferably including all these types, stocked year-round with 35 cows (600–800 kg body weight) and two bulls, i.e. 2.7 ha $animal^{-1}$, supplementary feed being provided in winter. Published data on available biomass in abandoned lands suggest primary productivity is sufficient to sustain this stocking rate. On "semi-open pasture" in Germany (Härdtle et al., 2002) fully grown cattle require 4.75 t $year^{-1}$ of forage, and in a pasture-based system in France intake is 3.7 t yr^{-1} cow^{-1} (Morel et al., 2016). In Estonia Uri et al. (2012) found a tree biomass (silver birch, *Betula pendula*) of 67.6 t ha^{-1} which, applying the findings of Johansson (1999) of leaves being 6.4% of tree biomass, implies a standing crop of tree leaves of 4.3 t ha^{-1}. The ground layer can provide 1% of aboveground biomass, or 0.676 t ha^{-1} in addition (Gilliam, 2007; Uri et al., 2012). Thus, with an edible biomess of about 50 t ha^{-1}, when the stocking rate is 35 cows per hundred hectares, a cow will have access to a standing crop of over 14 t; though rates of increment of understorey biomass under a foraging regime are not documented.